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Report on
Supplementary Geotechnical Investigation

Wagga Wagga Base Hospital Redevelopment,
Phase 2/3 and Portion A
Edward Street, Wagga Wagga

Prepared for
Health Infrastructure

Project 72320.06
January 2013

**Douglas Partners**
*Geotechnics / Environment / Groundwater*

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MANAGEMENT SYSTEM

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114
PO Box 472
West Ryde NSW 1685
Phone (02) 9809 0666
Fax (02) 9809 4095

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# Report on Supplementary Geotechnical Investigation
# Wagga Wagga Base Hospital Redevelopment, Phase 2/3 and Portion A
# Wagga Wagga Base Hospital, Edward Street, Wagga Wagga

## 1. Introduction

This report presents the results of a supplementary geotechnical investigation carried out by Douglas Partners Pty Ltd (DP) for the Wagga Wagga Base Hospital redevelopment project at Edward Street (Sturt Highway), Wagga Wagga. This investigation work was commissioned by Health Infrastructure and was carried out in accordance with DP's proposal SYD120971, dated 6 September 2012, and subsequent variations.

It is understood that the redevelopment project will involve the progressive demolition and redevelopment of majority of the existing hospital buildings. The next phases of the project are the Acute Hospital, understood to be a new, eight-storey building (Phase 2) and demolition of existing multi-storey ward building and construction of car parking in its place (Phase 3).

A separate, smaller addition is also proposed at the hospital (under the provision of the Infrastructure SEPP), including a new single storey mortuary and two-storey central energy plant (CEP) building ("Portion A").

The locations of the proposed redevelopment areas are indicated on Drawing No. 1 in Appendix B.

This report has been prepared for the purpose of development application for Phase 2/3 and to inform the Review of Environmental Factors (REF) for Portion A, as well as for preliminary planning and design of construction for the development. DP also carried out a preliminary contamination assessment in conjunction with the current supplementary geotechnical investigation which is reported separately (refer DP report 72320.06 Rev 1, dated 7 December 2012).

## 2. Background

DP has had continuing involvement with the Wagga Wagga Base Hospital redevelopment and has completed the following geotechnical investigations on the site for Health Infrastructure:

- *Geotechnical Investigation, Proposed Wagga Wagga Base Hospital Redevelopment, Edward Street, Wagga Wagga,* reference 72320.00, dated September 2011 (DP 2011a). Included drilling BH 101 to 109.
- *Supplementary Geotechnical Investigation Proposed Redevelopment, Wagga Wagga Base Hospital, Edward Street, Wagga Wagga, NSW;* reference 72320.03, dated October 2011 (DP 2011b). Included CPT 1 to 5 and BH 201 to 211.

The locations of all intrusive investigations to date (i.e boreholes and cone penetration tests) are shown on Drawing No. 1, included in Appendix B. For specific details, reference should be made to the individual reports.

Settlement analysis and construction inspections have also been carried out by DP for various parts of the redevelopment (references 72320.02 and 72320.04).

## 3. Site Description and Geology

The sites for the proposed redevelopment are located within the existing hospital complex at Edward Street (Sturt Highway), Wagga Wagga. The two areas which are the subject of the current supplementary investigation are indicated on Drawing No. 1, Appendix B.

Phase 2/3 area is currently occupied by existing ambulance bay and other hospital infrastructure along the eastern boundary (which is bordered by Lewis Drive), access roads and out-buildings to the west, and existing, multi-storey hospital buildings to the north. The area covers approximately 10,000 $m^2$.

Portion A is directly to the south of the Phase 2/3 area and is bordered by Rawson Avenue to the south. The area is currently occupied by the existing laundry and boiler room as well as some workshops to the east, and access and parking areas, with some minor landscaping areas, to the north. The area covers approximately 3,500 $m^2$.

The site generally falls to the north by approximately 2 m over 270 m.

Reference to the Wagga Wagga 1:250 000 Geological Series Sheet (SI 55-15) indicates that the northern half of the site is underlain by unconsolidated sand, silt, clay and gravel (floodplain sediments) and includes high-level Tertiary aged terrace sediments of the Murray Valley comprising gravel, sand, silt and clay. The southern half of the site is shown to be underlain by the Wagga Marginal Base Formation comprising shale, slate, quartzite, sandstone and subgreywacke.

The subsurface profile encountered during the investigations generally included pavement and filling/topsoil materials overlying alluvial clays and sands (comprising interbedded layers of silty/gravelly/sandy clay and sand) to depths in excess of 30 m.

Regional groundwater and surface water is expected to flow in the north-east direction towards the Murrumbidgee River. Groundwater was observed at a depth of around 6.3 m (RL 176.3 m AHD) during the previous investigations.

## 4. Field Work Methods

The current supplementary geotechnical investigation included seven (7) cone penetration tests (CPT 301 to CPT 307) conducted to depths of between 18 m and 34 m.

The test locations were initially excavated to 1.2 m with a combination of hand tools and water blast/vacuum truck techniques in order to check for underground services and carry out environmental sampling, before being backfilled with gravel and commencing the CPT.

The cone penetration test involves forcing a 35 mm diameter cone into the ground at a constant rate of 1 m per minute using the thrust provided by hydraulic rams on a 15 tonne table top truck. Strain gauges in the cone tip and on the 130 mm long friction sleeve record the resistance to penetration at 20 mm depth intervals. The resistances are plotted in real time on a computer, along with the cone inclination. The supervising engineer monitors the test results continuously as the test proceeds and will normally abort the test if the inclination form vertical exceeds about 5 – 10 degrees. In this way a truly vertical soil profile is obtained. When the test reaches target depth or refusal, the test data is recorded directly to computer memory and transmitted to the office for engineering analysis.

The test locations are also shown on Drawing No. 1 in Appendix B, along with test locations from DP's previous investigations (DP 2011a and 2011b). The locations of the CPTs were selected by the client in order to supplement the existing site information. CPT 301, 302 and 304 were located within Portion A, whilst CPT 303, and 305 to 307 were located within the Phase 2/3 area. The ground surface levels at the test locations were estimated using information contained on a survey drawing provided by the client.

## 5. Field Work Results

Details of the conditions encountered during the investigations are provided in Appendix C, together with notes defining classification methods and descriptive terms. For details relating to previous investigations, reference should be made to the specific reports (referenced in Section 2).

The boreholes and CPTs with the Phase 2/3 and Portion A areas generally encountered filling over alluvial clay. The subsurface conditions may be generally summarised as follows:

- **PAVEMENTS:** encountered in boreholes BH102 (roadbase only), BH103, BH104, BH107, BH107A, BH204, BH205, BH206 (roadbase only), BH207 and BH208 (roadbase only) and comprised asphaltic concrete (AC), apart from where mentioned above, over roadbase with a combined pavement thickness of between 0.1 m and 0.2 m;
- **TOPSOIL:** encountered in bores BH101, BH105, BH106, BH108, BH109, BH201 to BH203, and BH209 and BH210 to depths of between 0.1 m and 0.7 m. The topsoil generally comprised sandy silt and silty clay;
- **FILLING:** encountered to depths of 0.2 m to 2.4 m in numerous locations and generally comprised poorly compacted silty clay filling with some building rubble (tiles and concrete fragments), silt and sand;

- **SILTY/SANDY CLAY AND GRAVELLY SILTY CLAY:** silty clay and some sandy clay encountered in all test locations to depths of 7.0 m to 32.5 m. The silty clay was of a typically very stiff to hard consistency in all bores. Gravelly silty clay was logged in bore BH101 between 7 m and 8 m depth and 16.0 m and 19.0 m depth, and was typically of hard consistency. The CPTs indicated some minor gravel bands of less than 0.4 m thickness extending to the maximum test depth of 32.5 m (RL 150 m), with minor interbeds of clayey sand and clayey sandy gravel interpreted in CPT4 only at depths of 8.5 m (RL 174.1 m) and 10.6 m (RL 172.0 m) with thicknesses of approximately 1.5 m.

During April and September 2011, free groundwater was observed during augering (or after leaving the boreholes open for a 12-hour period) in borehole BH107A at a depth of 13.10 m. The use of water during washbore drilling prevented the measurement of groundwater in other boreholes below depths of around 8.50 m.

Water levels within the standpipes in boreholes BH101 and BH106 were recorded after completion of the drilling and "bailing out" the standpipes. The water level measurements are given in Table 1.

**Table 1: Standing Water Levels in Standpipes**

| Borehole | Surface RL | Water Level Measurements | | |
|---|---|---|---|---|
| | (m AHD) | Date | Depth (m) | RL (m AHD) |
| BH101 | 183.0 | 31.3.11<br>7.4.11<br>20.9.11 | 6.6<br>6.7<br>7.3 | 176.4<br>176.3<br>175.7 |
| BH106 | 182.6 | 6.4.11<br>20.9.11 | 6.3<br>5.8 | 176.3<br>176.8 |

Groundwater was not encountered during the current investigation due to the CPT holes collapsing before measurements could be taken. It should be noted that groundwater measurements should only be considered accurate on the date of the measurement, and should be expected to fluctuate both seasonally and climatically.

## 6. Geotechnical Model

The natural sub-surface profile at the site comprises alluvial clays. The sediments consist of interbedded layers of clay and silty/sandy clay with some gravel bands. Due to their origin these soil materials are expected to be variable across the site, varying in depth, thickness and extent, depending on the alignment and size of ancient river channels. Previous laboratory test results (refer DP 2011b) suggest that the clayey soils are of moderate plasticity.

Groundwater has previously been encountered below depths of 6 m, at about RL 176.3 m.

# 7. Proposed Development

It is understood that the proposed redevelopment of the site includes three stages of construction activities, including the progressive demolition of almost all existing buildings.

The areas which are the subject of the current supplementary investigation includes the following:

- Phase 2/3 area – including acute hospital building, entry forecourt and carparking; and
- Portion A – new mortuary (single storey) and CEP building (two storey). It is noted that Portion A is to be approved separately from Phase 2/3 under the provisions of the Infrastructure SEPP.

Based on advice from the structural engineer (Mott Macdonald), estimated maximum working column loads for the acute hospital building will be around 8,000 kN. The loads will need to be supported on relatively deep, large diameter piles / pile groups.

The proposed mortuary and CEP building/s are understood to be relatively lightly loaded structures.

Comments related to site preparation and earthworks, excavation, shallow foundations (for other areas of the site) and pavements are included in DP's previous report (DP 2011b) which should be referred to where required.

# 8. Comments

## 8.1 Shallow Foundations

The loads for the proposed mortuary and CEP building should be readily supported on high level footings founded within the very stiff to hard clay, either in the form of a raft slab or pad/strip footings.

As a guide, for raft slab foundations, preliminary settlement analyses has been carried out assuming a uniform distributed slab pressure of around 20 kPa over an area of 20 m by 20 m. Based on the results of the analyses, the preliminary design of raft slabs to support column and floor loadings may be based on a modulus of subgrade reaction in the order of 2.5 to 5 kPa/mm for the broad loaded area (i.e. 20 m by 20 m). Settlements in the order of 5 mm to 15 mm could be expected under the assumed loads. The modulus of subgrade reaction value will vary with the load and the size of the loaded area and for detailed design of a raft foundation, modelling the soil profile as an elastic solid is preferred.

Recommended maximum allowable bearing pressures and modulus values for the very stiff to hard clay encountered below depths of 0.2 m to 1.6 m within Portion A are presented in Table 2 for pad and strip footings.

**Table 2: Design Parameters for Pad and Strip Footings**

| Material Description | Allowable Bearing Pressure (kPa) | Field Elastic Modulus, E (MPa) |
|---|---|---|
| Very stiff to Hard Clay | 400 | 50 |

The settlement of foundations proportioned on the basis of the above allowable parameters would be expected not to exceed 1% of the footing width.

## 8.2 Pile Foundations

It is understood that the proposed acute hospital building is likely to be supported on continuous flight auger (CFA) piles, which may be in the order of 25 m deep, at diameters of 900 mm or 1200 mm. The piles will be founded in predominantly hard clays, with some very stiff clay.

Based on the likely pile dimensions, analysis has been carried out using DP's in-house software (ConePile) for the available information at the proposed acute hospital building within the Phase 2/3 area. The results are included in Appendix D. Ultimate end bearing pressure and shaft adhesion values for the hard clays encountered based on the analysis are given below:

- Ultimate End Bearing Pressure (compression) 2250 kPa
- Ultimate Shaft Adhesion (compression) 30 kPa (ignoring the upper 3 m of shaft)
- Ultimate Shaft Adhesion (tension) 20 kPa (ignoring the upper 3 m of shaft)

Table 3 provides a comparison of the possible Working loads capable of being supported on 25 m deep CFA piles with different diameters (900 mm and 1200 mm), based on a geotechnical strength reduction factor of 0.6 (refer Section 8.2.1).

**Table 3: Example of Working pile loads**

| Pile Diameter (mm) | CFA Piles | | | |
|---|---|---|---|---|
| | Ultimate Shaft Load [1] (kN) | Ultimate End Bearing Load (kN) | Total Ultimate Load ($R_{ug}$, kN) | Total Working Load[2] ($R_g$, kN) |
| 900 | 1866 | 1431 | 3297 | 1978 |
| 1200 | 2488 | 2545 | 5033 | 3020 |

Notes:

1. Assuming pile in compression, pile depth of 25 m below surface level, but only taking into account the lower 22 m in hard clay
2. Assuming a geotechnical reduction factor of 0.6 (refer Section 8.2.1).

### 8.2.1 Geotechnical Strength Reduction Factor

Based on the Piling Code (AS 2159-2009), the design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor ($\varphi_g$), such that:

- $R_{d,g} = \varphi_g \, . \, R_{d,ug}$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect $E_d$. Selection of the geotechnical strength reduction factor ($\varphi_g$) is based on a series of individual risk ratings (IRR) which

are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of $\varphi_g$ depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime: testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy - whether other piles can take up load if a given pile settles or fails.

A 'basic' geotechnical strength reduction factor ($\varphi_{gb}$) would be in the range 0.42 to 0.50 based on the type and number of previous tests. However, with good construction control/monitoring and a comprehensive testing regime, an ARR between 1.5 and 2 may be able to be achieved, and the basic geotechnical strength reduction factors may be able to be improved to 0.61 and 0.7 for single piles (low redundancy) and groups (high redundancy) respectively.

### 8.2.2 Pile Settlements

For a single, floating pile founded 25 m within the very stiff to hard clay soils encountered at the site, under a 4,000 kN load, the following settlement may be expected:

- 900 mm diameter pile – up to 8 mm of settlement
- 1200 mm diameter pile – up to 6 mm of settlement

Settlements for pile groups, if adopted, will be larger than settlements for individual piles due to the increased zone of influence below the base of the pile group. Specific advice and detailed analysis would be required to predict the settlement of pile groups.

## 9. Limitations

Douglas Partners (DP) has prepared this report for a project at Wagga Wagga Base Hospital, NSW in accordance with DPs proposal dated 26 September 2012. The report is provided for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

**Douglas Partners Pty Ltd**

# Appendix A

About this Report

# About this Report

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## Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations 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.

## Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

## Borehole and Test Pit Logs

The borehole and test pit logs presented in this report 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 or excavation. 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 and test pits 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 or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

## Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements 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.

## Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP 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 conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

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

# *About this Report*

## 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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

## Information for Contractual Purposes

Where information obtained from this report 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. DP 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 and environmental 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.

# Appendix B

Drawing No. 1 – Test Location Plan


Locality Plan

EDWARD STREET

DOCKER STREET

MURRAY STREET

RAWSON AVENUE

BROOKONG AVENUE

HARDY AVENUE

BH106 BH201 BH202 BH203 BH204 BH105 BH205 BH108 BH104 BH103 BH107 BH107A BH209 BH109 BH210 BH101 BH207 BH206 BH208 BH102 BH211

306 307 303 305 302 304 301

CPT1 CPT3 CPT4 CPT2 CPT5

PHASE 2/3 AREA

APPROXIMATE OUTLINE OF PROPOSED ACUTE HOSPITAL BUILDING

PORTION A

0 5 10 20 30 40 50 75 100 150m

1:1500 @ A3

## LEGEND

- Current Test Location (CPT & Shallow borehole)
- Previous Borehole Location (April 2011)
- Previous CPT Location (September 2011)
- Previous Borehole Location (September 2011)
- Approximate Hospital Boundary

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| | | | |
|---|---|---|---|
| CLIENT: Health Infrastructure | | TITLE: **Test Location Plan** | PROJECT No: 72320.06 |
| OFFICE: Sydney | DRAWN BY: PSCH | **Wagga Wagga Base Hospital Redevelopment** | DRAWING No: 1 |
| SCALE: As shown | DATE: 27.11.2012 | **Edward Street, Wagga Wagga** | REVISION: 0 |

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# Appendix C

Results of Field Work

## Sampling

Sampling is carried out during drilling or test pitting 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 it to obtain 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.

## Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

## Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally 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 samples.

## Continuous Spiral Flight Augers

The borehole 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 sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

## Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud 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 the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

## Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

## Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils 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 before the full penetration depth, 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 SPT tests can be related empirically to the engineering properties of the soils.

### Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. 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 types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

# Soil Descriptions

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## Description and Classification Methods

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

## Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

| Type | Particle size (mm) |
|---|---|
| Boulder | >200 |
| Cobble | 63 - 200 |
| Gravel | 2.36 - 63 |
| Sand | 0.075 - 2.36 |
| Silt | 0.002 - 0.075 |
| Clay | <0.002 |

The sand and gravel sizes can be further subdivided as follows:

| Type | Particle size (mm) |
|---|---|
| Coarse gravel | 20 - 63 |
| Medium gravel | 6 - 20 |
| Fine gravel | 2.36 - 6 |
| Coarse sand | 0.6 - 2.36 |
| Medium sand | 0.2 - 0.6 |
| Fine sand | 0.075 - 0.2 |

The proportions of secondary constituents of soils are described as:

| Term | Proportion | Example |
|---|---|---|
| And | Specify | Clay (60%) and Sand (40%) |
| Adjective | 20 - 35% | Sandy Clay |
| Slightly | 12 - 20% | Slightly Sandy Clay |
| With some | 5 - 12% | Clay with some sand |
| With a trace of | 0 - 5% | Clay with a trace of sand |

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

## Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

| Description | Abbreviation | Undrained shear strength (kPa) |
|---|---|---|
| Very soft | vs | <12 |
| Soft | s | 12 - 25 |
| Firm | f | 25 - 50 |
| Stiff | st | 50 - 100 |
| Very stiff | vst | 100 - 200 |
| Hard | h | >200 |

## Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

| Relative Density | Abbreviation | SPT N value | CPT qc value (MPa) |
|---|---|---|---|
| Very loose | vl | <4 | <2 |
| Loose | l | 4 - 10 | 2 -5 |
| Medium dense | md | 10 - 30 | 5 - 15 |
| Dense | d | 30 - 50 | 15 - 25 |
| Very dense | vd | >50 | >25 |

# *Soil Descriptions*

## Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

# Symbols & Abbreviations

Douglas Partners

## Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

## Drilling or Excavation Methods

| | |
|---|---|
| C | Core Drilling |
| R | Rotary drilling |
| SFA | Spiral flight augers |
| NMLC | Diamond core - 52 mm dia |
| NQ | Diamond core - 47 mm dia |
| HQ | Diamond core - 63 mm dia |
| PQ | Diamond core - 81 mm dia |

## Water

| | |
|---|---|
| ▷ | Water seep |
| ▽ | Water level |

## Sampling and Testing

| | |
|---|---|
| A | Auger sample |
| B | Bulk sample |
| D | Disturbed sample |
| E | Environmental sample |
| $U_{50}$ | Undisturbed tube sample (50mm) |
| W | Water sample |
| pp | pocket penetrometer (kPa) |
| PID | Photo ionisation detector |
| PL | Point load strength Is(50) MPa |
| S | Standard Penetration Test |
| V | Shear vane (kPa) |

## Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

### Defect Type

| | |
|---|---|
| B | Bedding plane |
| Cs | Clay seam |
| Cv | Cleavage |
| Cz | Crushed zone |
| Ds | Decomposed seam |
| F | Fault |
| J | Joint |
| Lam | lamination |
| Pt | Parting |
| Sz | Sheared Zone |
| V | Vein |

### Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

| | |
|---|---|
| h | horizontal |
| v | vertical |
| sh | sub-horizontal |
| sv | sub-vertical |

### Coating or Infilling Term

| | |
|---|---|
| cln | clean |
| co | coating |
| he | healed |
| inf | infilled |
| stn | stained |
| ti | tight |
| vn | veneer |

### Coating Descriptor

| | |
|---|---|
| ca | calcite |
| cbs | carbonaceous |
| cly | clay |
| fe | iron oxide |
| mn | manganese |
| slt | silty |

### Shape

| | |
|---|---|
| cu | curved |
| ir | irregular |
| pl | planar |
| st | stepped |
| un | undulating |

### Roughness

| | |
|---|---|
| po | polished |
| ro | rough |
| sl | slickensided |
| sm | smooth |
| vr | very rough |

### Other

| | |
|---|---|
| fg | fragmented |
| bnd | band |
| qtz | quartz |

# Symbols & Abbreviations

## Graphic Symbols for Soil and Rock

### General


Asphalt


Road base


Concrete


Filling

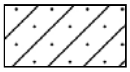
### Soils


Topsoil

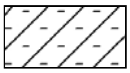

Peat


Clay

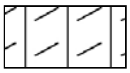

Silty clay

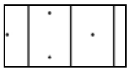

Sandy clay

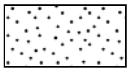

Gravelly clay

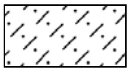

Shaly clay

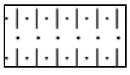

Silt


Clayey silt


Sandy silt

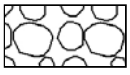

Sand

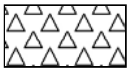

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

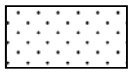

Talus

### Sedimentary Rocks

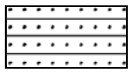

Boulder conglomerate

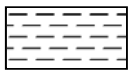

Conglomerate


Conglomeratic sandstone

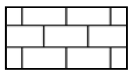

Sandstone


Siltstone


Laminite

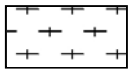

Mudstone, claystone, shale

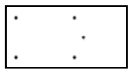

Coal


Limestone

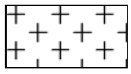
### Metamorphic Rocks

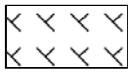

Slate, phyllite, schist

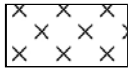

Gneiss

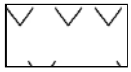

Quartzite

### Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.9 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 301
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| | 0.03 | ASPHALTIC CONCRETE | | | | | | | |
| | | ROADBASE - sandy gravel roadbase | | E/A | 0.1 | | | | |
| | 0.2 | SILTY CLAY - orange brown silty clay | | | 0.2 | | | | |
| 182 | 1 | | | E/A* | 1.0 | | | | 1 |
| | 1.2 | Bore discontinued at 1.2m - target depth | | | 1.2 | | | | |
| 181 | | | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:** *BD2/ 071112

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.5 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 302
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 182 | 0.05 | ASPHALTIC CONCRETE | | | | | | | |
| | 0.1 | ROADBASE - sandy gravel roadbase | | | | | | | |
| | | SILTY CLAY - orange brown silty clay | | E/A | 0.1<br>0.2 | | | | |
| | 1 | | | | | | | | 1 |
| | 1.2 | Bore discontinued at 1.2m<br>- target depth | | | | | | | |
| 181 | | | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | U$_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.5 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 303
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 182 | | TOPSOIL brown silty clay topsoil with trace rootlets | | E/A* | 0.1 | | | | |
| | 0.2 | SILTY CLAY - orange brown silty clay | | | 0.2 | | | | |
| | 1 | | | E/A | 1.0 | | | | 1 |
| | 1.2 | Bore discontinued at 1.2m - target depth | | | 1.2 | | | | |
| 181 | | | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:** *BD1/ 041112

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 183.3 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 304
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 183 | 0.05 | ASPHALTIC CONCRETE | | | | | | | |
| | | ROADBASE - sandy gravel roadbase | | E/A | 0.1 | | | | |
| | 0.2 | SILTY CLAY - orange brown silty clay | | | 0.2 | | | | |
| | 1 | | | E/A | 1.0 | | | | 1 |
| 182 | 1.2 | Bore discontinued at 1.2m - target depth | | | 1.2 | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** CF **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | U$_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 183.5 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 305
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| | 0.05 | ASPHALTIC CONCRETE | | | | | | | |
| | | ROADBASE - sandy gravel roadbase | | E/A | 0.1 | | | | |
| 183 | 0.2 | SILTY CLAY - orange brown silty clay | | | 0.2 | | | | |
| | 1 | | | E/A | 1.0 | | | | 1 |
| | 1.2 | Bore discontinued at 1.2m - target depth | | | 1.2 | | | | |
| 182 | | | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | U$_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.5 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 306
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| | | CONCRETE | | | | | | | |
| 182 | 0.2 | FILLING - orange-brown silty clay filling with some sand (reworked natural material) | | E/A | 0.2 | | | | |
| | 1 | | | E/A | 1.0 | | | | 1 |
| | 1.2 | Bore discontinued at 1.2m - target depth | | | 1.2 | | | | |
| 181 | | | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:** Located within service trench

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.2 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 307
**PROJECT No:** 72320.06
**DATE:** 7/11/2012
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 182 | | FILLING - light yellow sand filling with a trace of roadbase gravel | | | | | | | |
| | 0.3 | SILTY CLAY - orange-brown silty clay | | | | | | | |
| | 1 | | | | | | | | 1 |
| 181 | 1.2 | Bore discontinued at 1.2m - target depth | | | | | | | |

**RIG:** Sucker Truck **DRILLER:** WWDD **LOGGED:** TS **CASING:** Uncased
**TYPE OF BORING:** Hand tool and water blast/ vacuum truck
**WATER OBSERVATIONS:** No free ground water observed
**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

Douglas Partners
Geotechnics / Environment / Groundwater

# Cone Penetration Tests

Douglas Partners

## Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance $q_c$
- Sleeve friction $f_s$
- Inclination (from vertical) i
- Depth below ground z

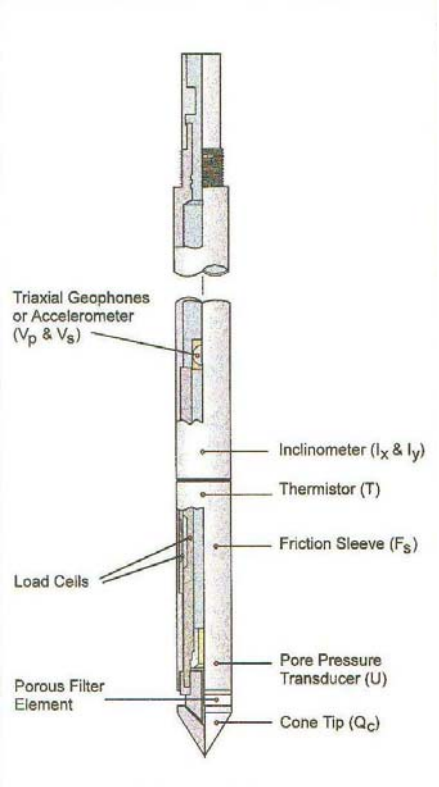



Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.

Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

## Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

| Type | Measures |
|---|---|
| Standard | Basic parameters ($q_c$, $f_s$, i & z) |
| Piezocone | Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters |
| Conductivity | Bulk soil electrical conductivity ($\sigma$) plus basic parameters |
| Seismic | Shear wave velocity ($V_s$), compression wave velocity ($V_p$), plus basic parameters |

## Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Qt) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

# Cone Penetration Tests

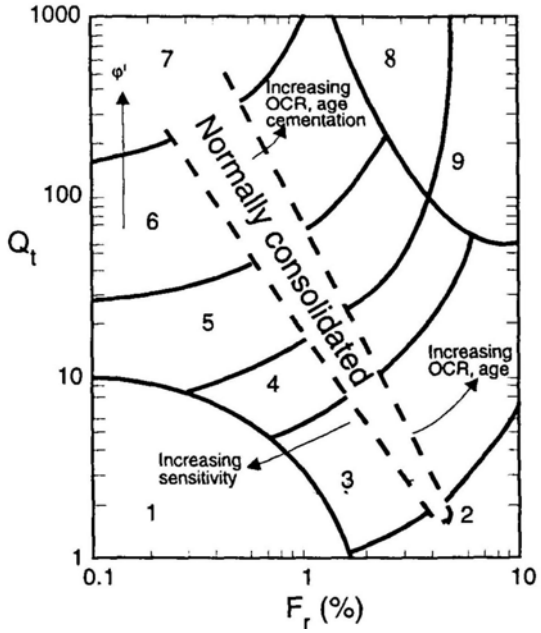



Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

## Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

**Settlement**

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

**Pile Capacity**

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation. The results are expressed in limit state format, consistent with the Piling Code AS2159.

**Dynamic or Earthquake Analysis**

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus $G_0$. Techniques have also been developed relating CPT results to the risk of soil liquefaction.

**Other Applications**

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

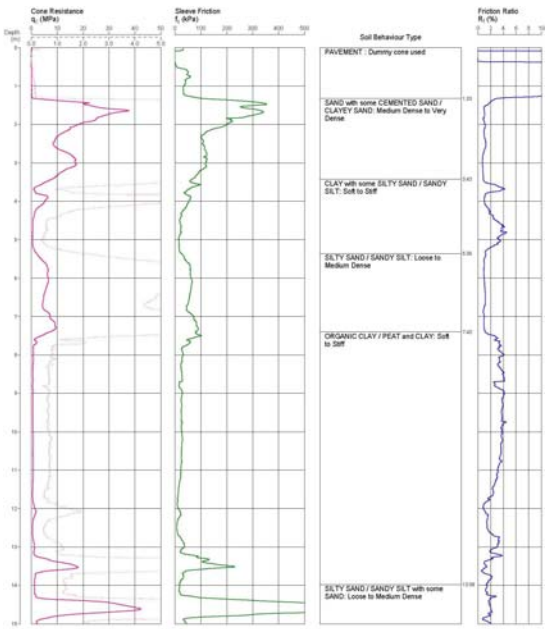



Figure 4: Sample Cone Plot

# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.9

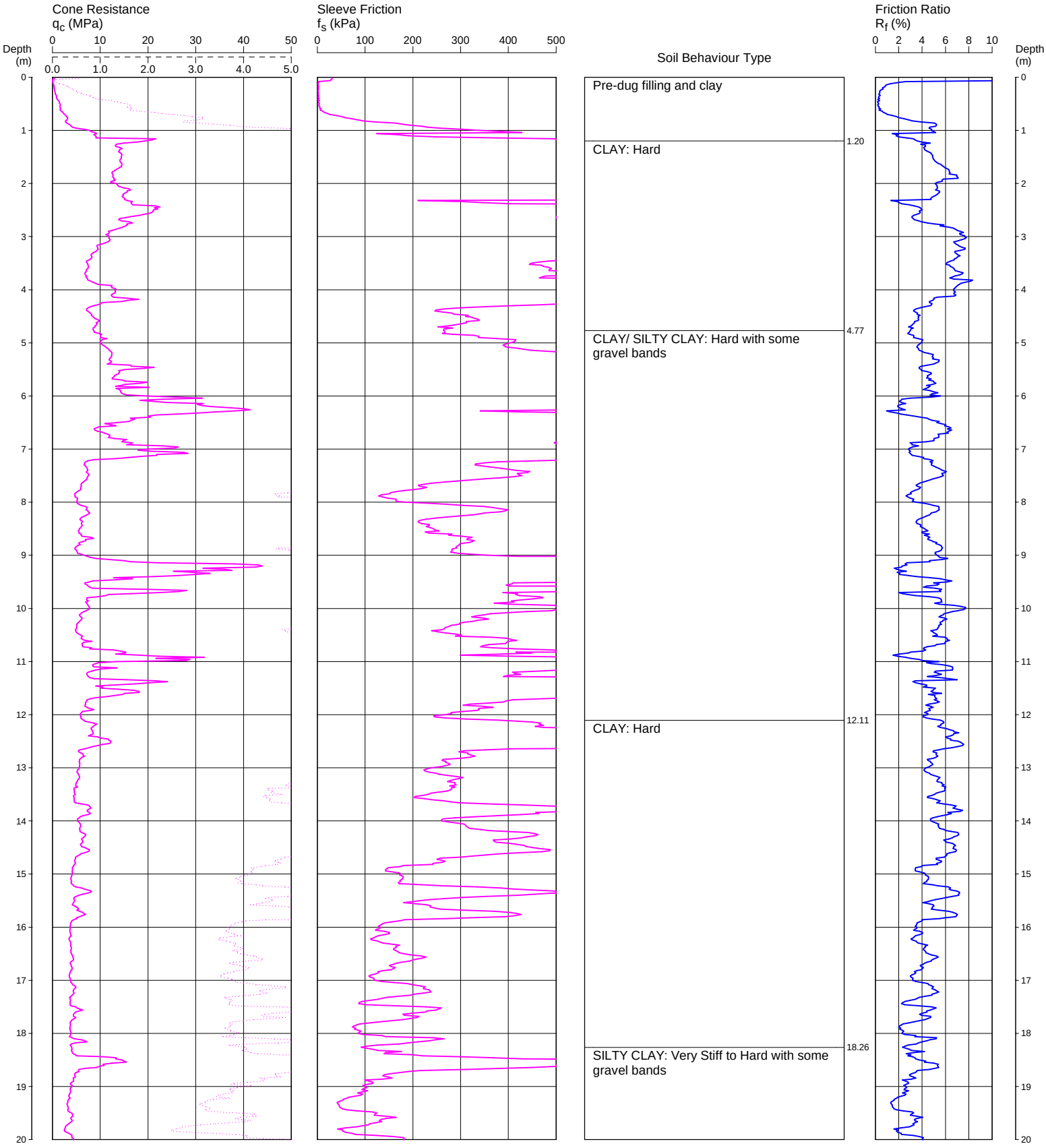
**COORDINATES:**

**301**



**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT 5.6m AFTER WITHDRAWAL OF RODS

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320301.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

ConePlot Version 5.9.2
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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

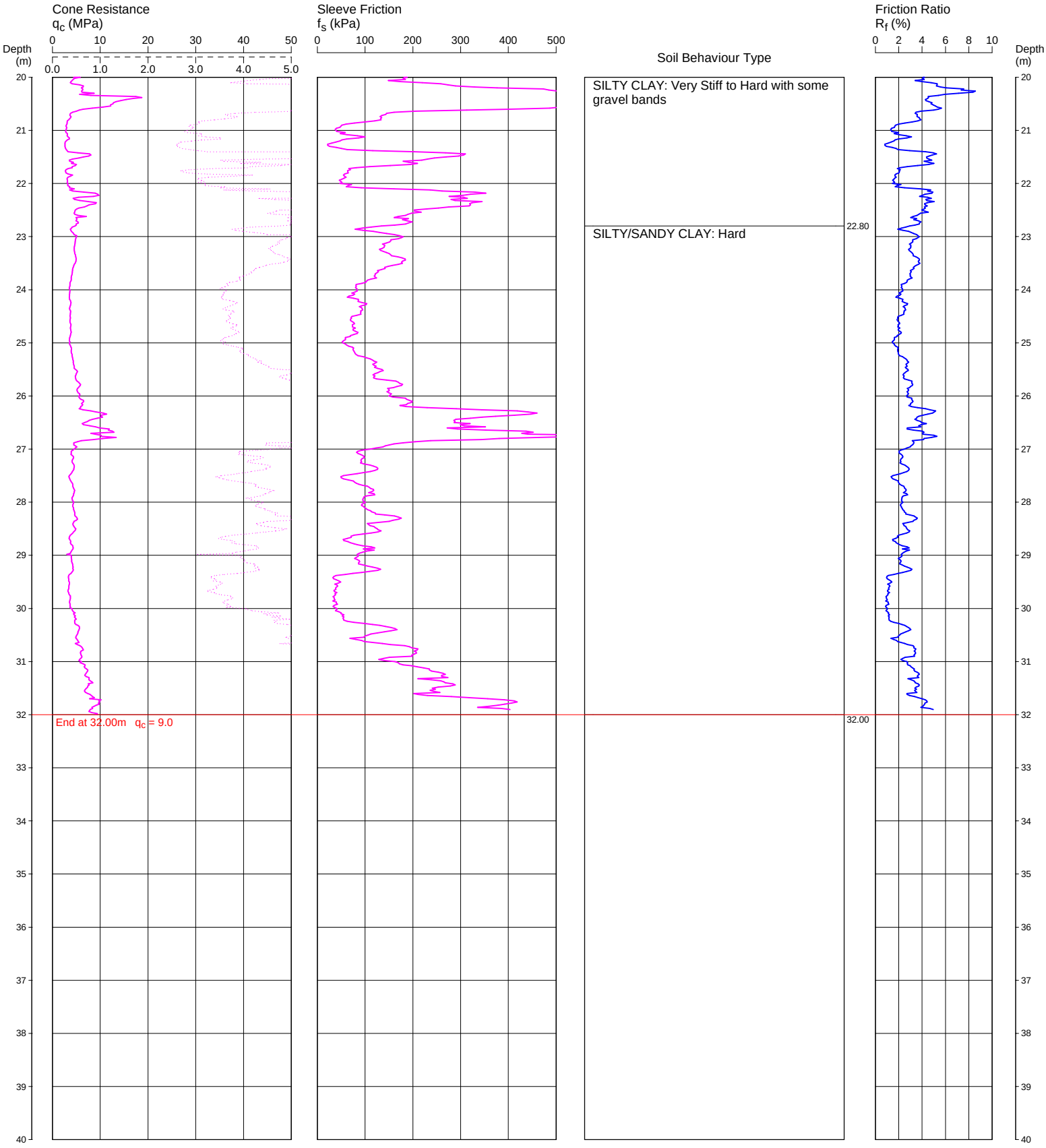
**REDUCED LEVEL:** 182.9

**COORDINATES:**

**301**
**Page 2 of 2**

**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT 5.6m AFTER WITHDRAWAL OF RODS

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320301.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

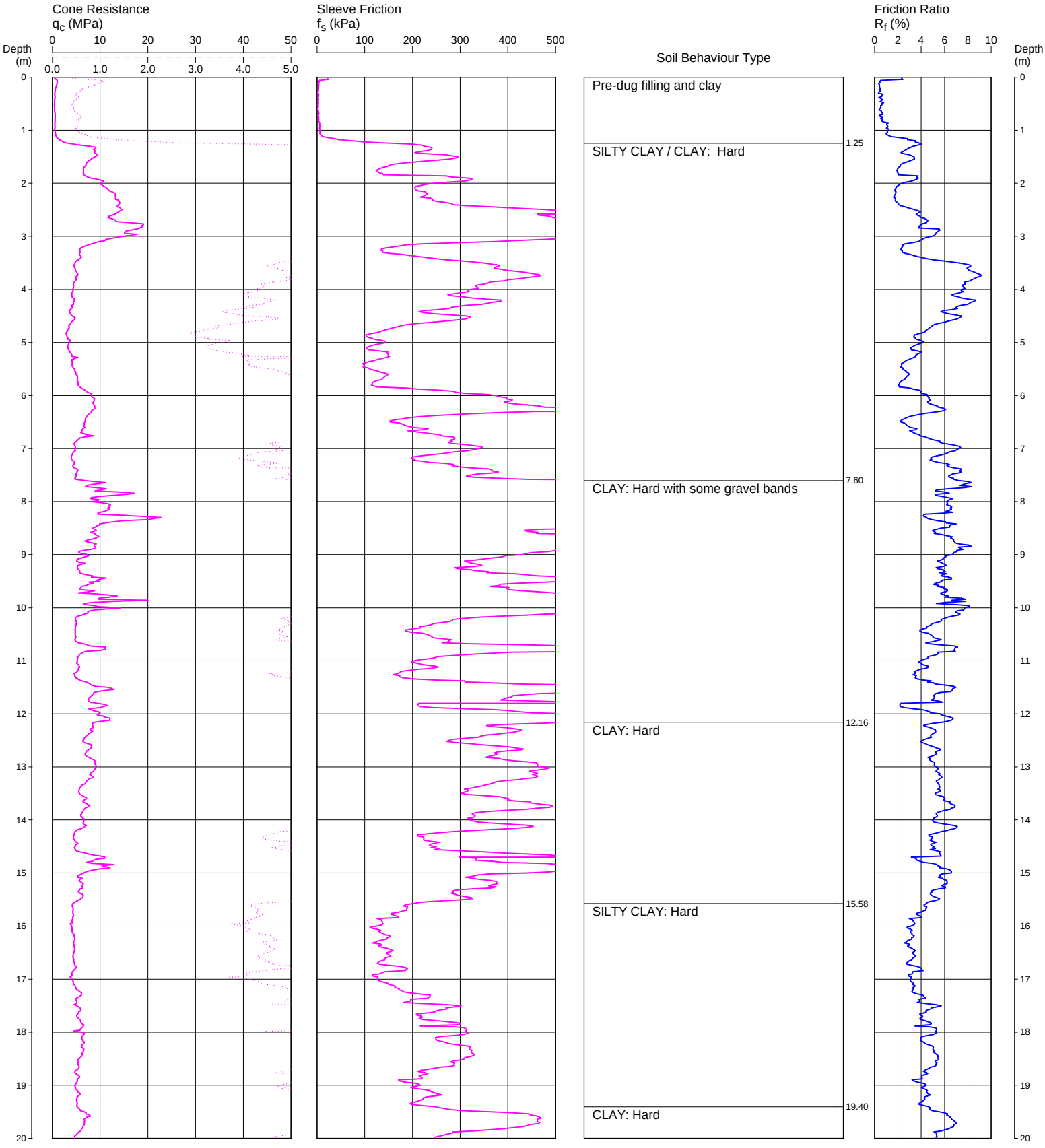
**REDUCED LEVEL:** 182.5

**COORDINATES:**

**302**
**Page 1 of 2**

**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT 0.8m AFTER WITHDRAWAL OF RODS

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320302.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.5

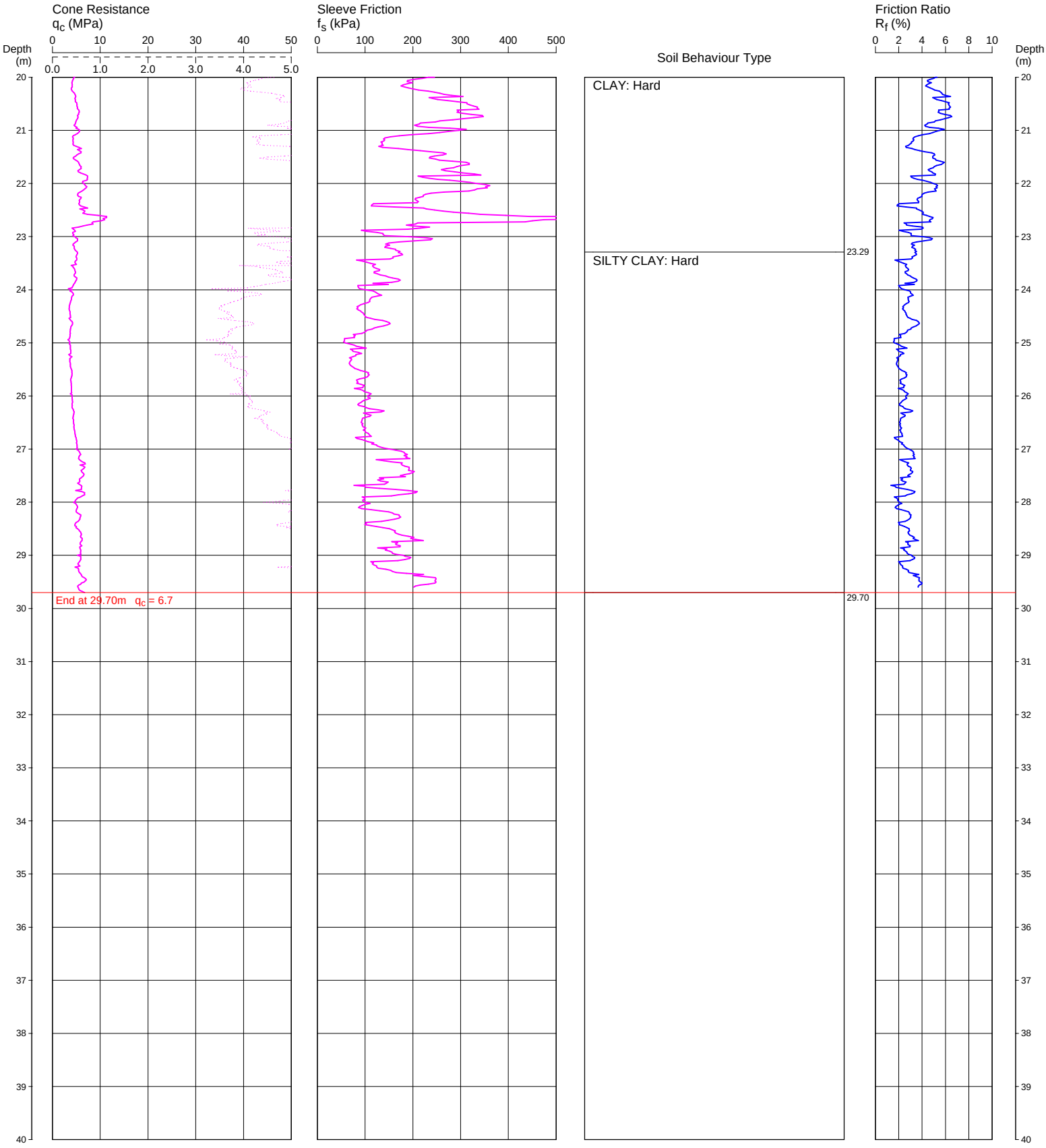
**COORDINATES:**

**302**

**Page 2 of 2**

**DATE** 7/11/2012

**PROJECT No:** 72320.06

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HOLE COLLAPSED AT 0.8m AFTER WITHDRAWAL OF RODS

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**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.1

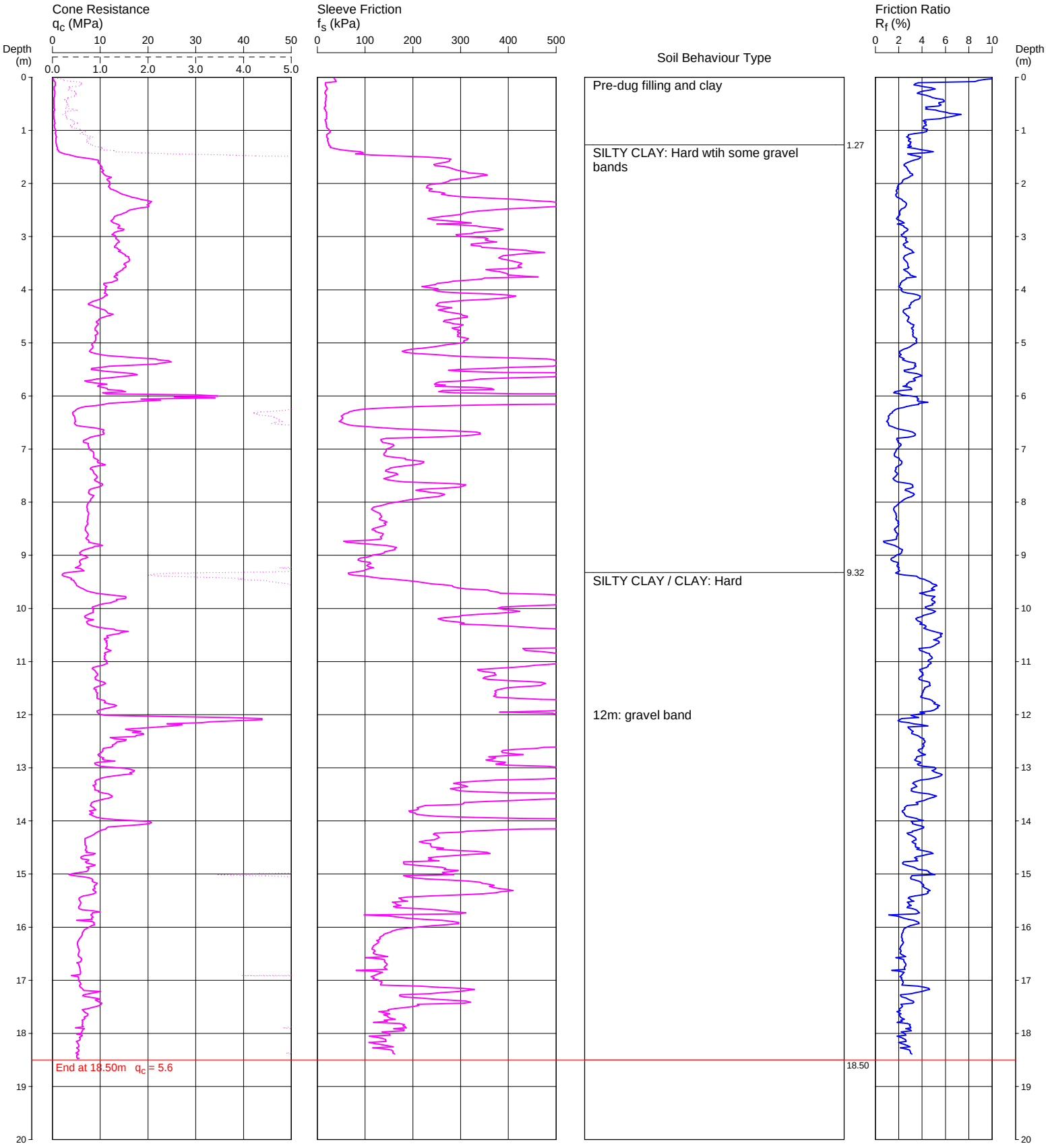
**COORDINATES:**

**303**

**Page 1 of 1**

**DATE** 15/01/2013

**PROJECT No:** 72320.06

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HOLE DRY TO 8m (LIMIT OF TAPE) AFTER WITHDRAWAL OF RODS

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**Cone ID:** CONE-425 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 183.3

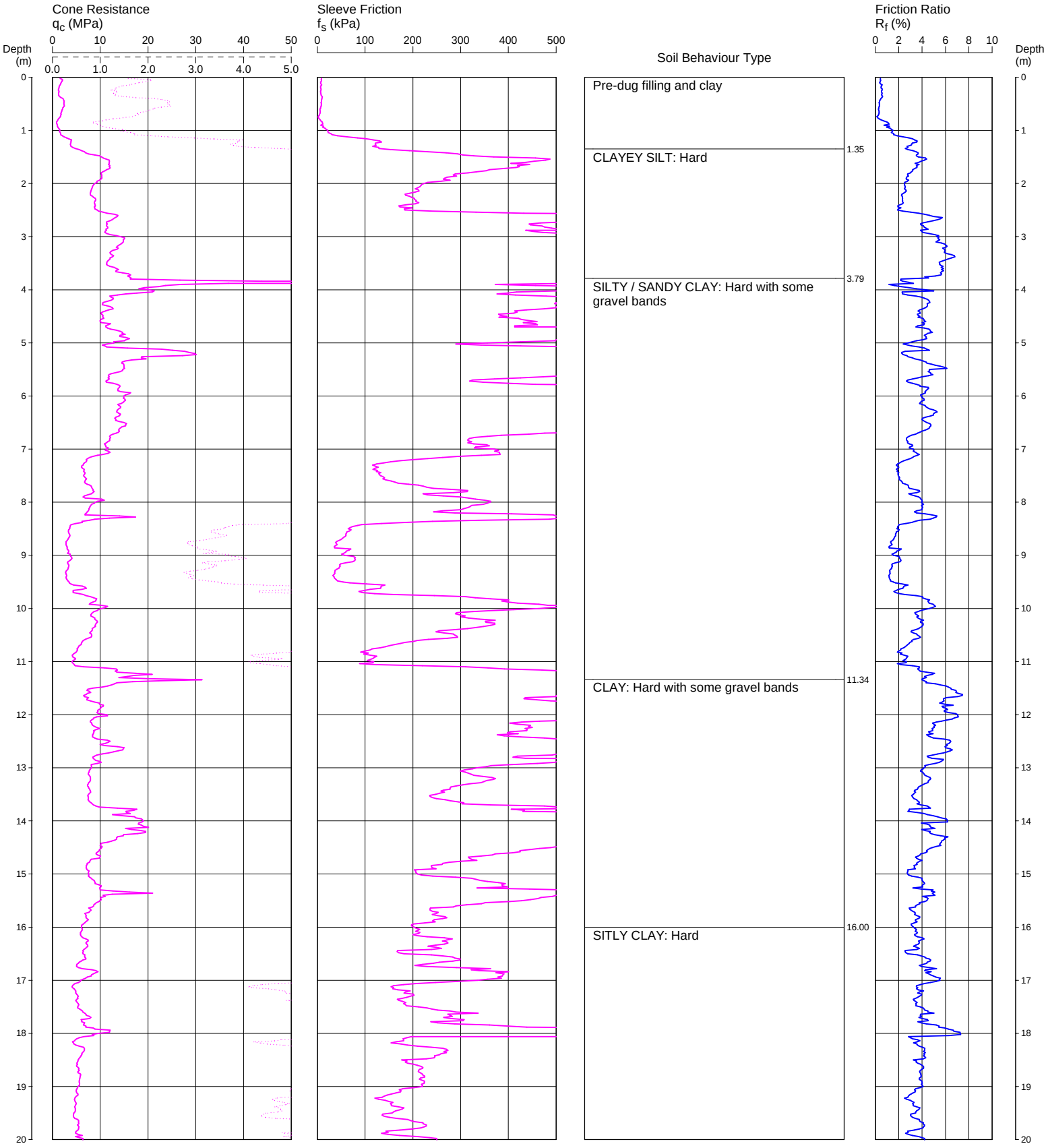
**COORDINATES:**

**304**



**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT SURFACE AFTER WITHDRAWAL OF RODS

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**Cone ID:** CONE-H4 **Type:** 2 Standard

ConePlot Version 5.9.2

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 183.3

**COORDINATES:**

**304**

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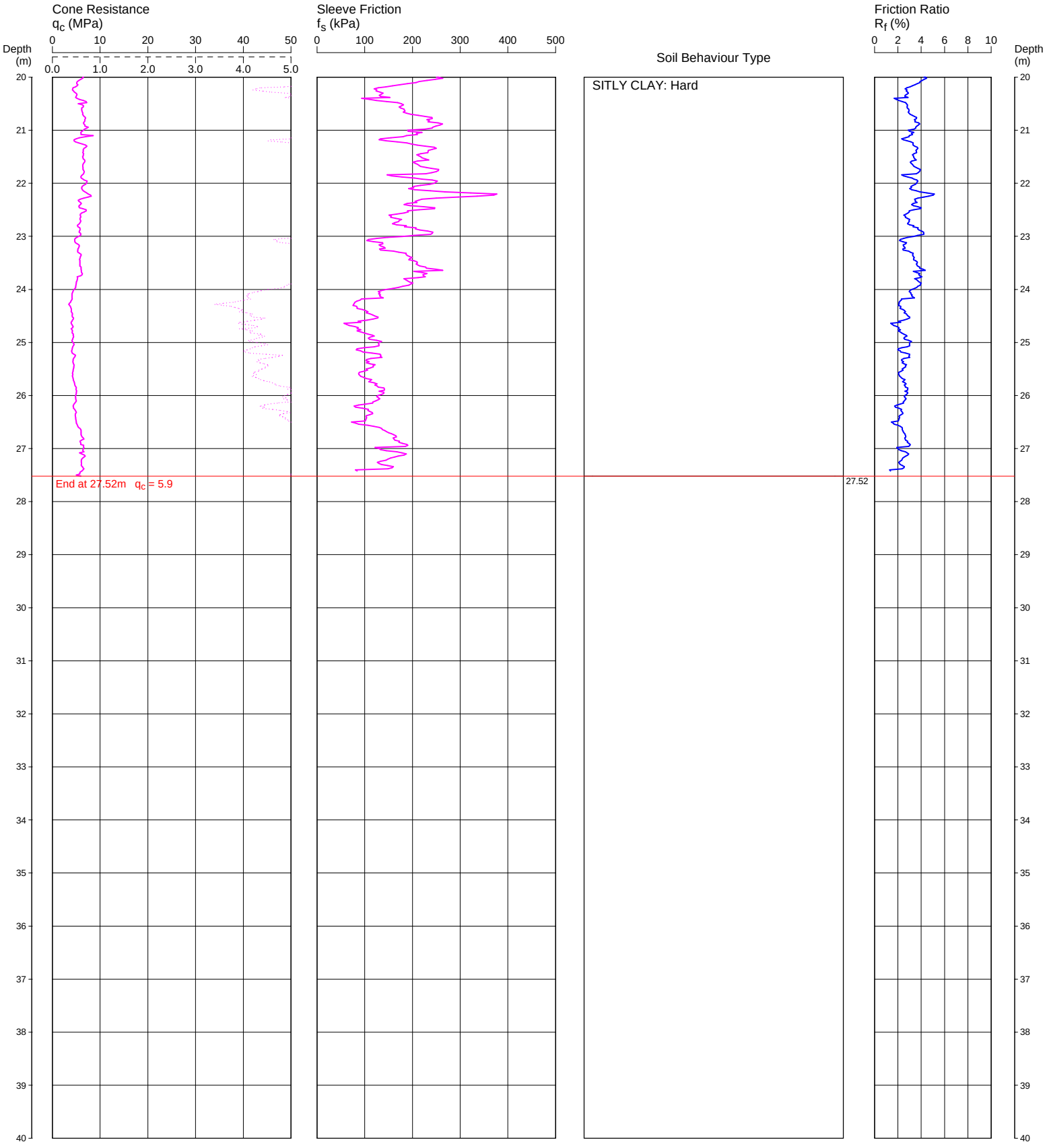
**DATE** 7/11/2012

**PROJECT No:** 72320.06

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 183.0

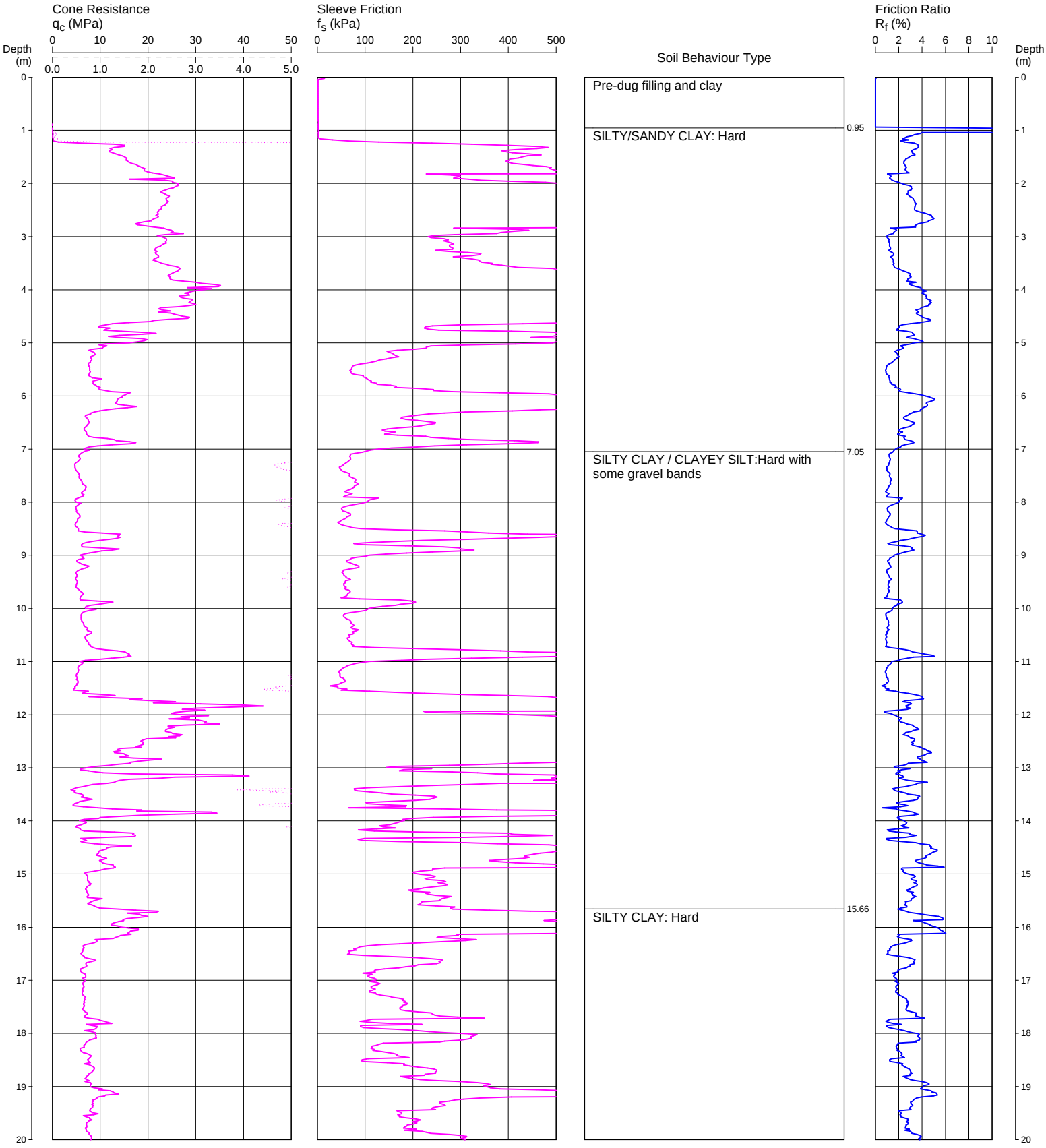
**COORDINATES:**

**305**



**DATE** 15/01/2013

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m
HOLE COLLAPSED AT 2.8m AFTER WITHDRAWAL OF RODS

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**Cone ID:** CONE-425 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

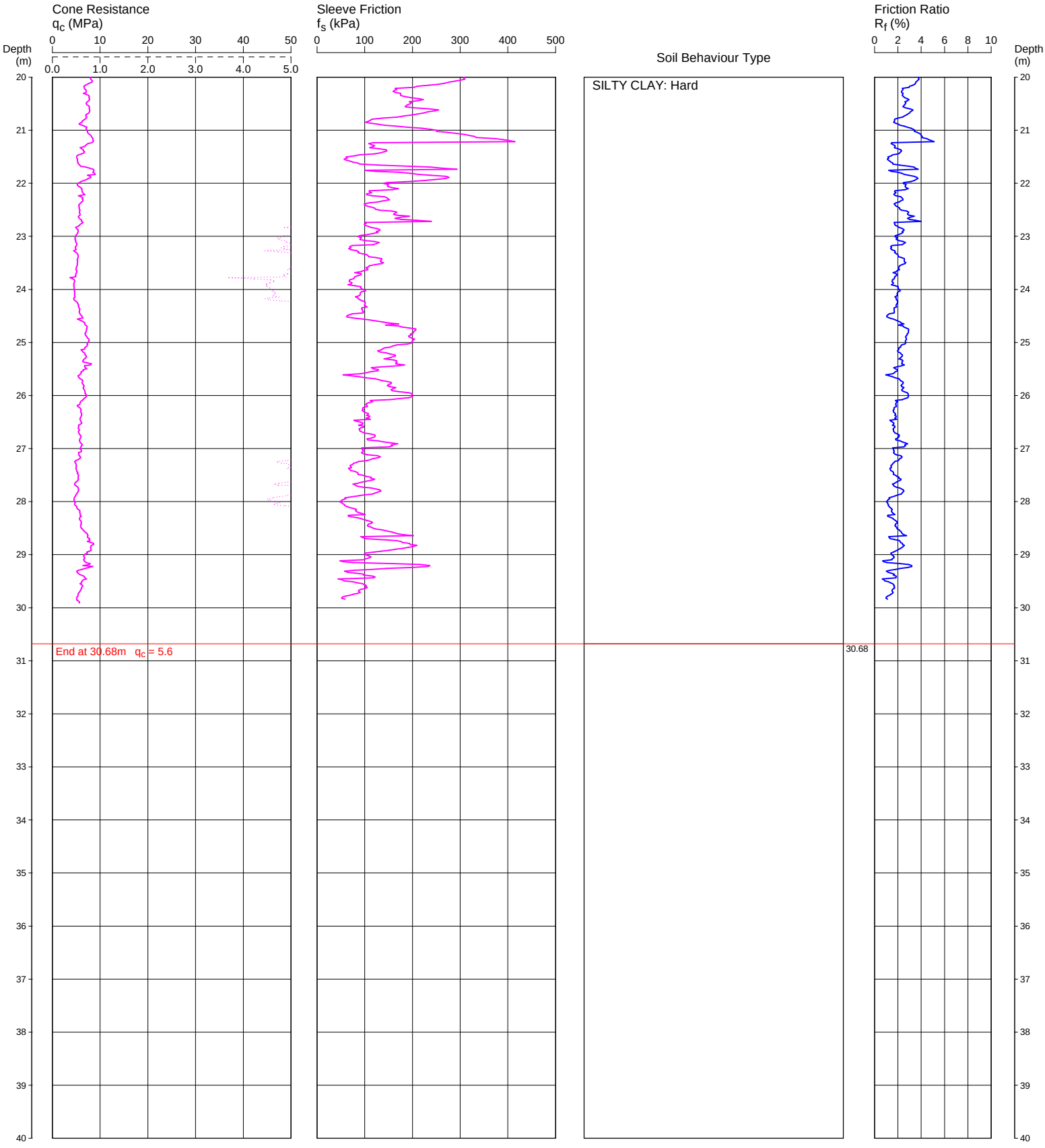
**REDUCED LEVEL:** 183.0

**COORDINATES:**

**305**
**Page 2 of 2**

**DATE** 15/01/2013

**PROJECT No:** 72320.06

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**Cone ID:** CONE-425 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.5

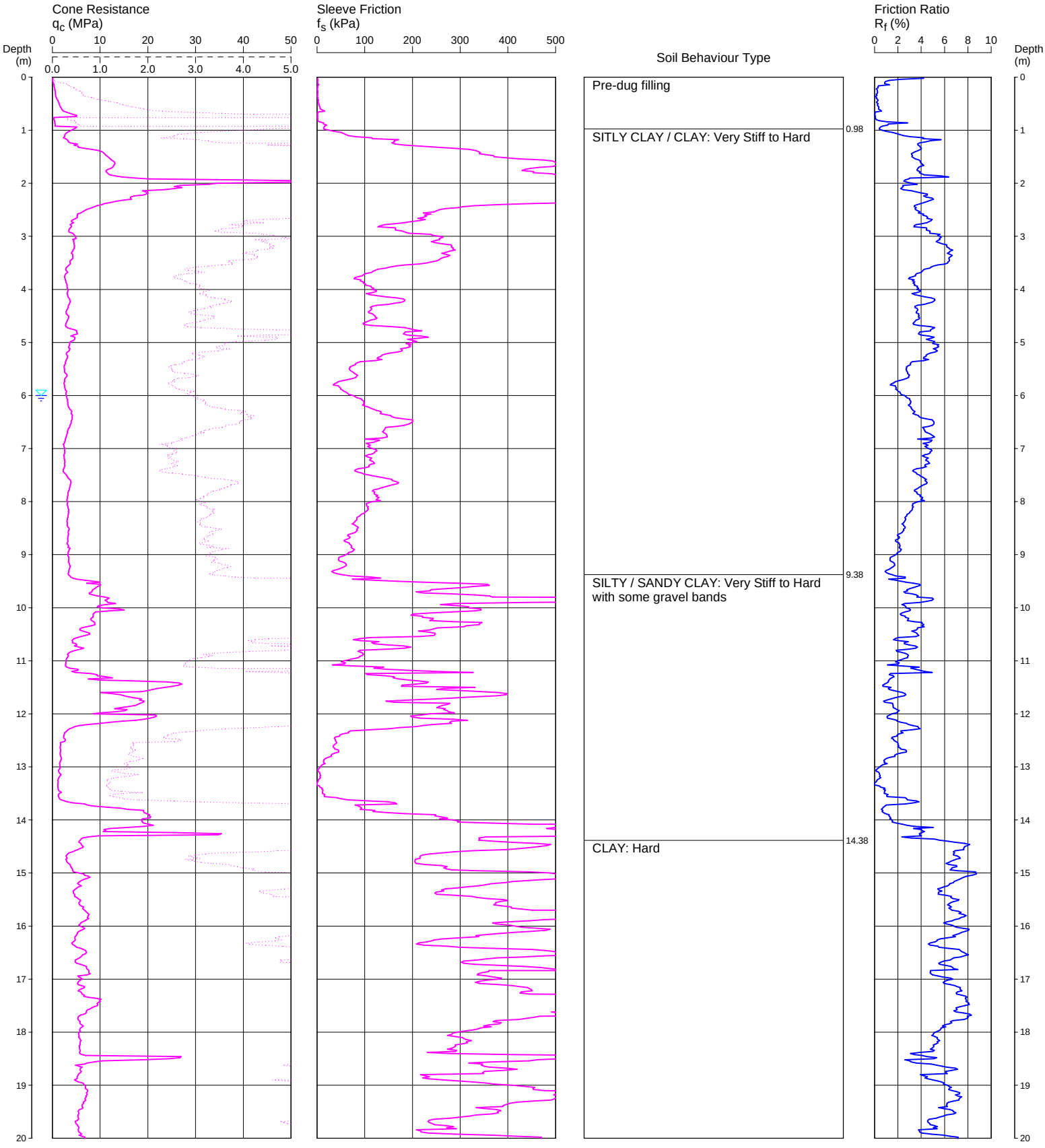
**COORDINATES:**

**306**



**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT SURFACE AFTER WITHDRAWAL OF RODS

**Water depth after test: 6.00m depth (assumed)**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5

**Cone ID:** CONE-H4 **Type:** 2 Standard

ConePlot Version 5.9.2

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

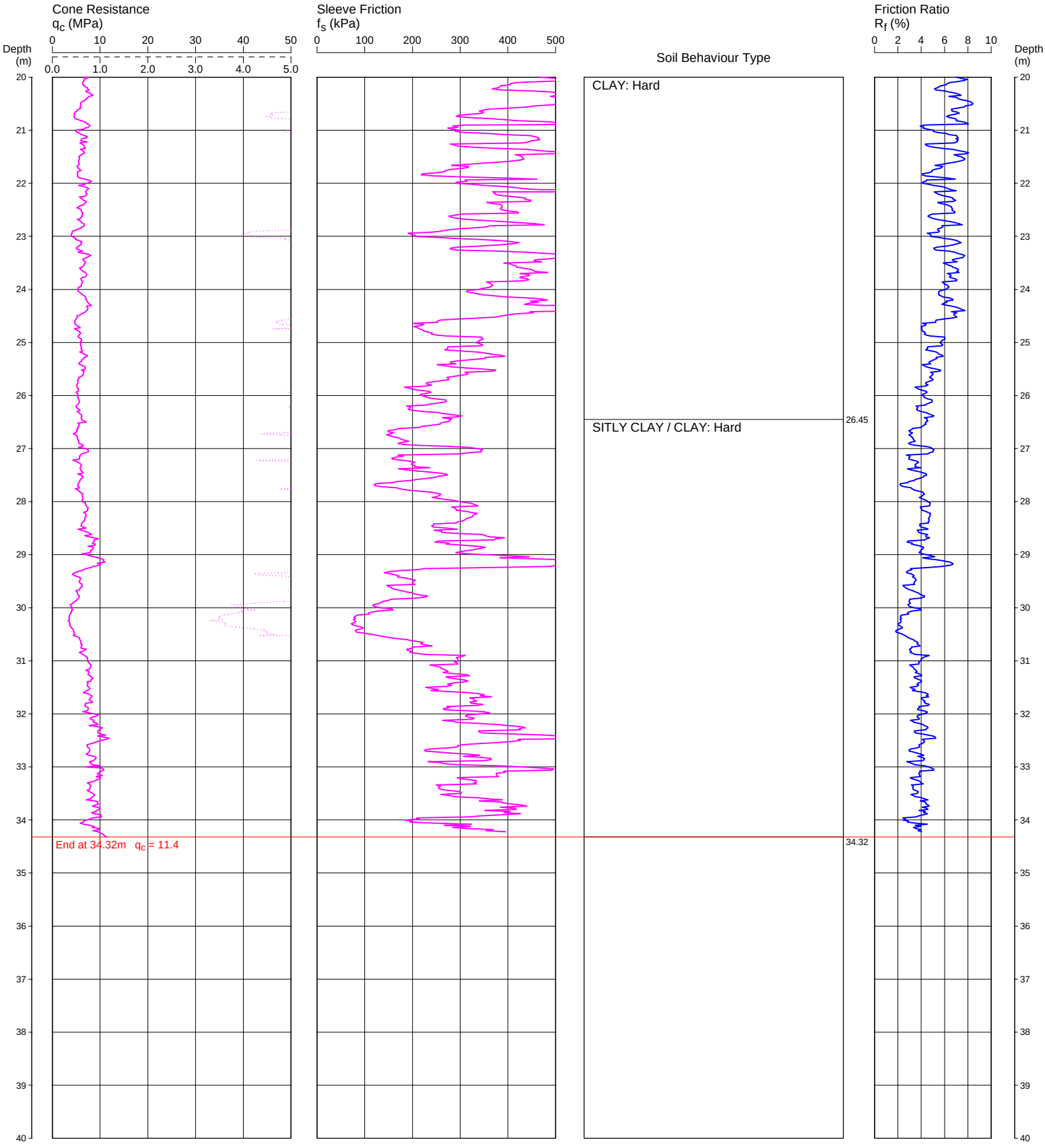
**REDUCED LEVEL:** 182.5

**COORDINATES:**

**306**
**Page 2 of 2**

**DATE** 7/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT SURFACE AFTER WITHDRAWAL OF RODS

**Water depth after test: 6.00m depth (assumed)**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.2

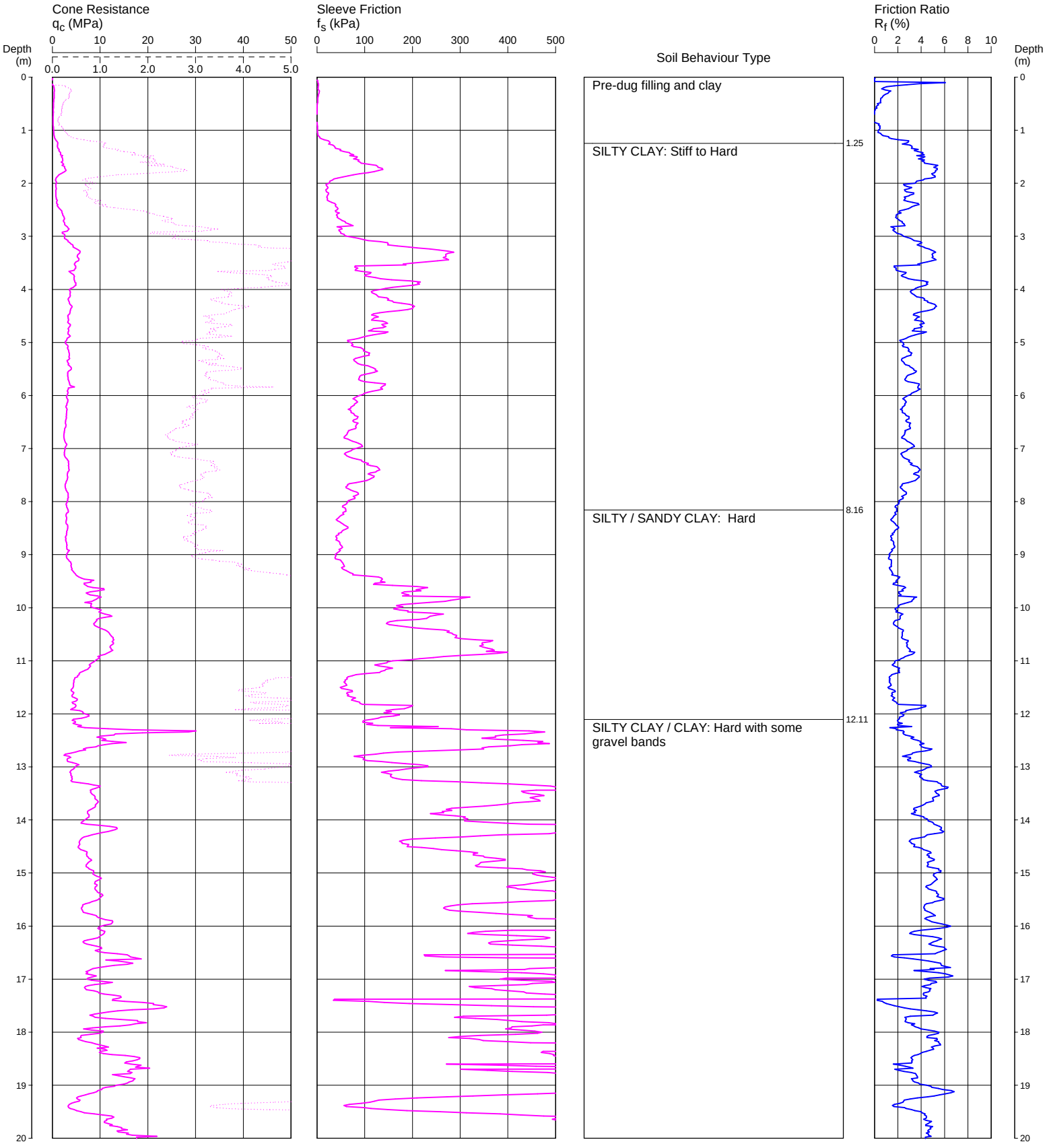
**COORDINATES:**

**307**



**DATE** 9/11/2012

**PROJECT No:** 72320.06




**REMARKS:** WASH BORED TO 1.2m, PREDRILLED TO 2.8m, BACKFILLED WITH GRAVEL
HOLE COLLAPSED AT SURFACE AFTER WITHDRAWAL OF RODS

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

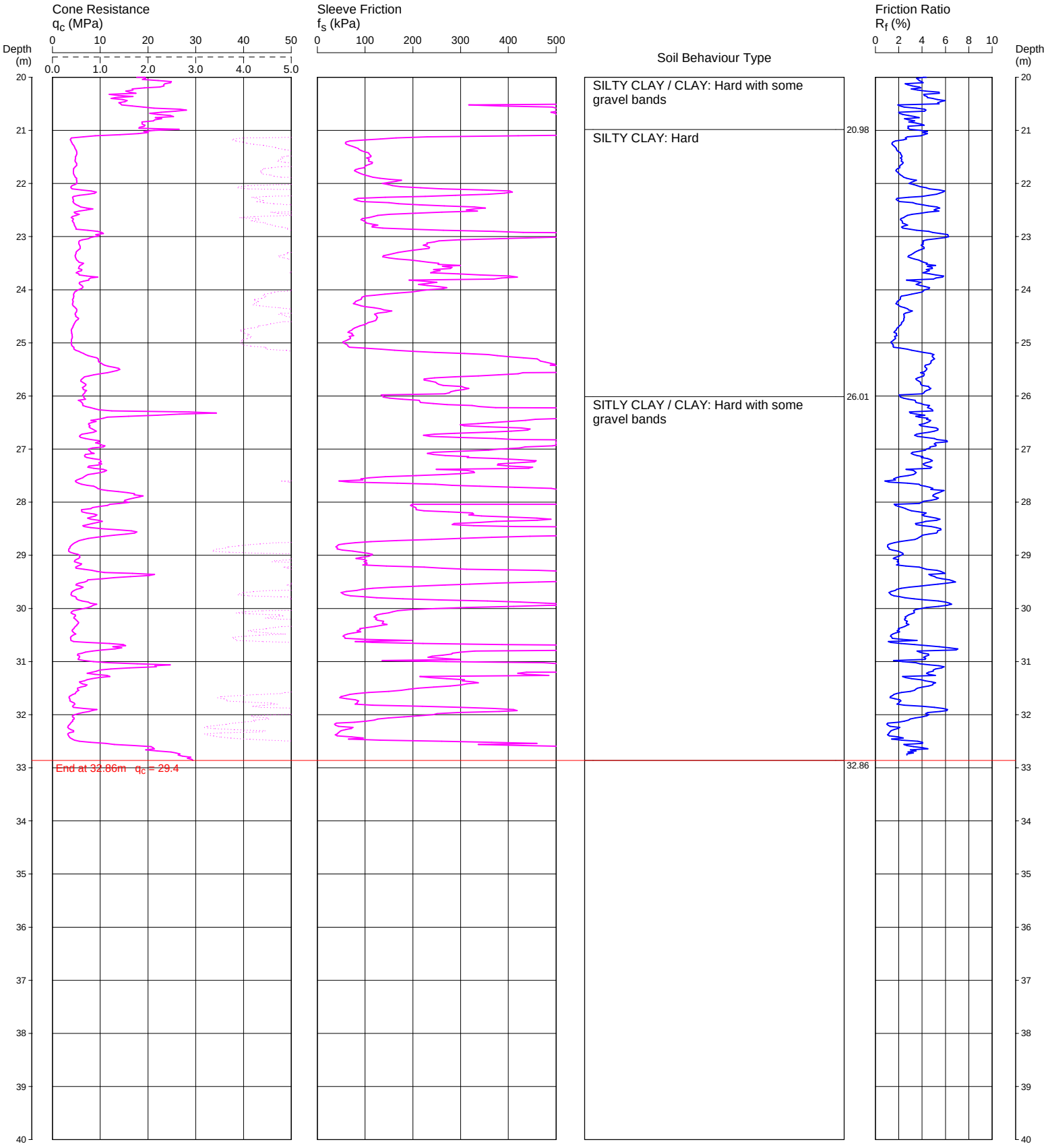
**REDUCED LEVEL:** 182.2

**COORDINATES:**

**307**
**Page 2 of 2**

**DATE** 9/11/2012

**PROJECT No:** 72320.06

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HOLE COLLAPSED AT SURFACE AFTER WITHDRAWAL OF RODS

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 181.8 m AHD

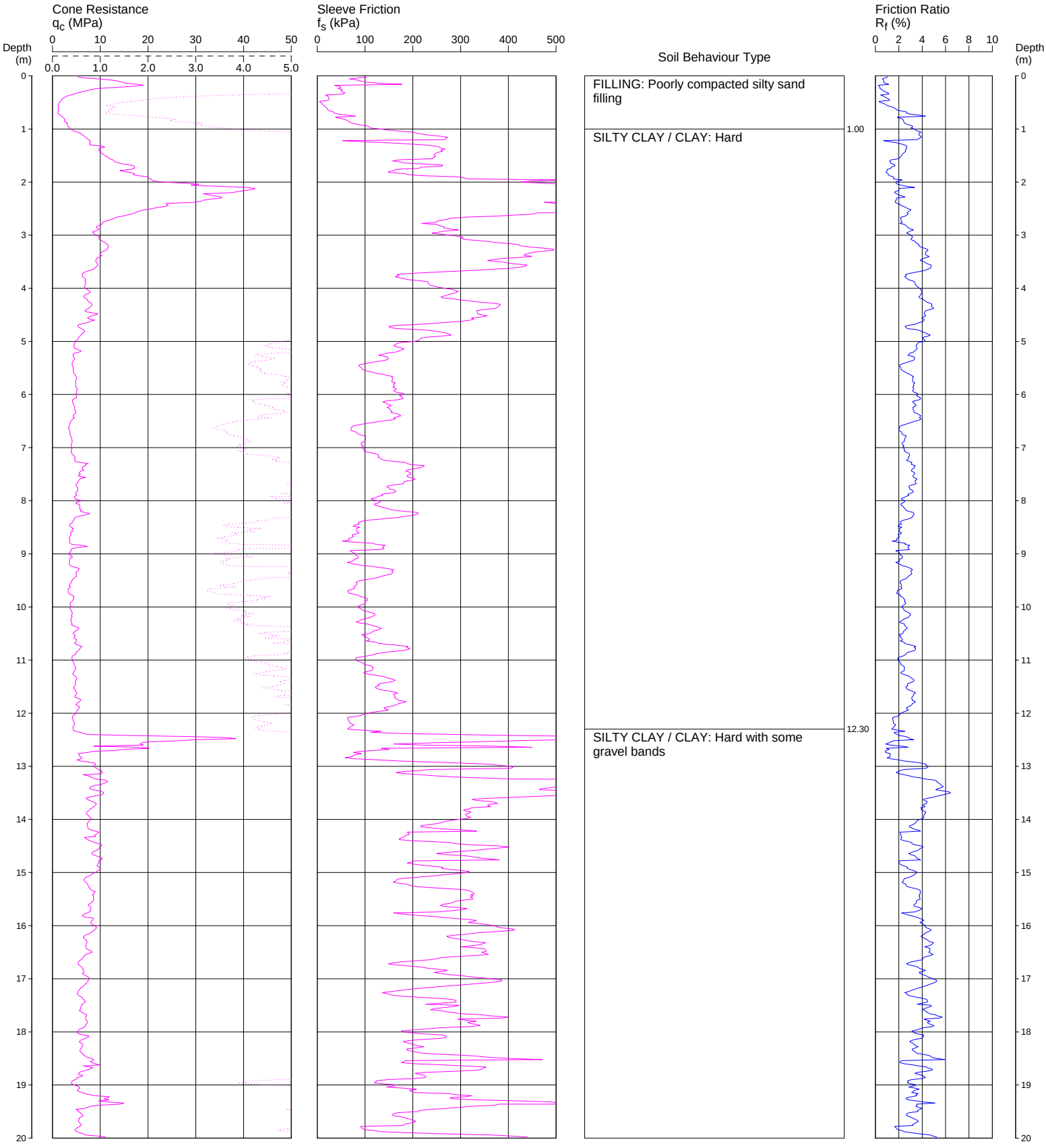
**COORDINATES:**

## CPT 3



**DATE** 20/9/2011

**PROJECT No:** 72320.03




**REMARKS:** TEST DISCONTINUED DUE TO LIMIT OF RIG HYDRAULIC THRUST

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePlot Version 5.9.1

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 181.8 m AHD

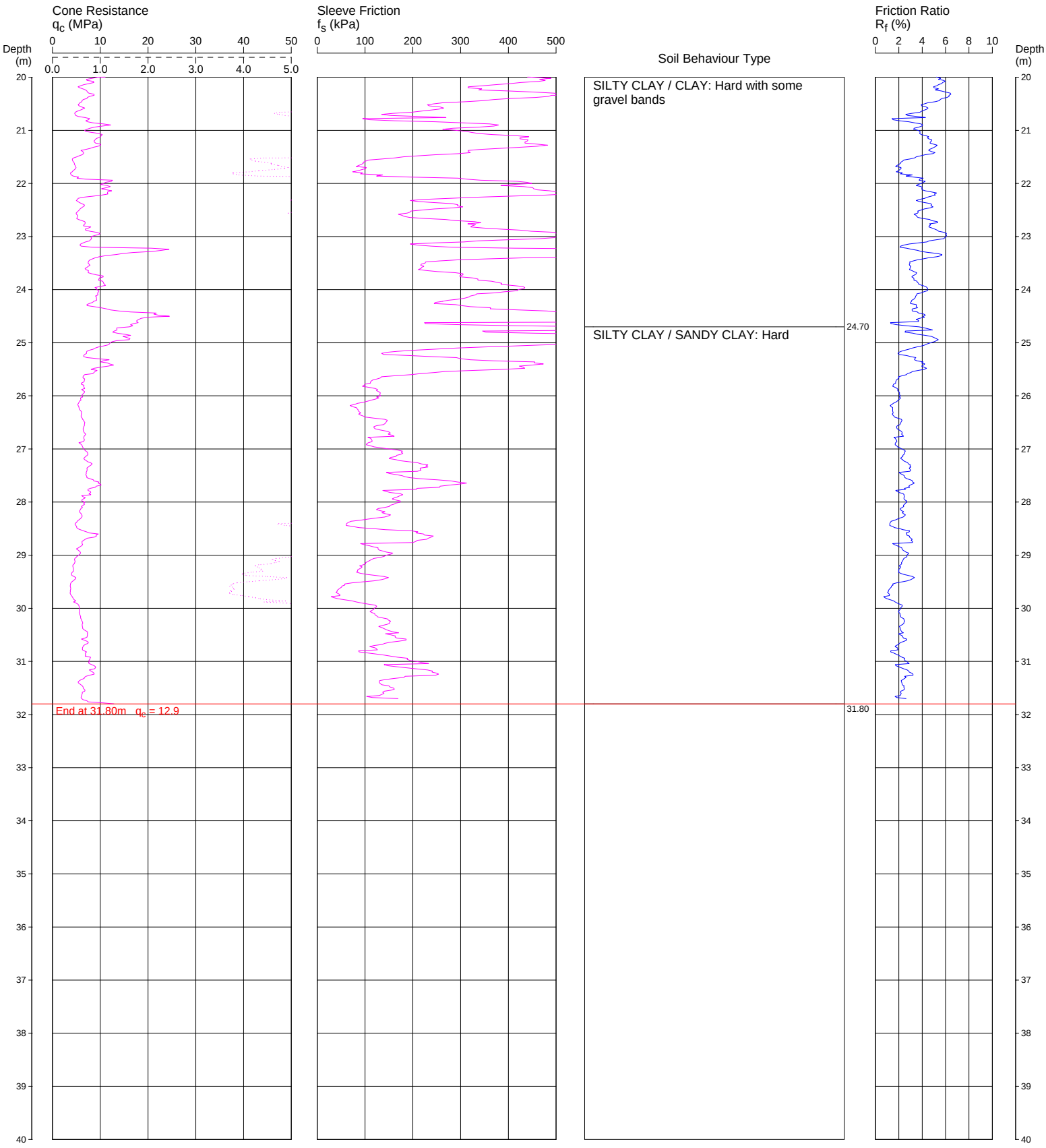
**COORDINATES:**

**CPT 3**



**DATE** 20/9/2011

**PROJECT No:** 72320.03




**REMARKS:** TEST DISCONTINUED DUE TO LIMIT OF RIG HYDRAULIC THRUST

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePlot Version 5.9.1

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.6 m AHD

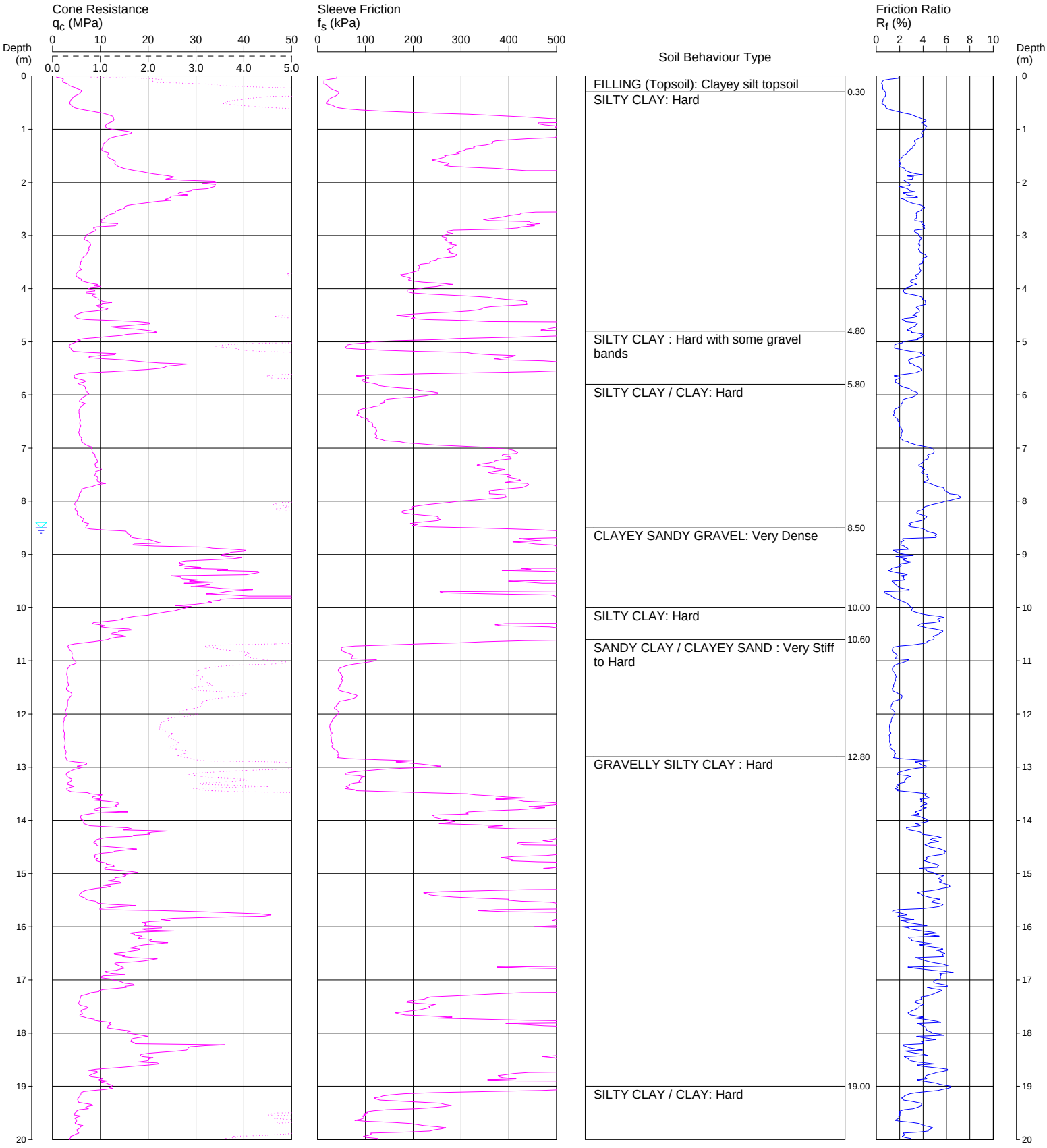
**COORDINATES:**

**CPT 4**



**DATE** 19/9/2011

**PROJECT No:** 72320.03




**REMARKS:** TEST DISCONTINUED DUE TO LIMIT OF RIG HYDRAULIC THRUST
WATER LEVEL MEASURED AT 8.5 m DEPTH AFTER REMOVAL OF RODS

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 182.6 m AHD

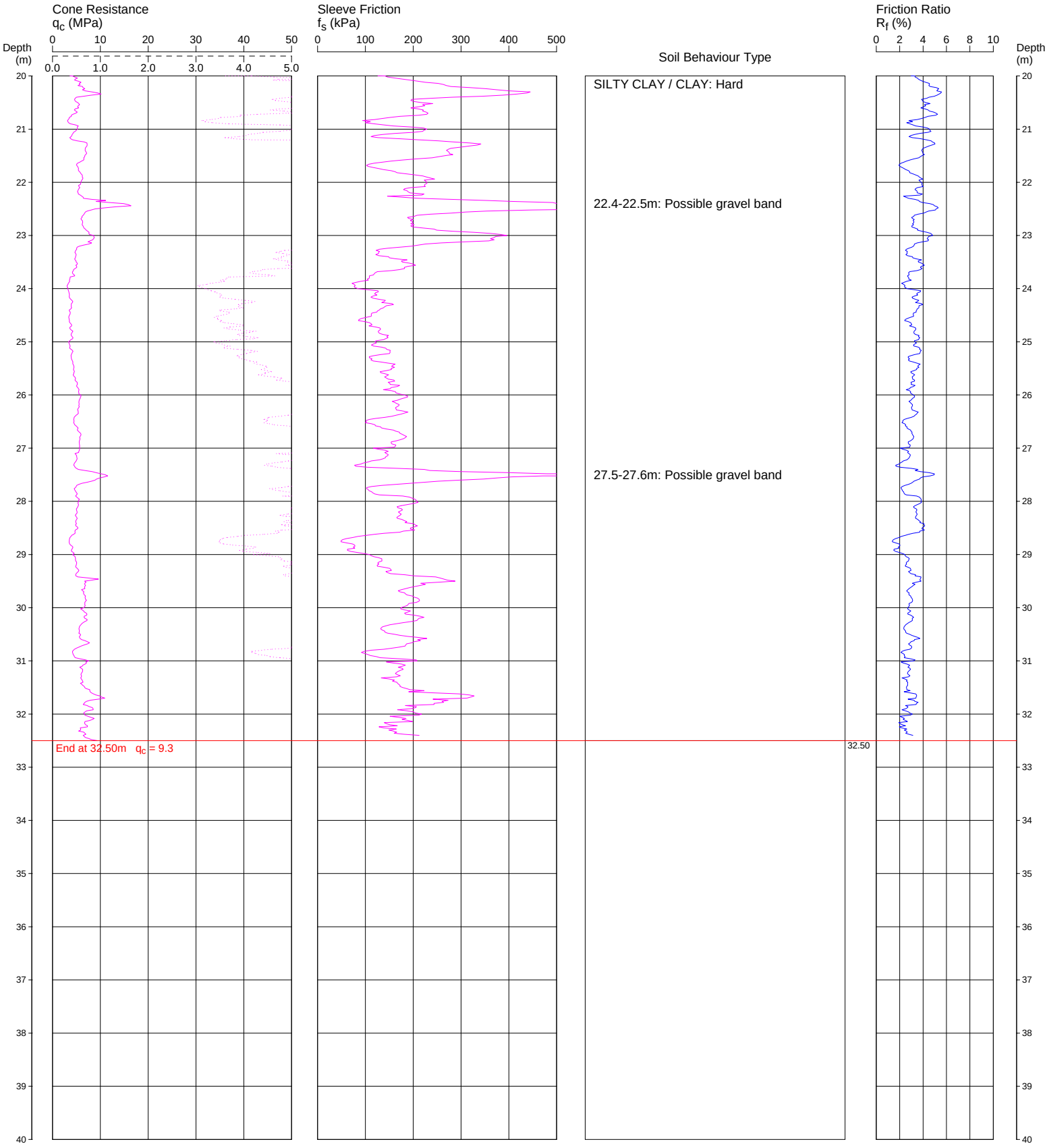
**COORDINATES:**

## CPT 4



**DATE** 19/9/2011

**PROJECT No:** 72320.03




**REMARKS:** TEST DISCONTINUED DUE TO LIMIT OF RIG HYDRAULIC THRUST
WATER LEVEL MEASURED AT 8.5 m DEPTH AFTER REMOVAL OF RODS

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePlot Version 5.9.1

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# CONE PENETRATION TEST

**CLIENT:** HEALTH INFRASTRUCTURE

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**REDUCED LEVEL:** 184.2 m AHD

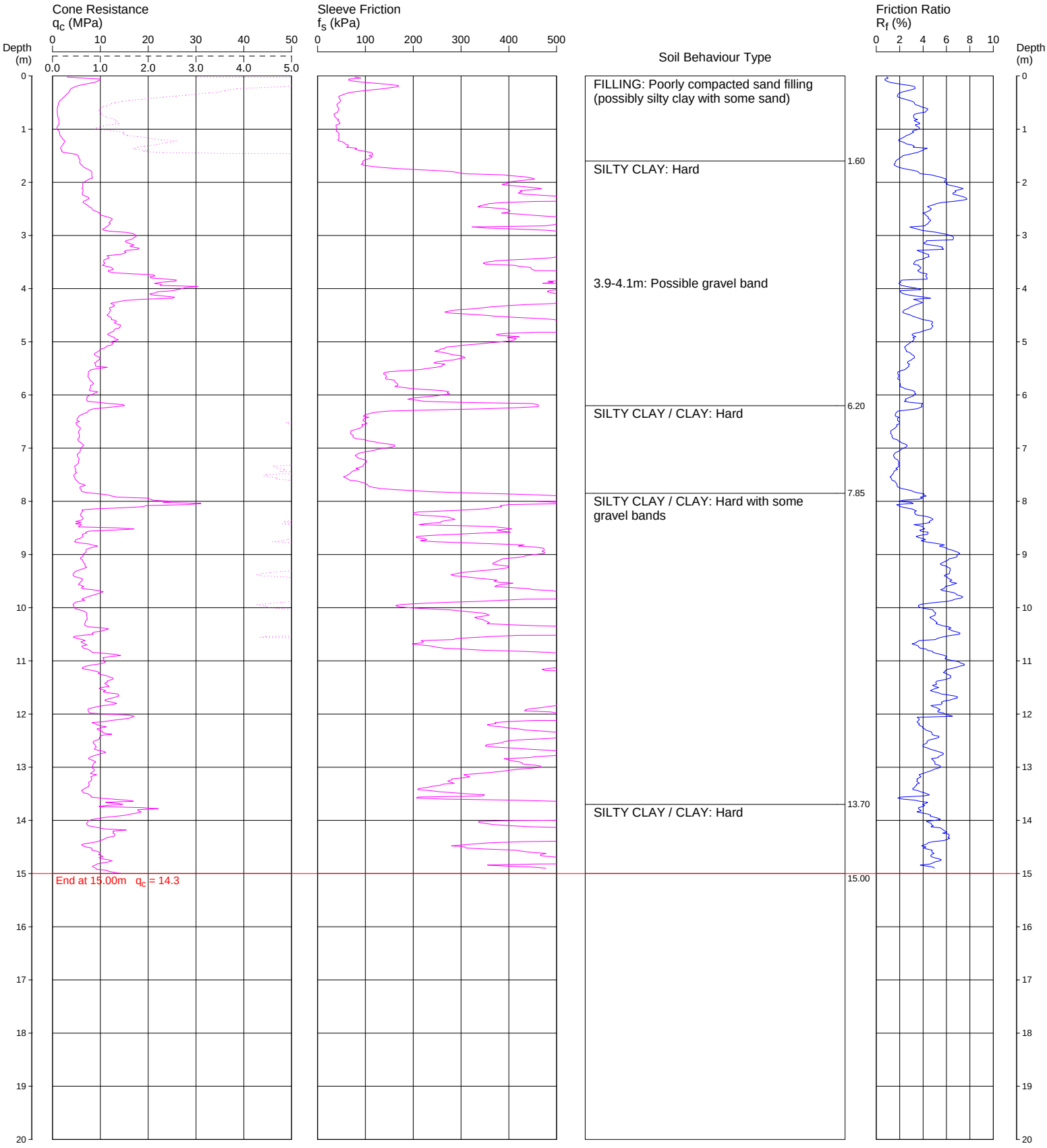
**COORDINATES:**

**CPT 5**

**Page 1 of 1**

**DATE** 20/9/2011

**PROJECT No:** 72320.03




**REMARKS:**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-05.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePlot Version 5.9.1
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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 183.0 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 101
**PROJECT No:** 72320.00
**DATE:** 28/3/2011
**SHEET** 1 OF 3

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| 183 | 0.2 | FILLING (TOPSOIL) - dark brown, sandy silt filling with rootlets, dry | | E | 0.1 | | | | Gatic cover |
| | | | | D | 0.2 | | | | Quick-set concrete |
| | 0.5 | SILTY CLAY - stiff to very stiff, brown silty clay with a trace of sand | | | 0.3 | | | | |
| | | | | E | 0.5 | | | | |
| | | SILTY CLAY - hard, red brown silty clay, dry | | | 0.6 | | | | Bentonite |
| 182 | 1 | | | | 1.0 | | | | |
| | | | | S | | | 20,22,20 N = 42 | | |
| | | | | | 1.45 | | | | |
| 181 | 2 | 2.0 SILTY CLAY - very stiff, orange brown silty clay, dry | | E | 2.0 | | | | |
| | | | | | 2.2 | | | | |
| | | | | | 2.5 | | | | |
| | | | | S | | | 10,13,17 N = 30 | | |
| 180 | 3 | | | | 2.95 | | | | |
| 179 | 4 | 4.0 SILTY CLAY - hard, orange brown silty clay with some sub-rounded ironstone gravel, dry | | S | 4.0 | | 16,22,20/100mm refusal | | |
| | | | | | 4.4 | | | | |
| | | 4.5-4.7m: rounded quartz gravel | | | | | | | |
| 178 | 5 | | | | | | | | |
| | | | | S | 5.5 | | 13,24,20/100mm refusal | | |
| 177 | 6 | | | | 5.9 | | | | |
| | | | | | | | | 31-03-11 | |
| 176 | 7 | 7.0 GRAVELLY SILTY CLAY - hard, orange brown, gravelly (sub-rounded ironstone and quartz gravel) silty clay, dry | | S | 7.0 | | 26,28,20/100mm refusal | | |
| | | | | | 7.4 | | | | |
| 175 | 8 | 8.0 SILTY CLAY - hard, orange brown, silty clay with a trace of ironstone gravel, moist | | | | | | | |
| | | | | S | 8.5 | | 10,16,17 N = 33 | | |
| 174 | 9 | | | | 8.95 | | | | |
| | 10.0 | | | | 10.0 | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** HQ to 8.8m

**TYPE OF BORING:** Solid flight auger (TC-bit) to 8.50m; Rotary (water) to 26.95m

**WATER OBSERVATIONS:** No free groundwater observed.Standpipe pumped dry on 30/3/11&4/4/11.Water level at 6.6m on 31/3/11& 6.7m on 5&7/4/11

**REMARKS:** Standpipe piezometer installed: Solid 0.0-6.0m; Slotted 6.0-26.95m; Bentonite plug 0.3-1.0m; Quick-set concrete 0.0-0.3m with Gatic cover

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 183.0 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 101
**PROJECT No:** 72320.00
**DATE:** 28/3/2011
**SHEET** 2 OF 3

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| 173 | | SILTY CLAY - very stiff, orange brown, silty clay with some schist gravel, moist | | S | 10.45 | | 10,10,12<br>N = 22 | | |
| 172 | 11 | | | | | | | | 11 |
| | | | | S | 11.5<br>11.8 | | 12,24<br>refusal<br>(bouncing) | | |
| 171 | 12 | 11.7m: ironstone gravel band (~100mm thick) | | | | | | | 12 |
| 170 | 13 13.0 | SILTY CLAY - hard, grey silty clay, moist | | S | 13.0<br>13.45 | | 13,21,23<br>N = 44 | | 13 |
| 169 | 14 | | | | | | | | 14 Backfilled with gravel |
| | 14.54 | SILTY CLAY - very stiff, red brown, silty clay with some ironstone gravel, moist | | S | 14.5<br>14.95 | | 7,9,13<br>N = 22 | | |
| 168 | 15 | | | | | | | | 15 |
| 167 | 16 16.0 | GRAVELLY SILTY CLAY - hard, red brown, gravelly (rounded quartz, schist and ironstone gravels) silty clay, moist | | S | 16.0<br>16.45 | | 9,15,23<br>N = 38 | | 16<br>Machine slotted PVC screen |
| 166 | 17 | | | | | | | | 17 |
| | | | | S | 17.5<br>17.95 | | 17,25/130mm<br>refusal | | |
| 165 | 18 | | | | | | | | 18 |
| 164 | 19 19.0 | SILTY CLAY - very stiff, red brown silty clay, moist | | S | 19.0<br>19.45 | | 7,10,14<br>N = 24 | | 19 |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** HQ to 8.8m

**TYPE OF BORING:** Solid flight auger (TC-bit) to 8.50m; Rotary (water) to 26.95m

**WATER OBSERVATIONS:** No free groundwater observed.Standpipe pumped dry on 30/3/11&4/4/11.Water level at 6.6m on 31/3/11& 6.7m on 5&7/4/11

**REMARKS:** Standpipe piezometer installed: Solid 0.0-6.0m; Slotted 6.0-26.95m; Bentonite plug 0.3-1.0m; Quick-set concrete 0.0-0.3m with Gatic cover

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▽ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 183.0 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 101
**PROJECT No:** 72320.00
**DATE:** 28/3/2011
**SHEET** 3 OF 3

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| | 20.3 | SILTY CLAY - very stiff, red brown silty clay, moist *(continued)* | | | | | | | |
| | | SILTY CLAY - very stiff, red brown silty clay with some ironstone gravel, moist | | S | 20.5 | | 7,10,14 N = 24 | | |
| | | | | | 20.95 | | | | |
| | | | | S | 23.5 | | 7,10,18 N = 28 | | |
| | | | | | 23.95 | | | | |
| | | | | S | 26.5 | | 10,12,20 N = 32 | | |
| | 26.95 | | | | 26.95 | | | | End cap |
| | | Bore discontinued at 26.95m - target depth achieved | | | | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** HQ to 8.8m

**TYPE OF BORING:** Solid flight auger (TC-bit) to 8.50m; Rotary (water) to 26.95m

**WATER OBSERVATIONS:** No free groundwater observed.Standpipe pumped dry on 30/3/11&4/4/11.Water level at 6.6m on 31/3/11& 6.7m on 5&7/4/11

**REMARKS:** Standpipe piezometer installed: Solid 0.0-6.0m; Slotted 6.0-26.95m; Bentonite plug 0.3-1.0m; Quick-set concrete 0.0-0.3m with Gatic cover

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.3 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 107
**PROJECT No:** 72320.00
**DATE:** 6 - 7/4/2011
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 182 | 0.07 | ASPHALT - 70mm thick | | | | | | | |
| | 0.4 | FILLING (ROADBASE) - angular blue metal gravel and sand | | | | | | | |
| | | FILLING - poorly compacted, red brown, silty clay filling with granite gravel, slag and some sand, moist | | S | 1.35 | | 3,3,2<br>N = 5 | | |
| 181 | 1 | | | | 1.8 | | | | |
| | | | | E | 1.9 | | | | |
| | 2 | | | | 2.0 | | | | |
| | 2.2 | | | A | 2.2 | | | | |
| 180 | 2.4 | FILLING - poorly compacted, medium grained sand filling with some clay, moist | | E | 2.4 | | | | |
| | | Bore discontinued at 2.4m<br>- hole abandoned due to obstruction | | | | | | | |
| | 3 | | | | | | | | |
| 179 | | | | | | | | | |
| | 4 | | | | | | | | |
| 178 | | | | | | | | | |
| | 5 | | | | | | | | |
| 177 | | | | | | | | | |
| | 6 | | | | | | | | |
| 176 | | | | | | | | | |
| | 7 | | | | | | | | |
| 175 | | | | | | | | | |
| | 8 | | | | | | | | |
| 174 | | | | | | | | | |
| | 9 | | | | | | | | |
| 173 | | | | | | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** Pot holing to 1.30m; Solid flight auger to 2.40m

**WATER OBSERVATIONS:** No free groundwater observed whilst auger drilling

**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▽ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.3 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 107A
**PROJECT No:** 72320.00
**DATE:** 7/4/2011
**SHEET** 1 OF 2

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| 182 | 0.07 | ASPHALT - 70mm thick | | | | | | | |
| | 0.4 | FILLING (ROADBASE) - brown, angular blue metal gravel filling with sand, dry | | E | 0.4<br>0.5 | | | | |
| | | SILTY CLAY - apparently very stiff, red brown silty clay, dry | | | | | | | |
| 181 | 1 | | | | | | | | 1 |
| | 1.5 | SILTY CLAY - very stiff, red brown, silty clay with some ironstone gravel, dry | | | 1.5 | | | | |
| | | | | S<br>E | 1.6<br>1.95 | | 7,9,18<br>N = 27 | | |
| 180 | 2 | | | | | | | | 2 |
| | 2.5 | SILTY CLAY - stiff, red brown, silty clay with a trace of ironstone gravel, dry | | | 2.5 | | | | |
| | | | | S | 2.95 | | 6,6,8<br>N = 14 | | |
| 179 | 3 | | | | | | | | 3 |
| | 4.0 | SILTY CLAY - very stiff, red brown, silty clay with a trace of ironstone gravel, dry | | | 4.0 | | | | |
| 178 | 4 | | | S | 4.45 | | 5,8,14<br>N = 22 | | 4 |
| | 5 | | | | | | | | 5 |
| 177 | | | | | 5.5 | | | | |
| | 6 | | | S | 5.95 | | 6,9,14<br>N = 23 | | 6 |
| 176 | 7 | | | | 7.0 | | | | 7 |
| | | | | S | 7.45 | | 4,6,11<br>N = 17 | | |
| 175 | 8 | | | | | | | | 8 |
| | 8.5 | SILTY CLAY - stiff to very stiff, red brown and grey, silty clay, moist | | | 8.5 | | | | |
| 174 | | | | S | 8.95 | | 6,7,9<br>N = 16 | | |
| | 9 | | | | | | | | 9 |
| 173 | 10.0 | | | | 10.0 | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** Pot holing to 1.2m; Solid flight auger (TC-bit) to 13.0m

**WATER OBSERVATIONS:** Free groundwater observed at 13.10m on SPT sampler

**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▽ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.3 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 107A
**PROJECT No:** 72320.00
**DATE:** 7/4/2011
**SHEET** 2 OF 2

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| 172 | 11 | SILTY CLAY - hard, red brown silty clay, moist | | S | 10.45 | | 9,14,30<br>N = 44 | | |
| 171 | 11.5 | SILTY CLAY - stiff, mottled orange brown and grey, silty clay, moist<br><br>12.0m: gravel | | S | 11.5<br>11.95 | | 5,6,7<br>N = 13 | | |
| 170 | 12 | | | | | | | | |
| 169 | 13 13.0 | SILTY CLAY - hard, orange brown silty clay, moist | | S | 13.0 | | 8,15,19<br>N = 34 | ▼ | |
| | 13.45 | Bore discontinued at 13.45m | | | 13.45 | | | | |
| 168 | 14 | | | | | | | | |
| 167 | 15 | | | | | | | | |
| 166 | 16 | | | | | | | | |
| 165 | 17 | | | | | | | | |
| 164 | 18 | | | | | | | | |
| 163 | 19 | | | | | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** Pot holing to 1.2m; Solid flight auger (TC-bit) to 13.0m

**WATER OBSERVATIONS:** Free groundwater observed at 13.10m on SPT sampler

**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.4 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 109
**PROJECT No:** 72320.00
**DATE:** 1 - 5/4/2011
**SHEET** 1 OF 2

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| 182 | 0.4 | FILLING (TOPSOIL) - poorly compacted, dark brown, silty clay filling (topsoil) with some sand, moist | | E | 0.1<br>0.2 | | | | |
| | | SILTY CLAY - apparently stiff, orange brown silty clay, dry | | B<br>A | 0.4<br>0.5<br>0.6 | | | | |
| 181 | 1.0 | SILTY CLAY - stiff, orange brown silty clay, dry | | S | 1.0<br>1.45 | | 4,4,9<br>N = 13 | | |
| 180 | 2 | | | S | 2.5<br>2.95 | | 4,5,7<br>N = 12 | | |
| 179 | 3 | | | | | | | | |
| 178 | 4.0 | SILTY CLAY - very stiff, orange brown silty clay, dry | | S | 4.0<br>4.45 | | 7,11,14<br>N = 25 | | |
| | 5 | 5.0m: trace of ironstone gravel | | | | | | | |
| 177 | | | | S | 5.5<br>5.95 | | 7,10,12<br>N = 22 | | |
| 176 | 6 | | | | | | | | |
| 175 | 7.0 | SILTY CLAY - stiff, orange brown, silty clay with a trace of ironstone gravel, dry | | S | 7.0<br>7.45 | | 4,7,8<br>N = 15 | | |
| 174 | 8 | | | | | | | | |
| | 8.5 | SILTY CLAY - hard, red brown, silty clay with a trace of ironstone gravel, dry | | S | 8.5<br>8.95 | | 10,12,21<br>N = 33 | | |
| 173 | 9 | | | | | | | | |
| | | | | | 10.0 | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** Uncased
**TYPE OF BORING:** Solid flight auger (TC-bit) to 10.0m
**WATER OBSERVATIONS:** No free groundwater observed
**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▽ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.4 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 109
**PROJECT No:** 72320.00
**DATE:** 1 - 5/4/2011
**SHEET** 2 OF 2

| RL | Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Depth | Sample | Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| | 10.15 | 10.10m: rounded quartz gravel | | S | 10.15 | | 20 refusal | | |
| | | Bore discontinued at 10.15m - target depth achieved | | | | | | | |

**RIG:** Scout **DRILLER:** JS **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** Solid flight auger (TC-bit) to 10.0m

**WATER OBSERVATIONS:** No free groundwater observed

**REMARKS:**

**SAMPLING & IN SITU TESTING LEGEND**

| | | | | | |
|---|---|---|---|---|---|
| A | Auger sample | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▽ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 181.8 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 209
**PROJECT No:** 72320.03
**DATE:** 21/9/2011
**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) |
|---|---|---|---|---|---|---|---|---|---|
| 181 | 0.4 | FILLING - poorly compacted, brown, silty sand filling with some building rubble (bricks, quartz cobbles and glass) | | D/E | 0.1<br>0.2 | | PID<1 | | |
| | | SILTY CLAY - hard, orange brown silty clay, moist | | A | 0.7<br>0.8 | | | | |
| | 1 | | | $U_{50}$ | | | pp>400 | | |
| | | | | | 1.1 | | | | |
| | | - rounded ironstone gravel from 1.5m to 1.9m | | A | 1.5<br>1.6 | | | | |
| 180 | 2 | | | | | | | | |
| | | | | | 2.5 | | | | |
| | | | | A | 2.6 | | | | |
| 179 | 3 | | | | | | | | |
| | 3.0 | Bore discontinued at 3.0m<br>- target depth achieved | | | | | | | |
| 178 | 4 | | | | | | | | |
| 177 | | | | | | | | | |

**RIG:** 5 tonne Excavator **DRILLER:** John Rapley **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** 200mm diameter auger

**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 | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 182.6 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 210
**PROJECT No:** 72320.03
**DATE:** 21/9/2011
**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) |
|---|---|---|---|---|---|---|---|---|---|
| 182 | 0.2 | FILLING (TOPSOIL) - brown sandy silt filling, dry | | E | 0.1 | | PID<1 | | |
| | | SILTY CLAY - very stiff, orange brown silty clay, dry | | | 0.2 | | | | |
| | | | | A | 0.5 | | | | |
| | 0.6 | SILTY CLAY - hard, orange brown silty clay, dry | | | 0.6 | | | | |
| 181 | 1 | | | E | 1.2 | | PID<1 | | |
| | | | | | 1.3 | | | | |
| 180 | 2 | | | A | 2.2 | | | | |
| | | | | | 2.3 | | | | |
| | | | | A | 2.9 | | | | |
| 179 | 3 | 3.0 Bore discontinued at 3.0m - target depth achieved | | | 3.0 | | | | |
| 178 | 4 | | | | | | | | |

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

**RIG:** 5 tonne Excavator **DRILLER:** John Rapley **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** 200mm diameter auger

**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 | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# BOREHOLE LOG

**CLIENT:** Health Infrastructure
**PROJECT:** Wagga Wagga Base Hospital Redevelopment
**LOCATION:** Edward Street, Wagga Wagga

**SURFACE LEVEL:** 184.2 AHD
**EASTING:**
**NORTHING:**
**DIP/AZIMUTH:** 90°/--

**BORE No:** 211
**PROJECT No:** 72320.03
**DATE:** 21/9/2011
**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) |
|---|---|---|---|---|---|---|---|---|---|
| 184 | 0.0 | | | | | | | | |
| | 0.1 | FILLING - poorly compacted, gravelly clay filling, dry | | A/E | 0.1 | | | | |
| | | FILLING - poorly compacted, medium to coarse grained sand filling with some clay, dry | | E* | 0.3<br>0.4 | | PID<1 | | |
| | 0.6 | FILLING - poorly compacted, silty clay filling with some sand, moist | | A/E* | 0.6<br>0.7 | | PID<1 | | |
| 183 | 1.1 | SILTY CLAY - very stiff then hard, orange brown silty clay, dry | | A | 1.3<br>1.4 | | | | |
| 182 | | | | A | 2.8<br>2.9 | | | | |
| 181 | 3.0 | Bore discontinued at 3.0m<br>- target depth achieved | | | | | | | |
| 180 | | | | | | | | | |

**RIG:** 5 tonne Excavator **DRILLER:** John Rapley **LOGGED:** PGH **CASING:** Uncased

**TYPE OF BORING:** 200mm diameter auger

**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 | G | Gas sample | PID | Photo ionisation detector (ppm) |
| B | Bulk sample | P | Piston sample | PL(A) | Point load axial test Is(50) (MPa) |
| BLK | Block sample | $U_x$ | Tube sample (x mm dia.) | PL(D) | Point load diametral test Is(50) (MPa) |
| C | Core drilling | W | Water sample | pp | Pocket penetrometer (kPa) |
| D | Disturbed sample | ▷ | Water seep | S | Standard penetration test |
| E | Environmental sample | ▼ | Water level | V | Shear vane (kPa) |

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# Appendix D

Pile Capacity Estimates – ConePile output

# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

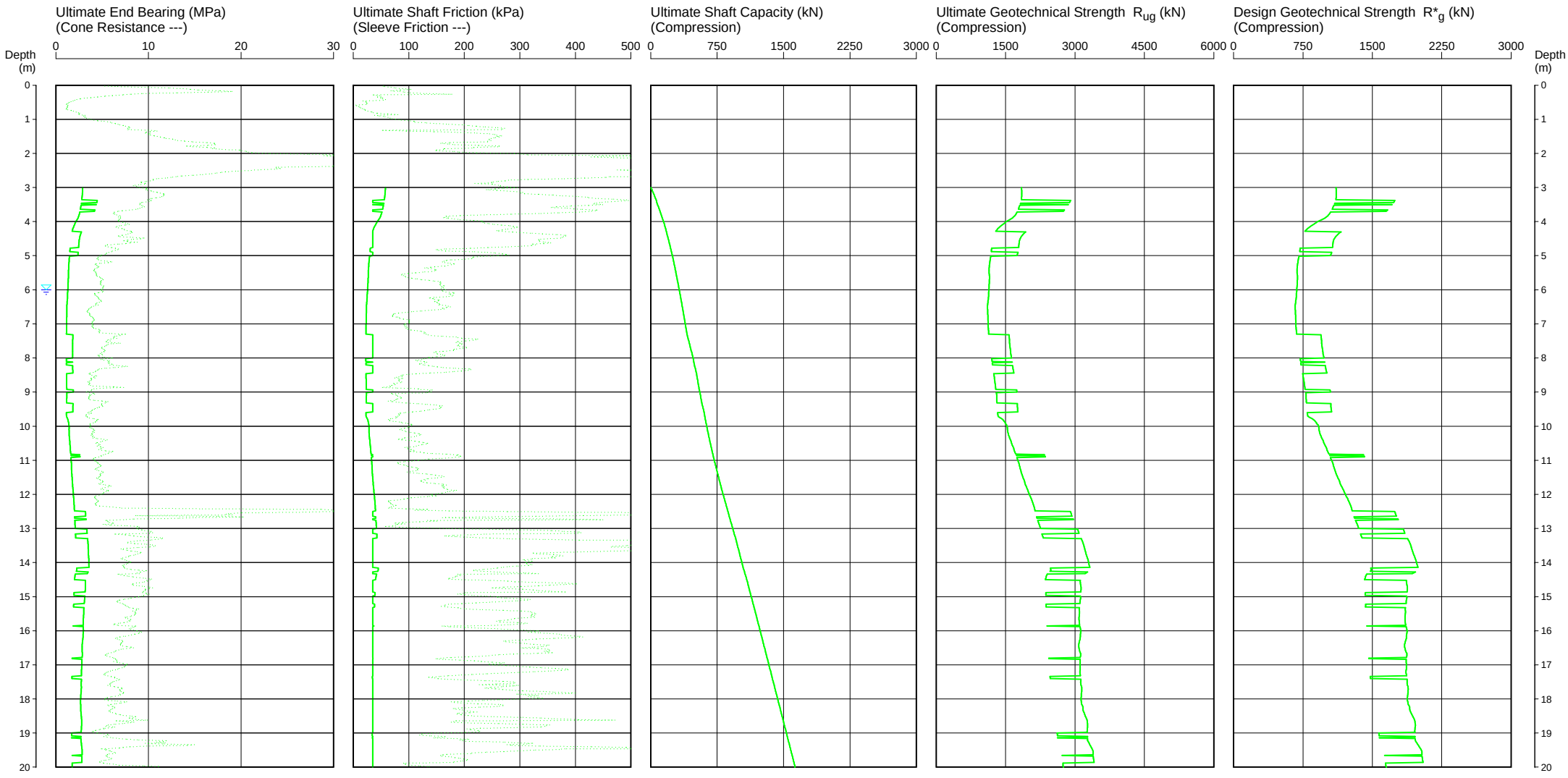
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 3



**DATE** 20/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 181.8 m AHD




**DISCLAIMER:**
These capacities have been estimated using accepted static theory, and are a guide only. Suitable verification procedures should be adopted (refer to AS2159), and piling contractors should confirm pile suitability and capacities. Structural capacity should be checked, and due allowance made for inclined or eccentric loads, and possible corrosion effects.

**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

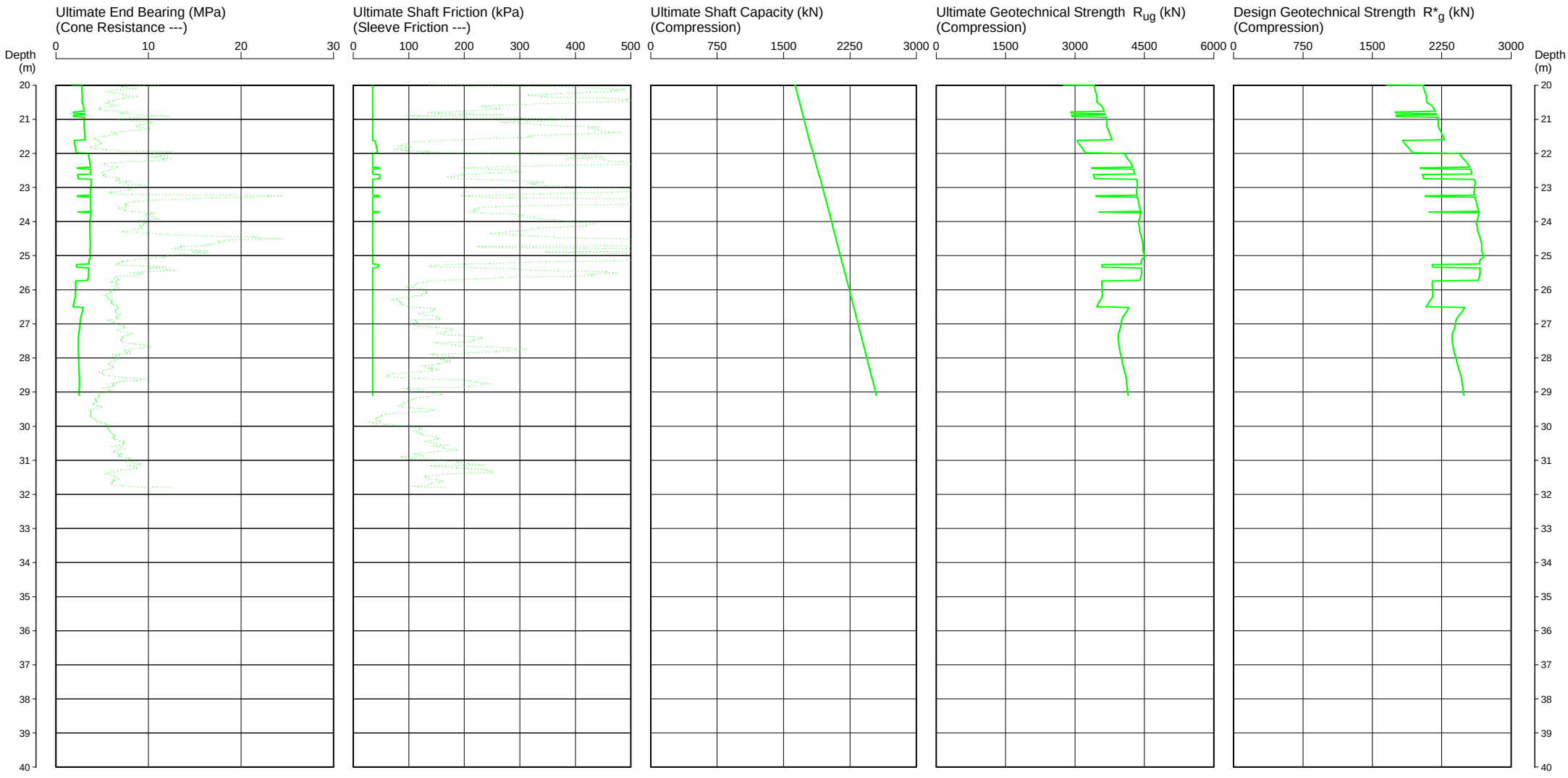
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 3



**DATE** 20/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 181.8 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

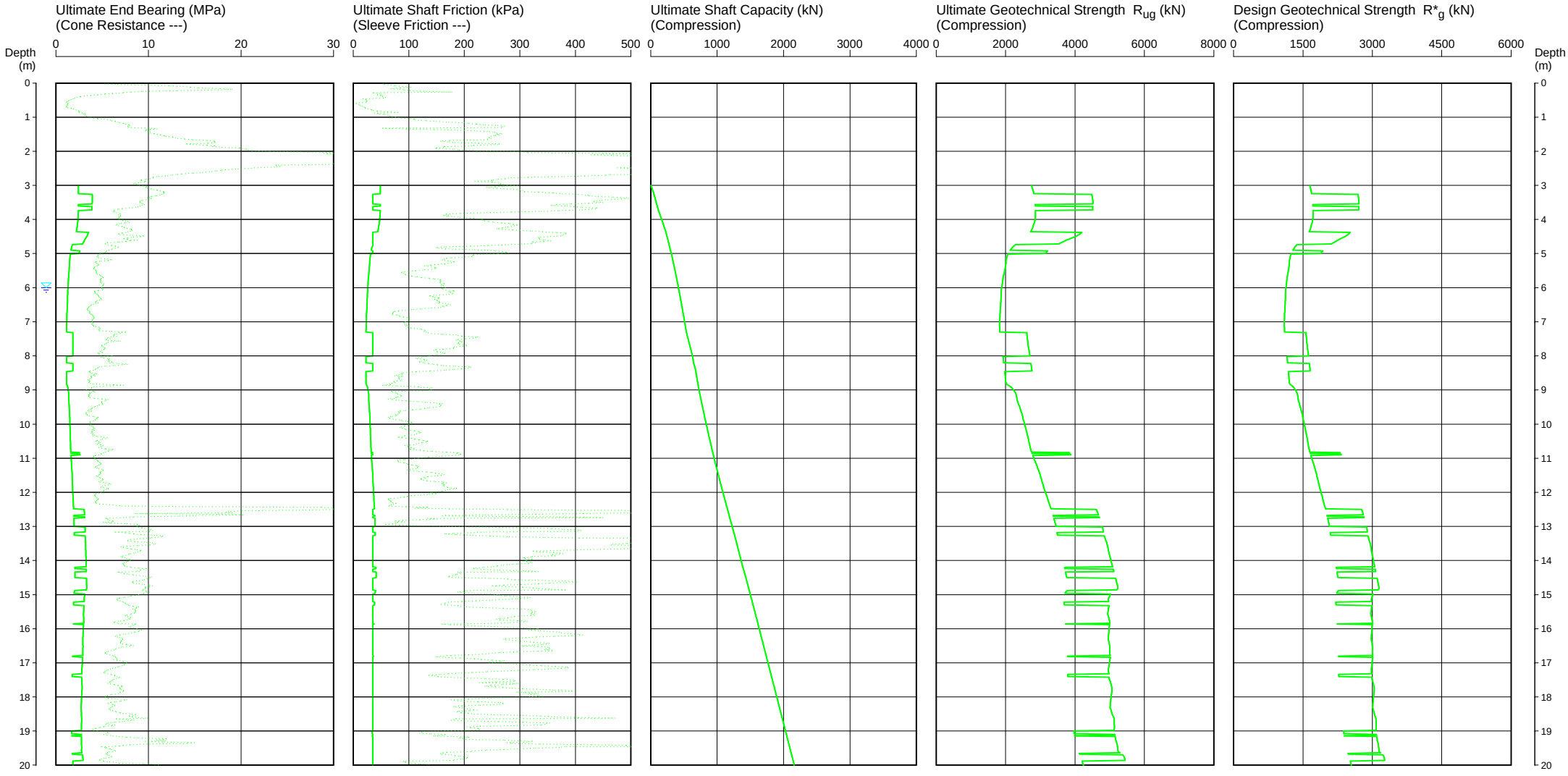
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 3



**DATE** 20/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 181.8 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

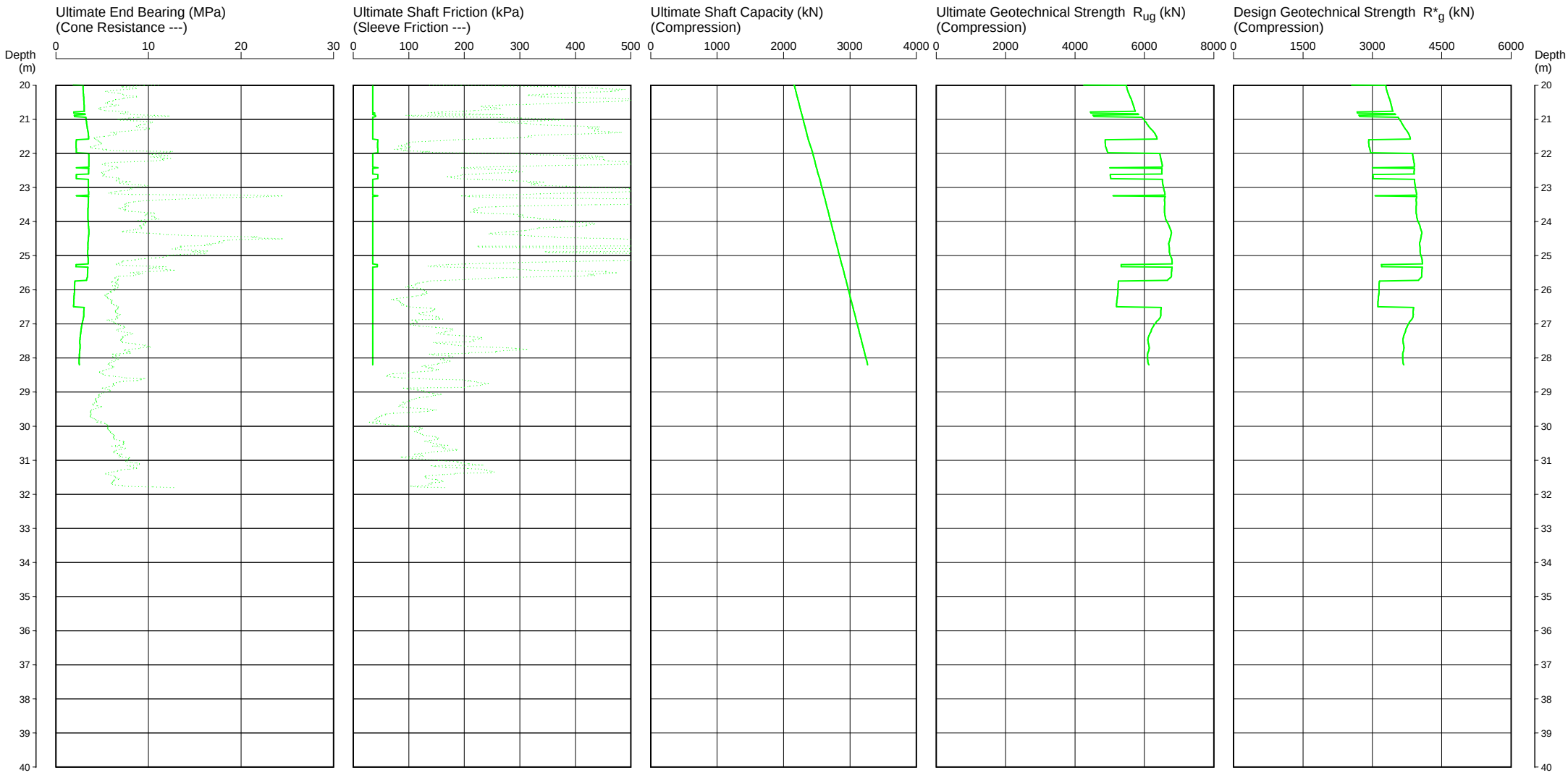
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 3



**DATE** 20/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 181.8 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-03.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

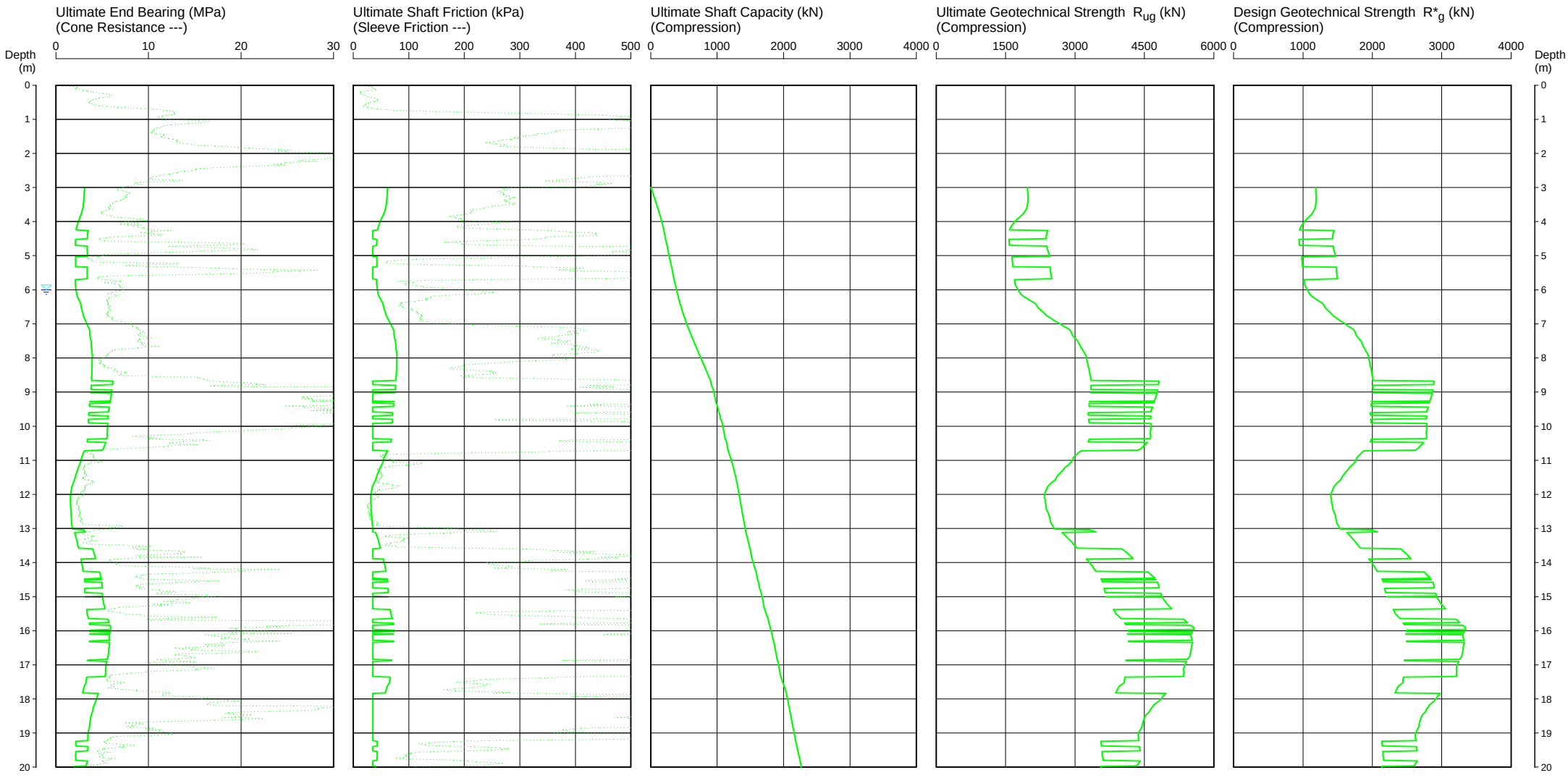
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 4



**DATE** 19/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 182.6 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

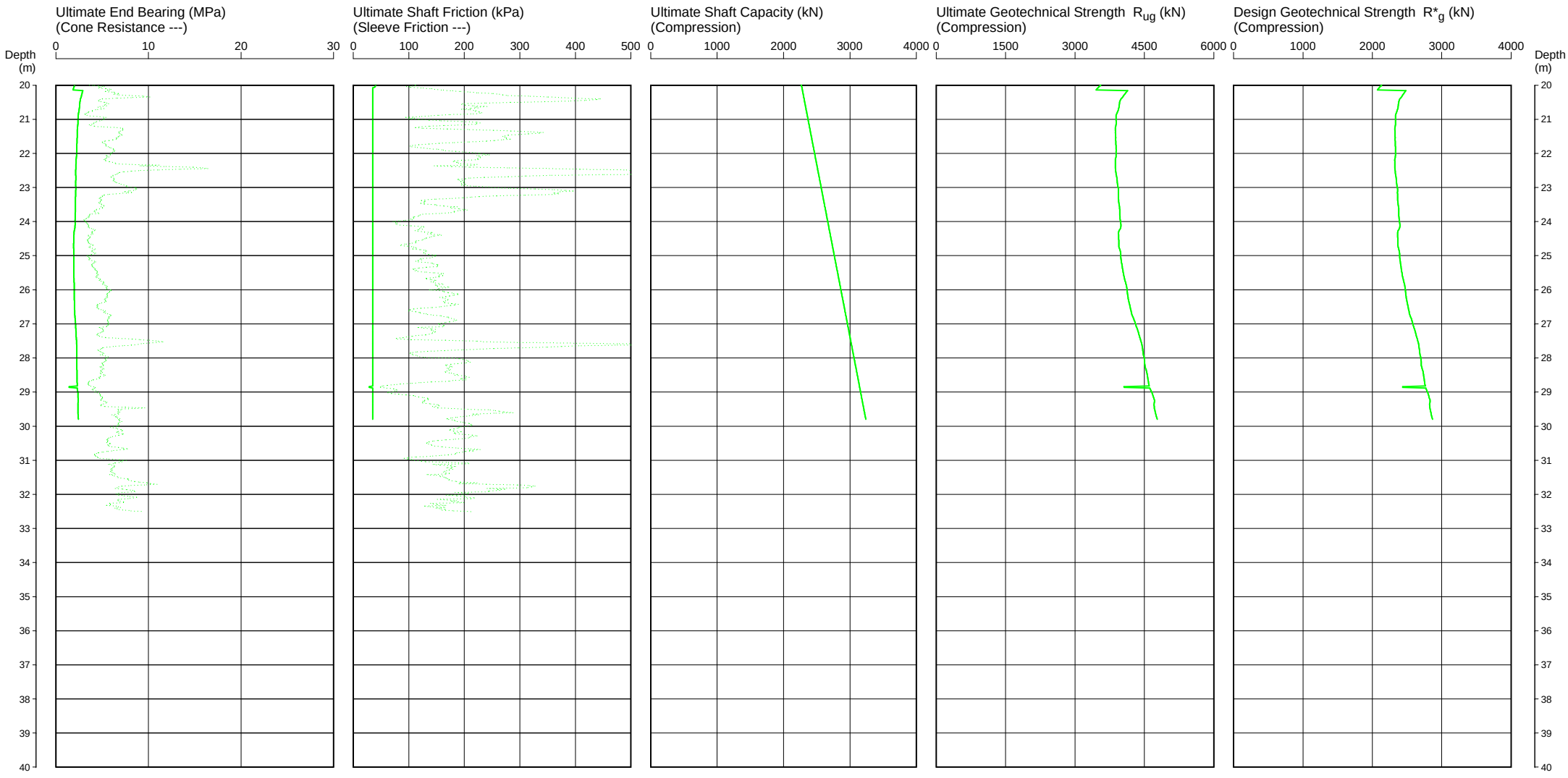
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 4



**DATE** 19/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 182.6 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

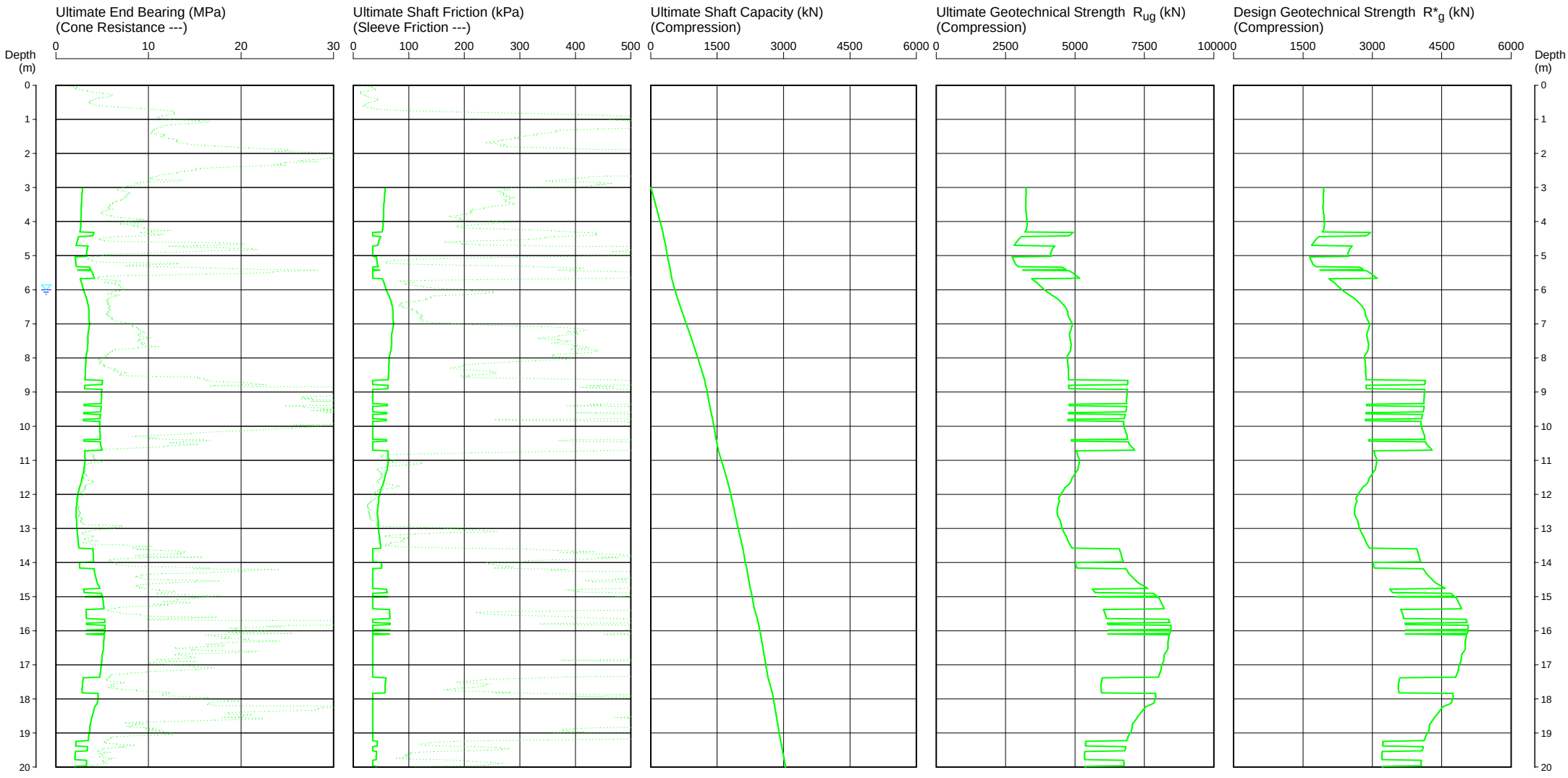
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 4



**DATE** 19/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 182.6 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT

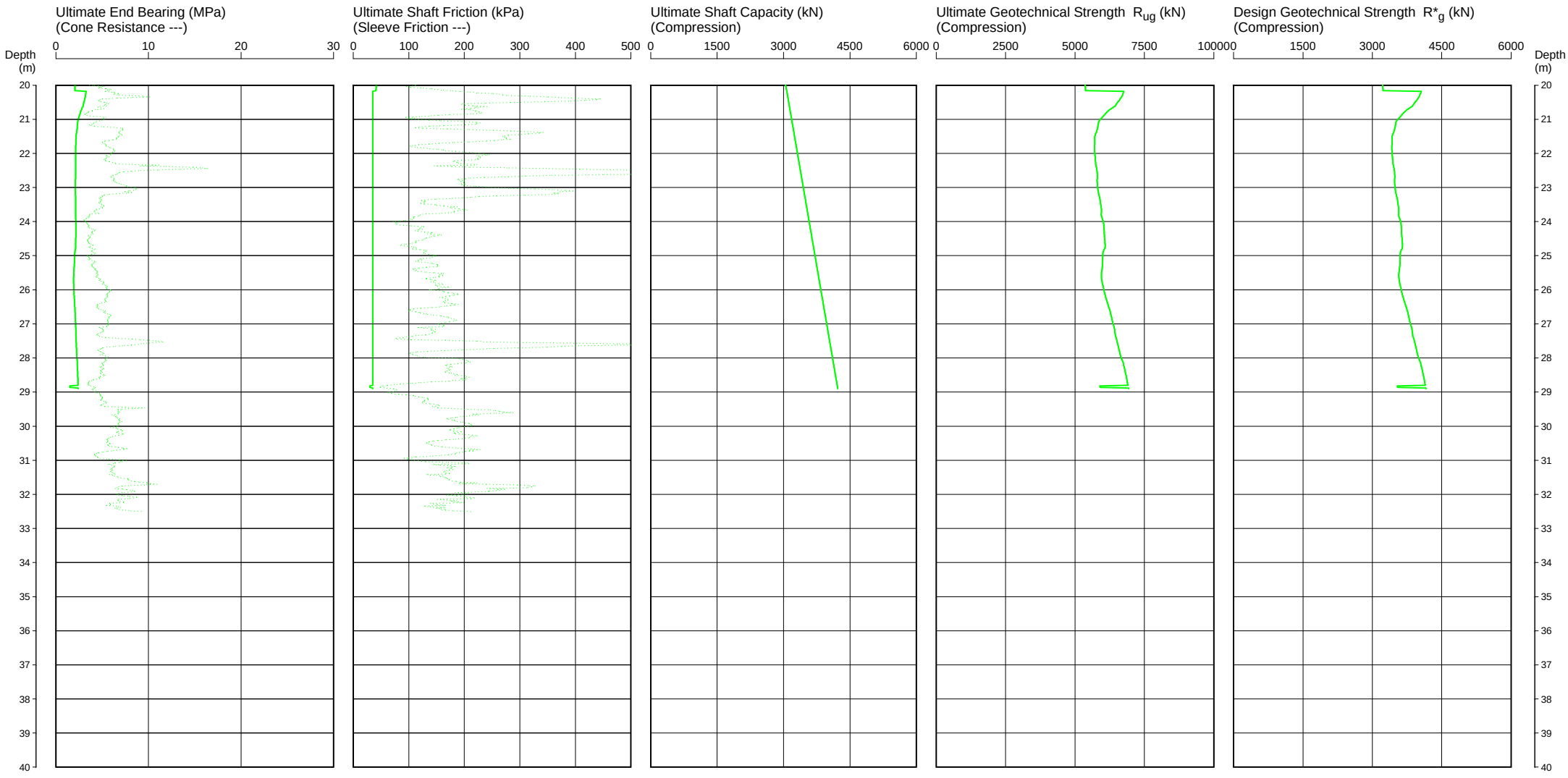
**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

## CPT 4



**DATE** 19/09/2011
**PROJECT No:** 72320.03
**SURFACE RL:** 182.6 m AHD

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**Water depth after test: 6.00m depth**

**File:** P:\72320.03 WAGGA WAGGA, Base Hospital Supplementary Geotechnical Investigation PGH\Field\72320.03-04.CP5
**Cone ID:** CONE-402 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

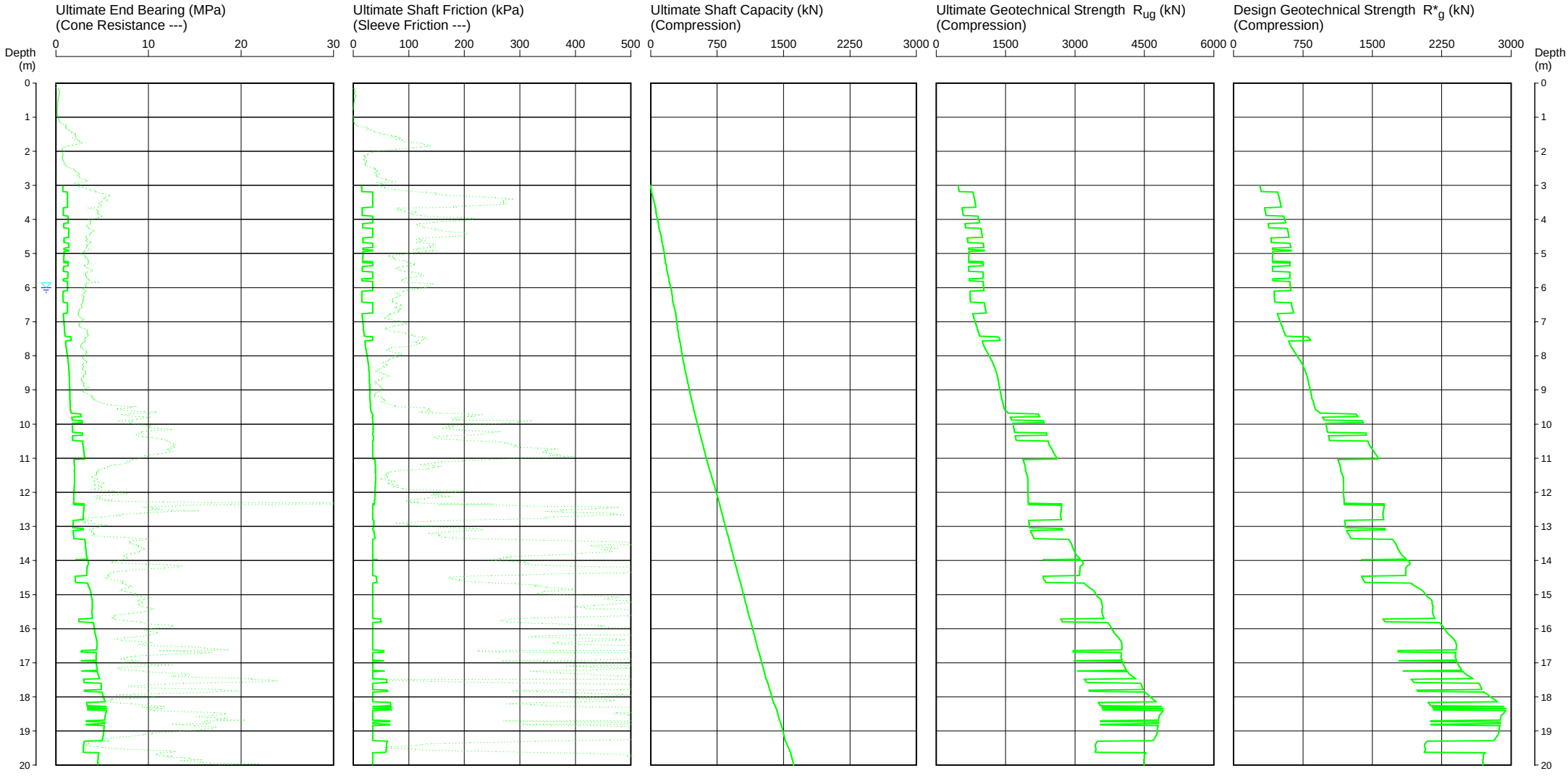
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**307**


**DATE** 9/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.2

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

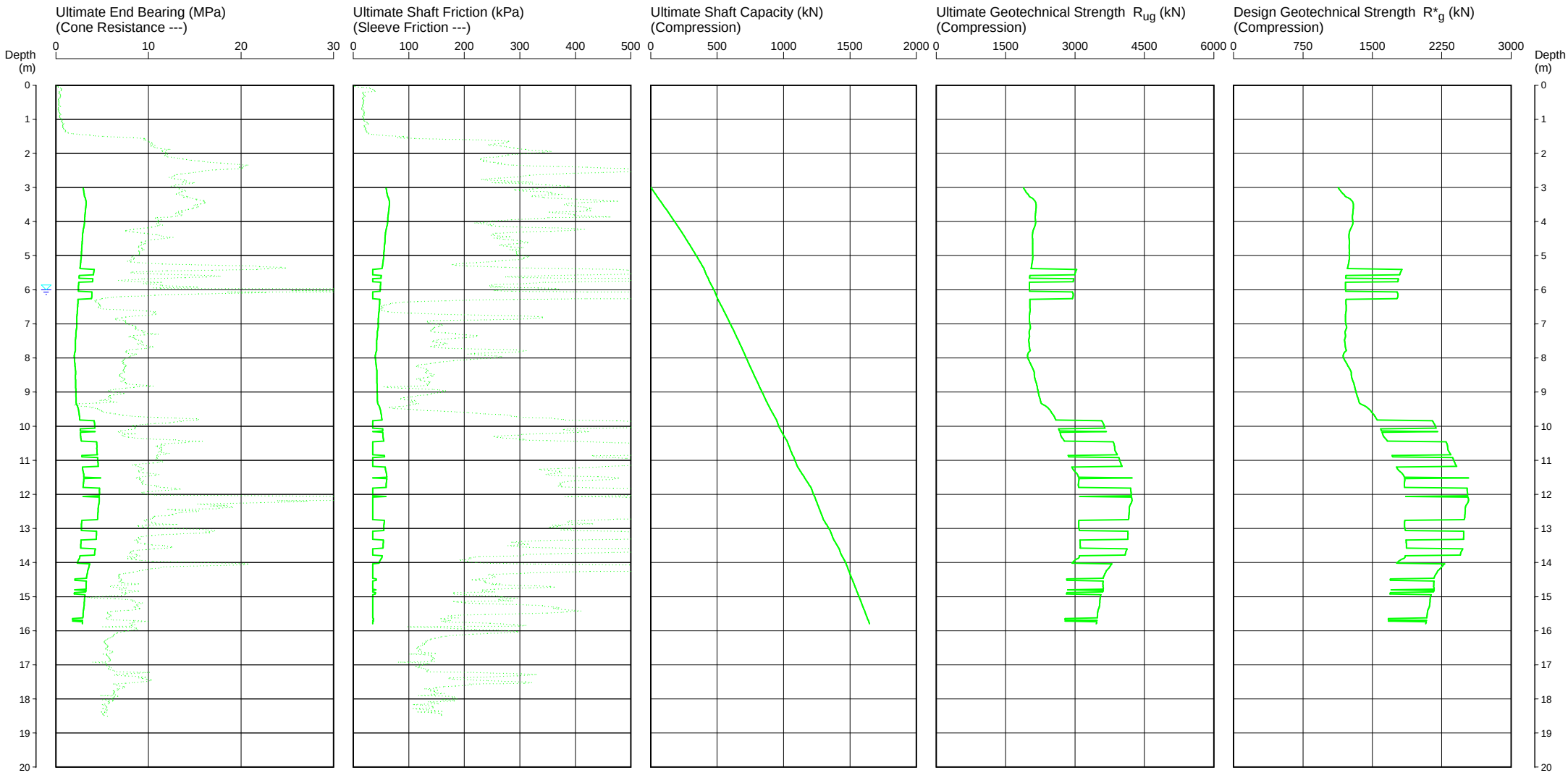
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**303**
**Page 1 of 1**

**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 182.1




**DISCLAIMER:**
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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-303.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

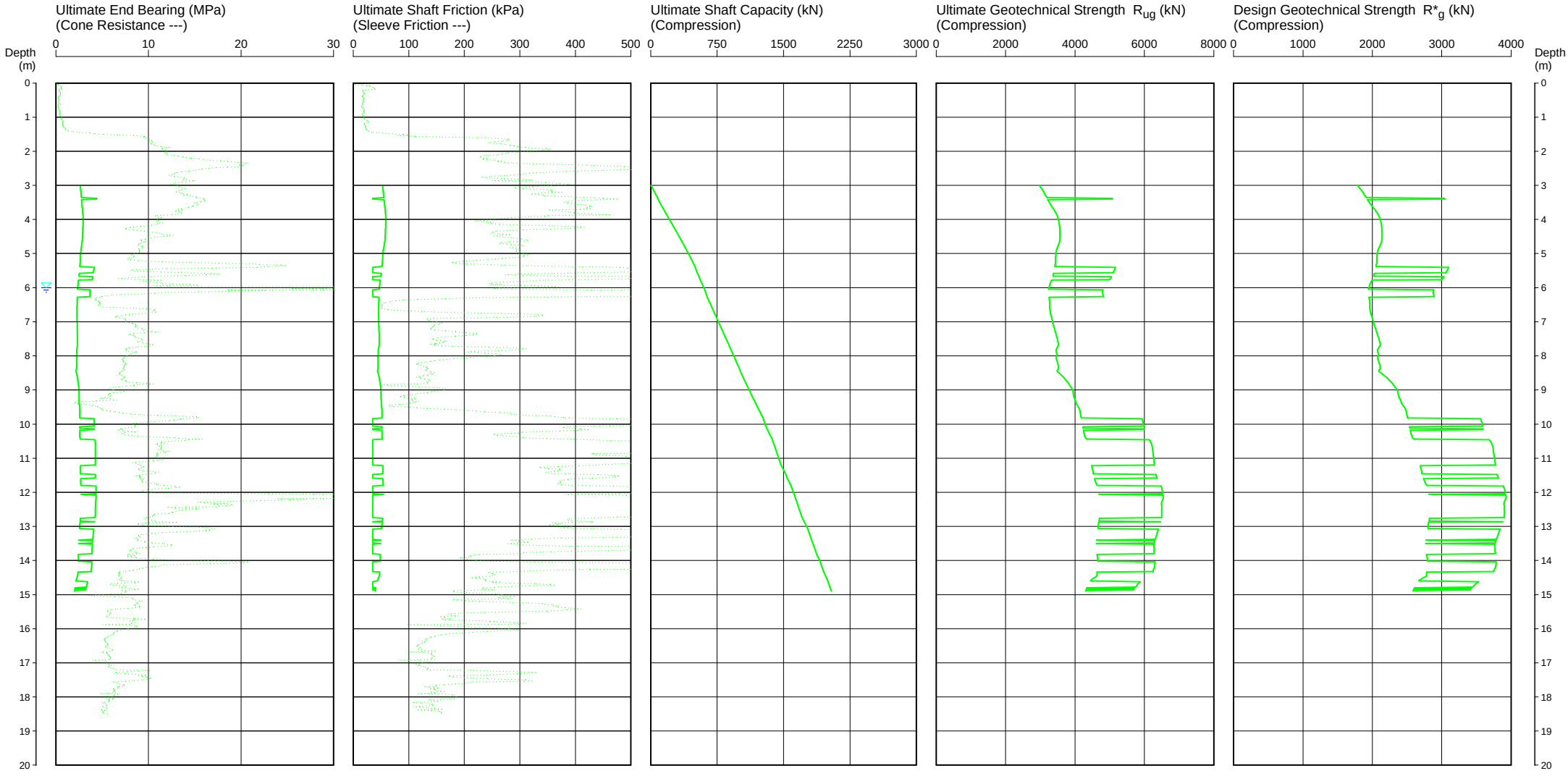
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**303**
**Page 1 of 1**

**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 182.1

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-303.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

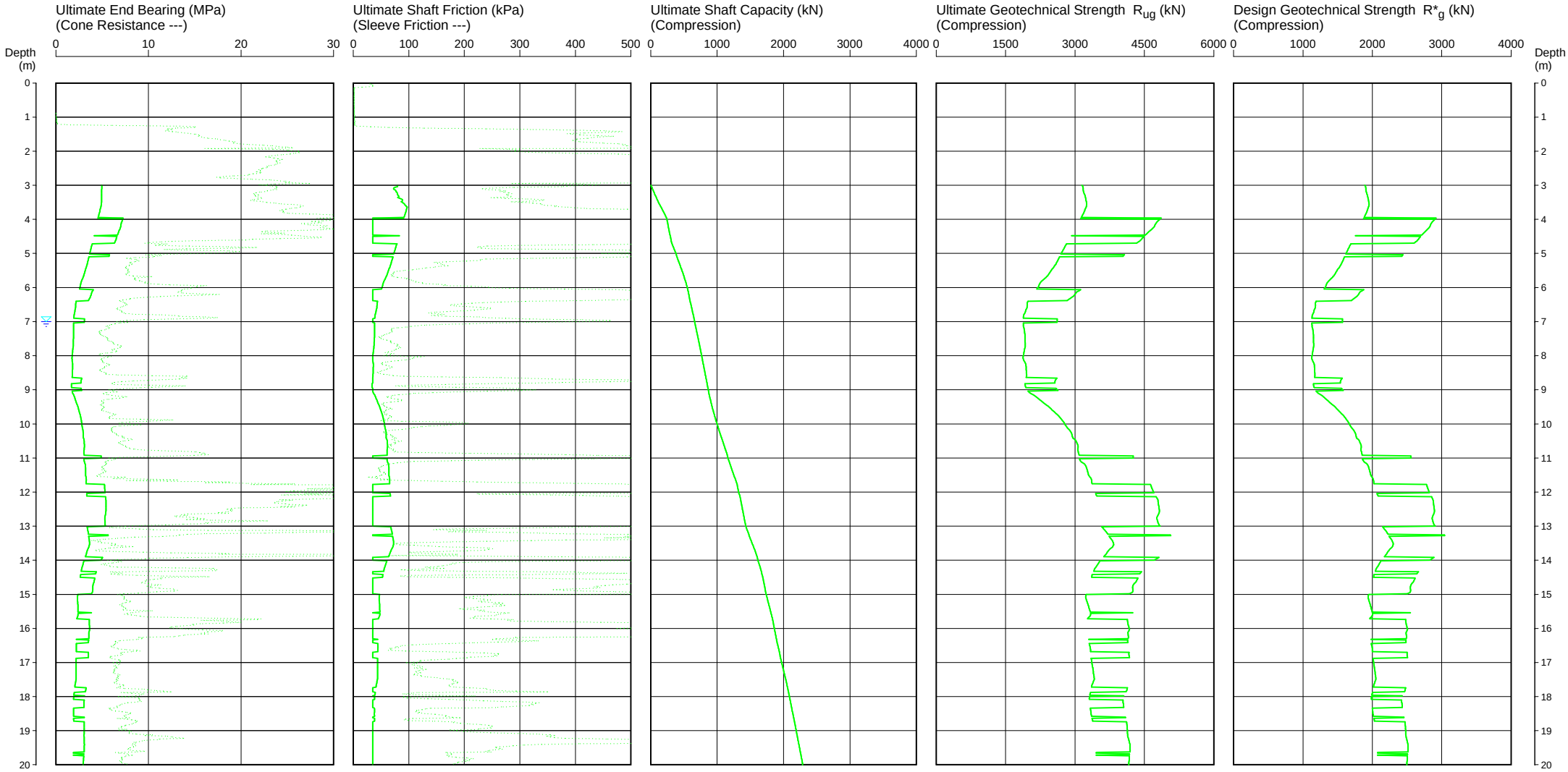
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**305**


**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 183.0

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**Water depth after test: 7.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-305.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

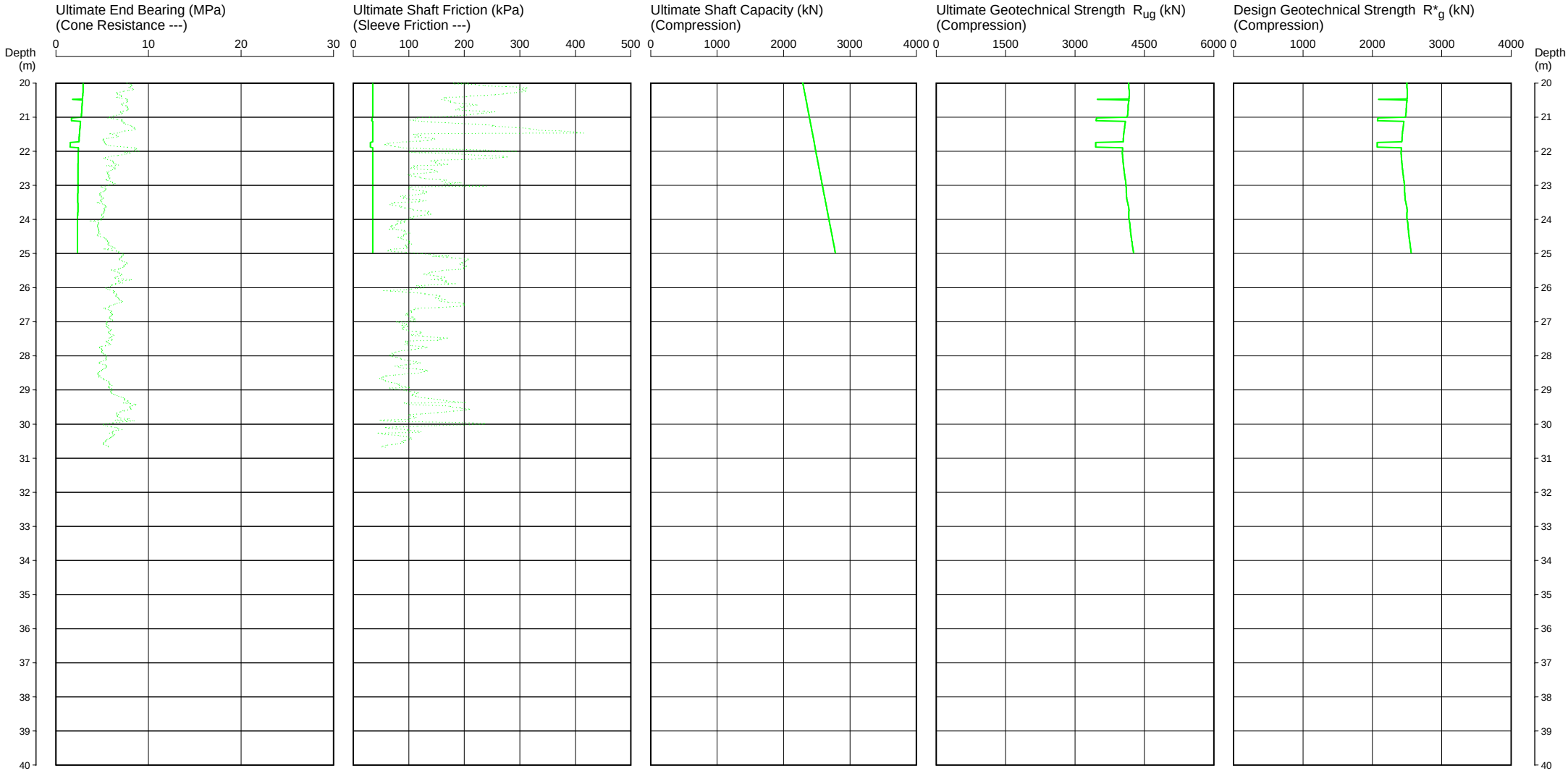
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**305**


**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 183.0




**DISCLAIMER:**
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**Water depth after test: 7.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-305.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

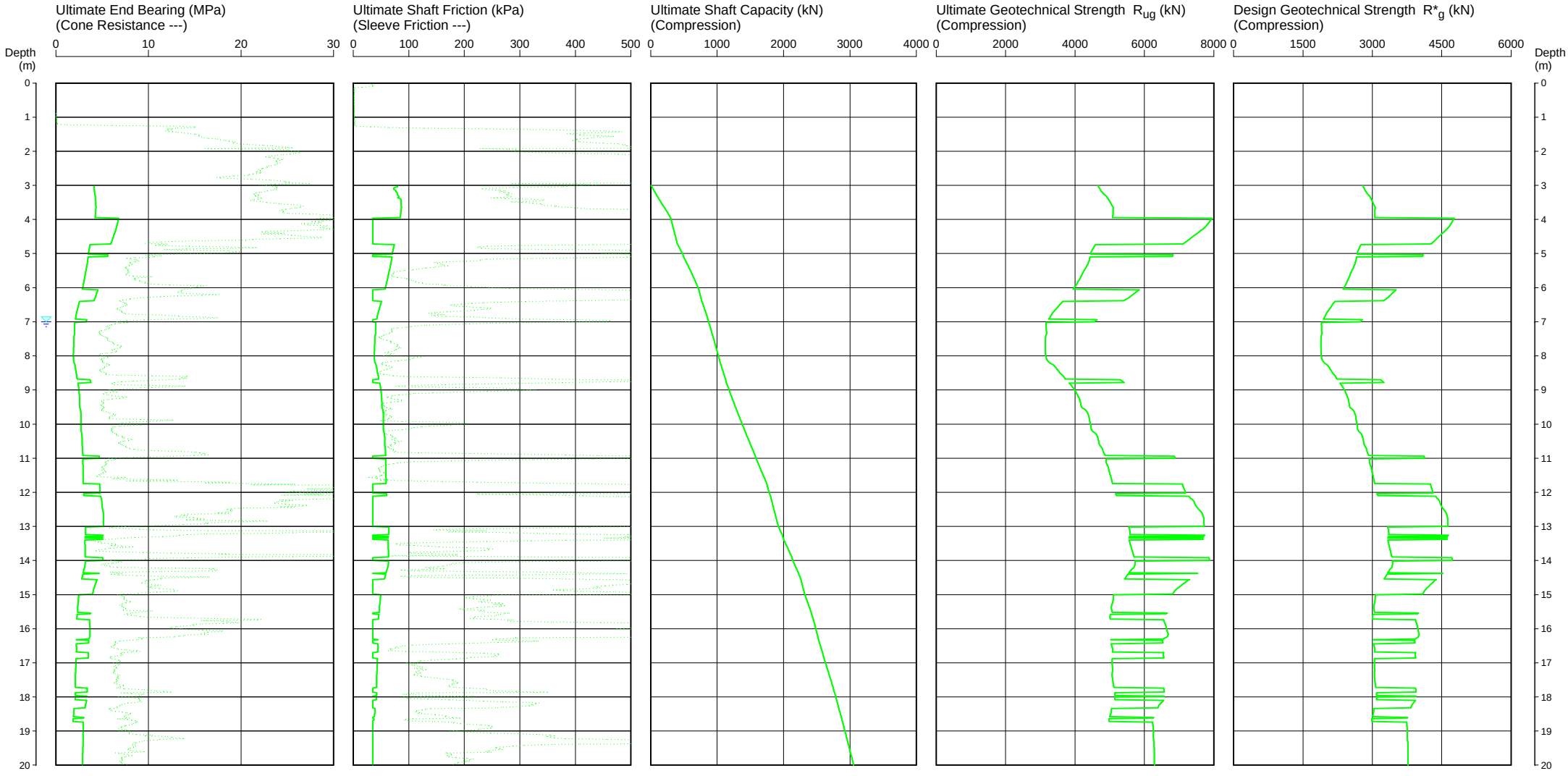
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**305**


**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 183.0

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**Water depth after test: 7.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-305.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

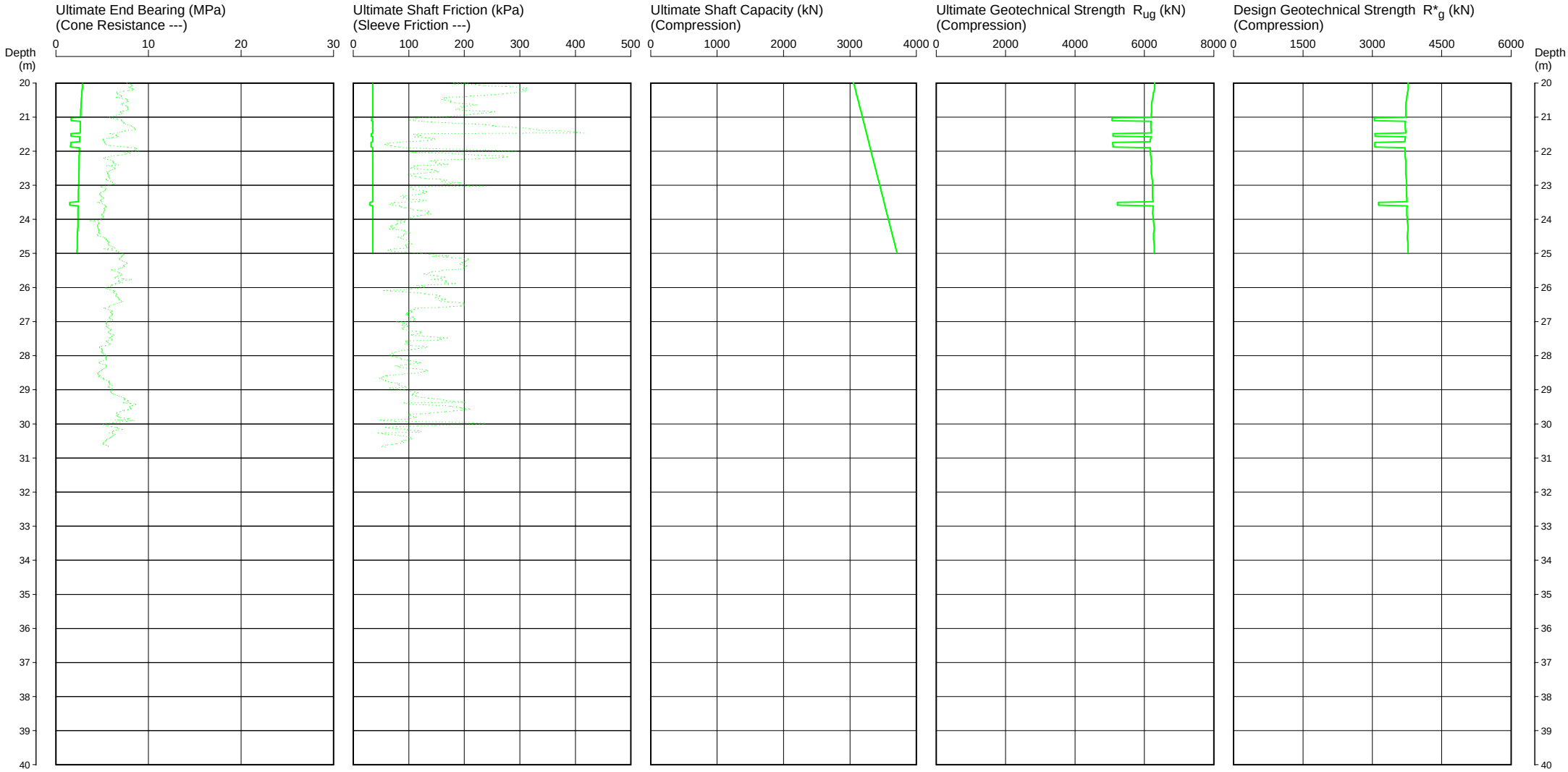
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**305**


**DATE** 15/01/2013
**PROJECT No:** 72320.06
**SURFACE RL:** 183.0

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**Water depth after test: 7.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\January\72320.06-305.CP5
**Cone ID:** CONE-425 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

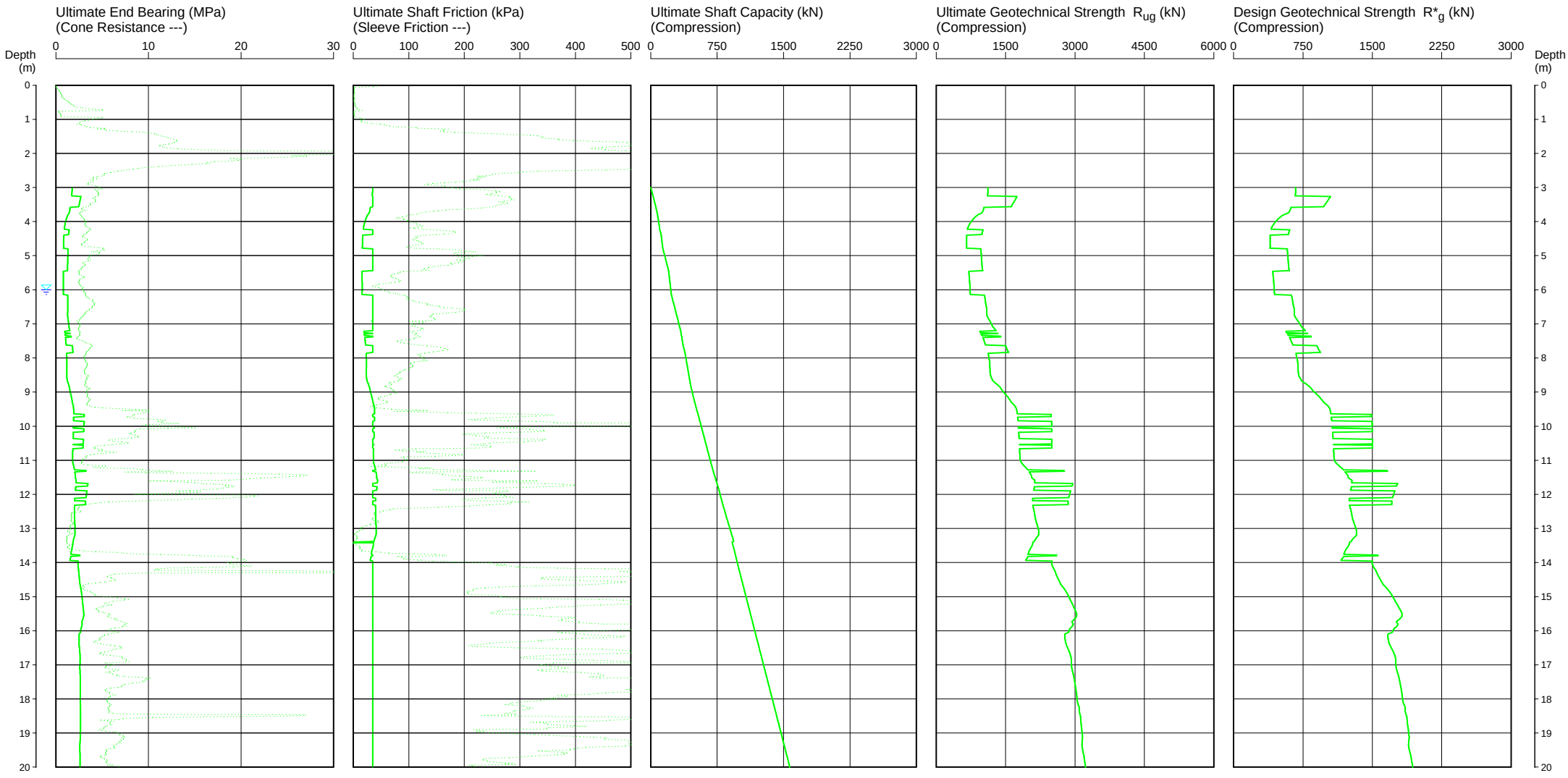
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**306**


**DATE** 7/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.5

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

ConePile Version 5.9.1
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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

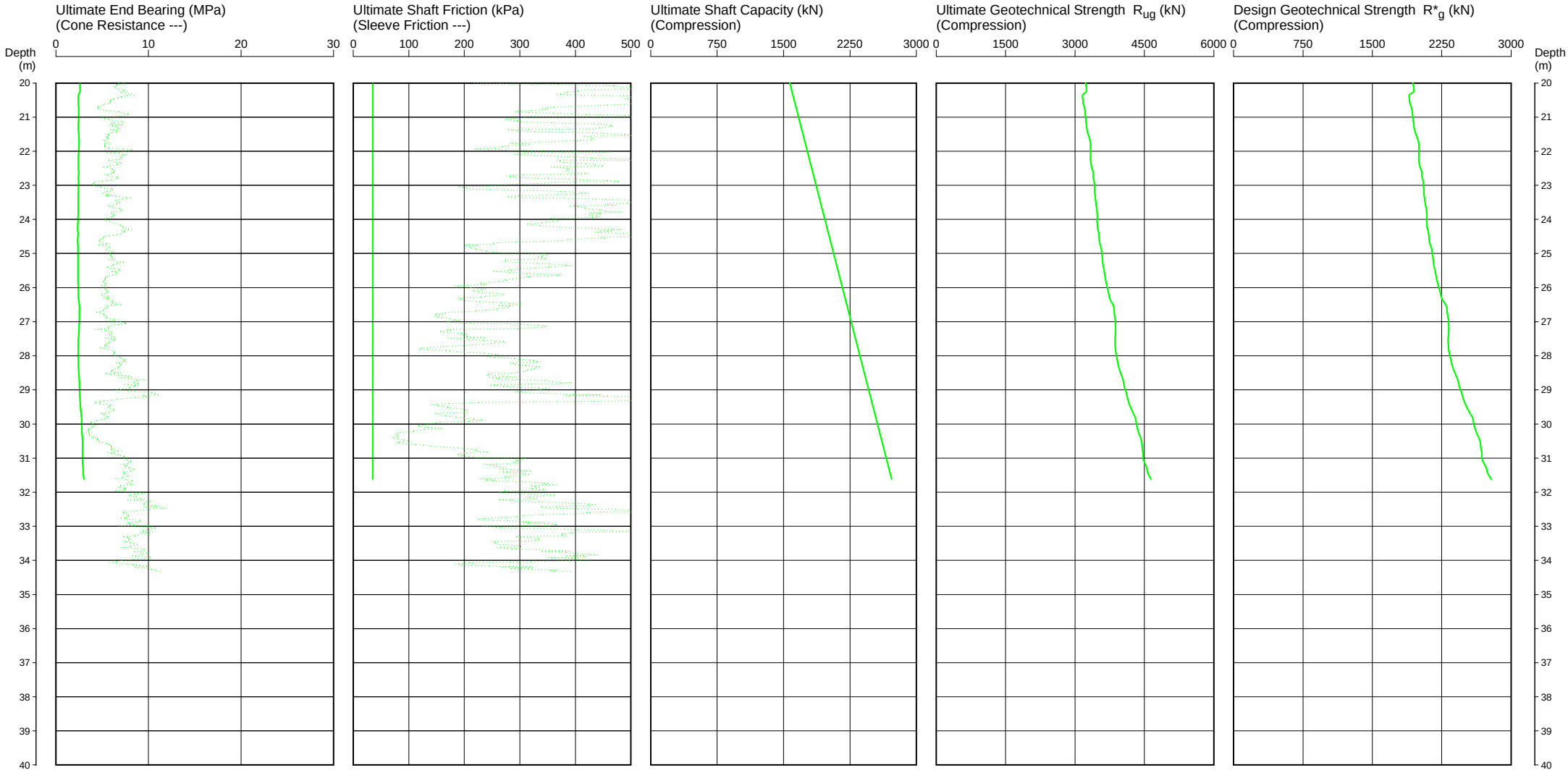
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**306**


**DATE** 7/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.5

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

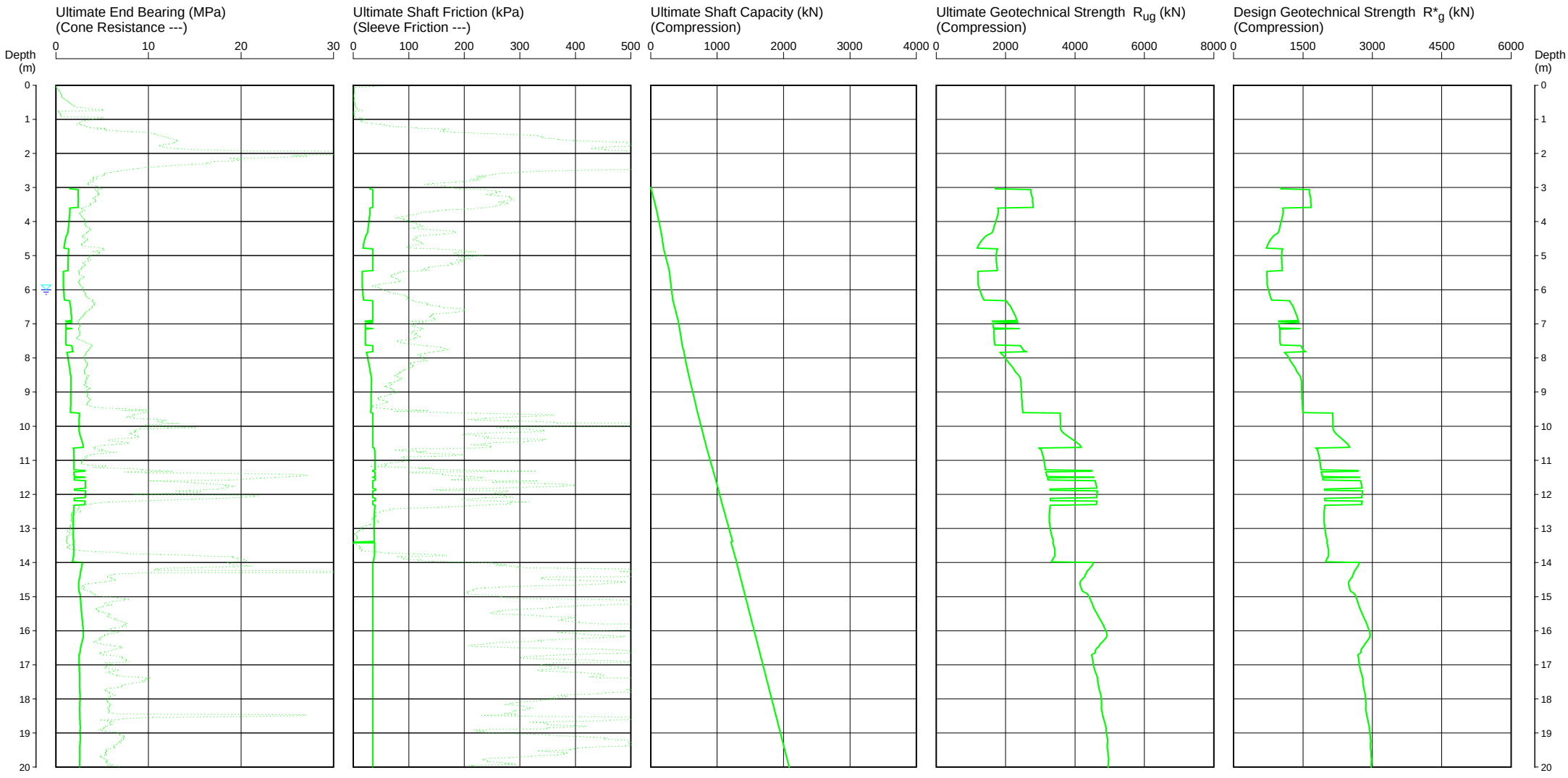
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**306**


**DATE** 7/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.5

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

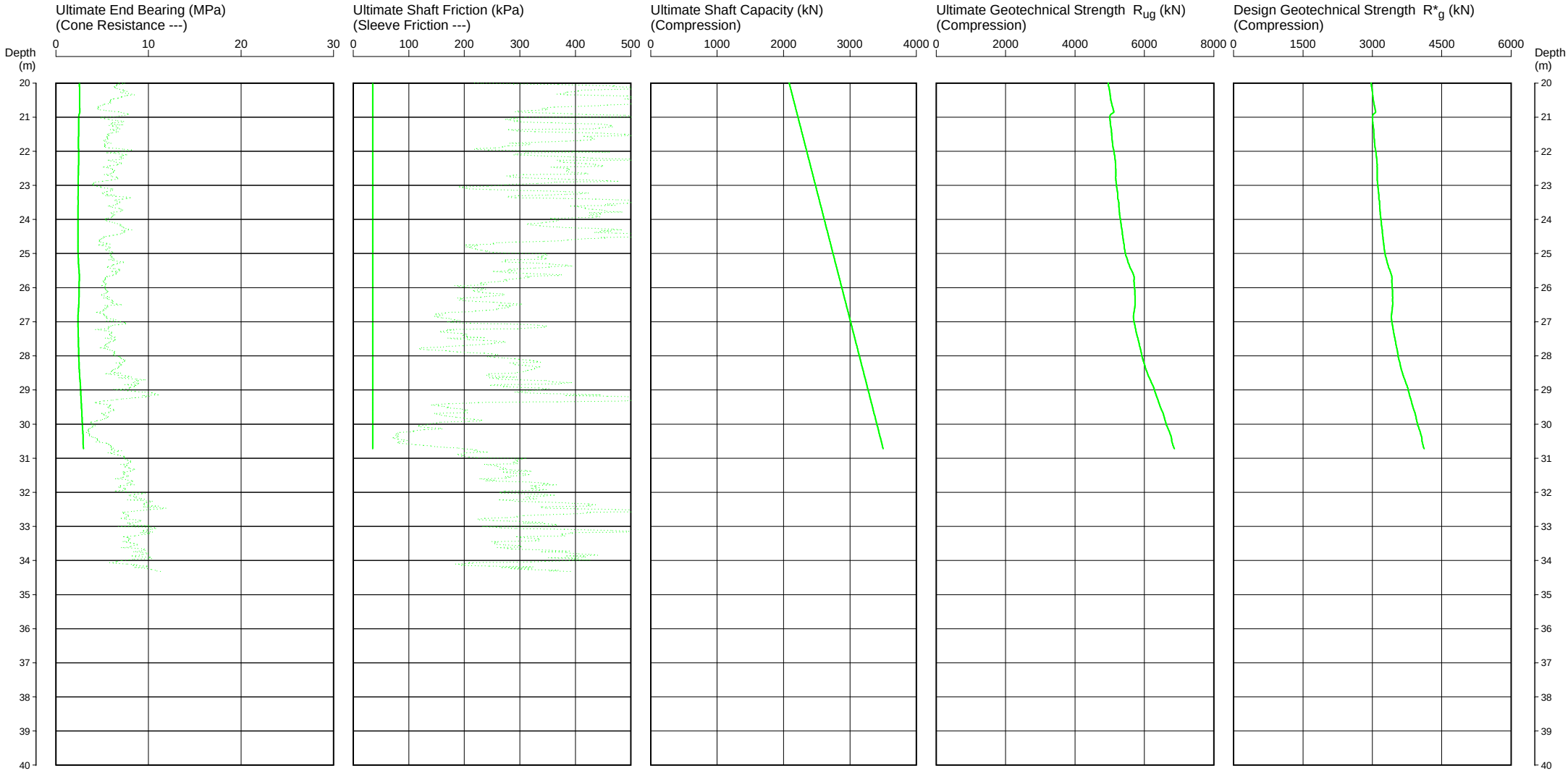
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**306**


**DATE** 7/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.5

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320306.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 0.90
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

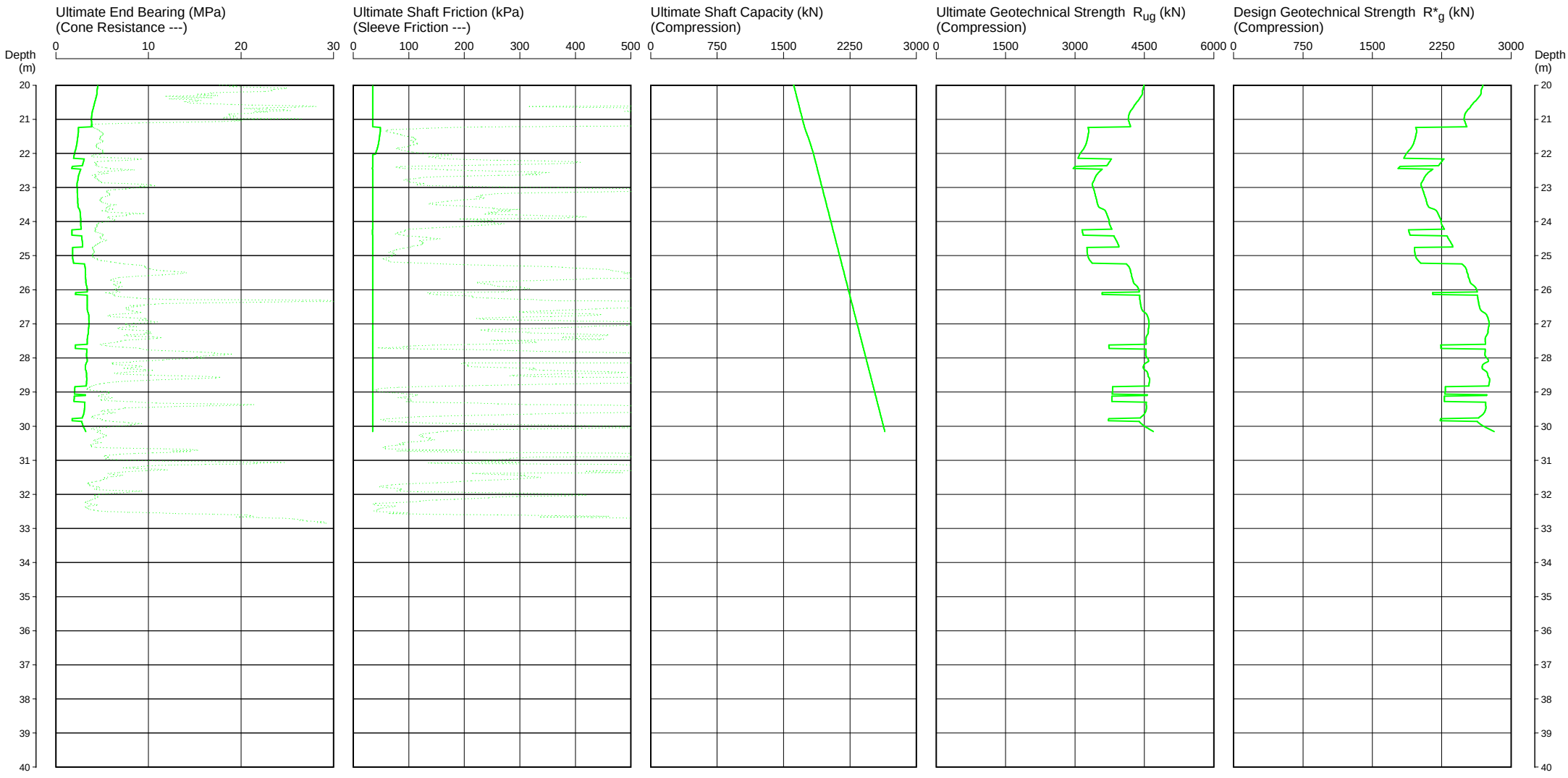
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**307**


**DATE** 9/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.2

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

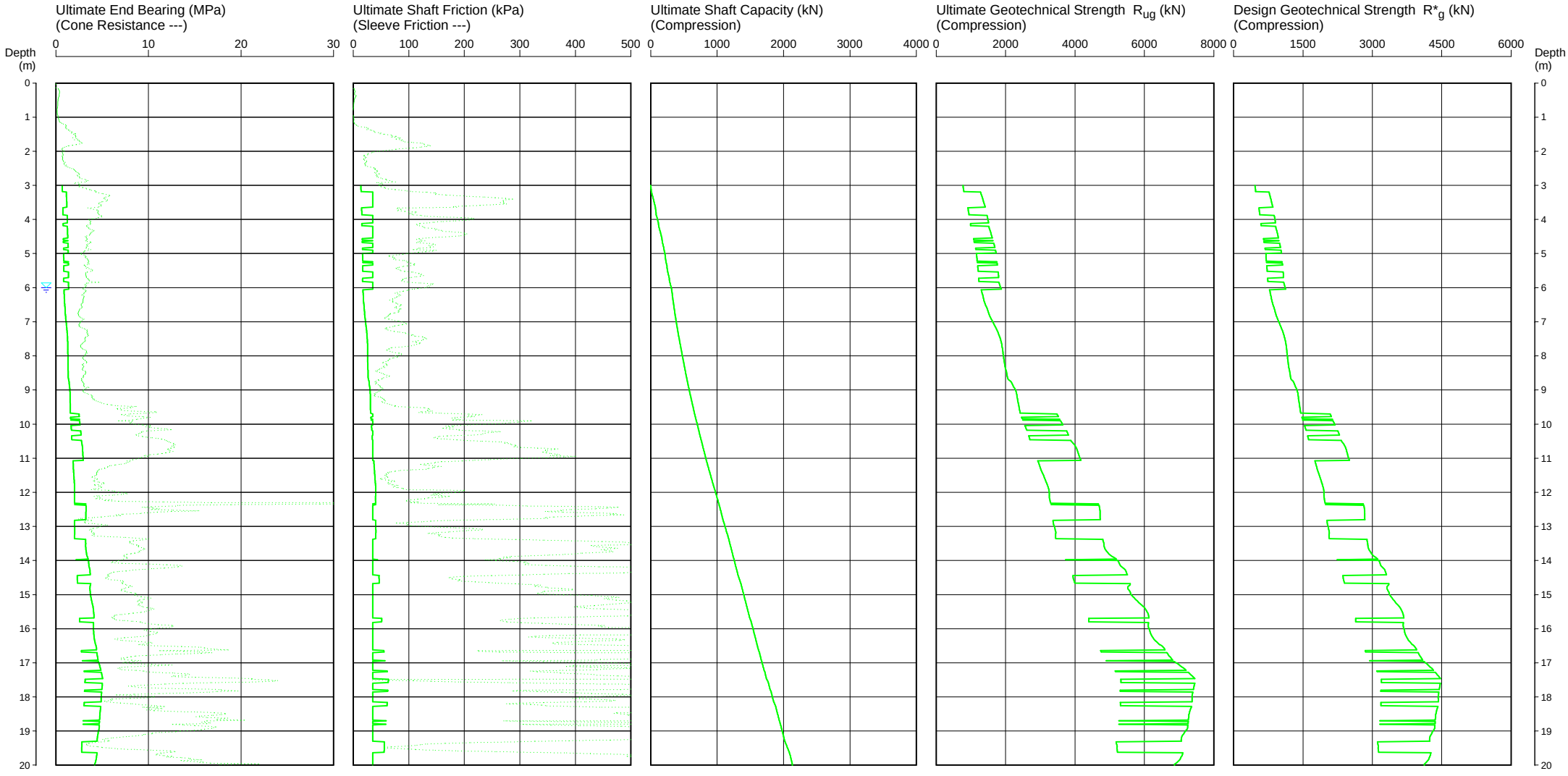
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**307**


**DATE** 9/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.2

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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# PILE CAPACITY ESTIMATE

**PILE TYPE:** Grout-Injected
**PILE SHAPE:** Round
**PILE SIZE:** Diameter = 1.20
**STRENGTH REDUCTION FACTOR $Ø_g$:** 0.60
**CALCULATION METHOD:** Douglas Method

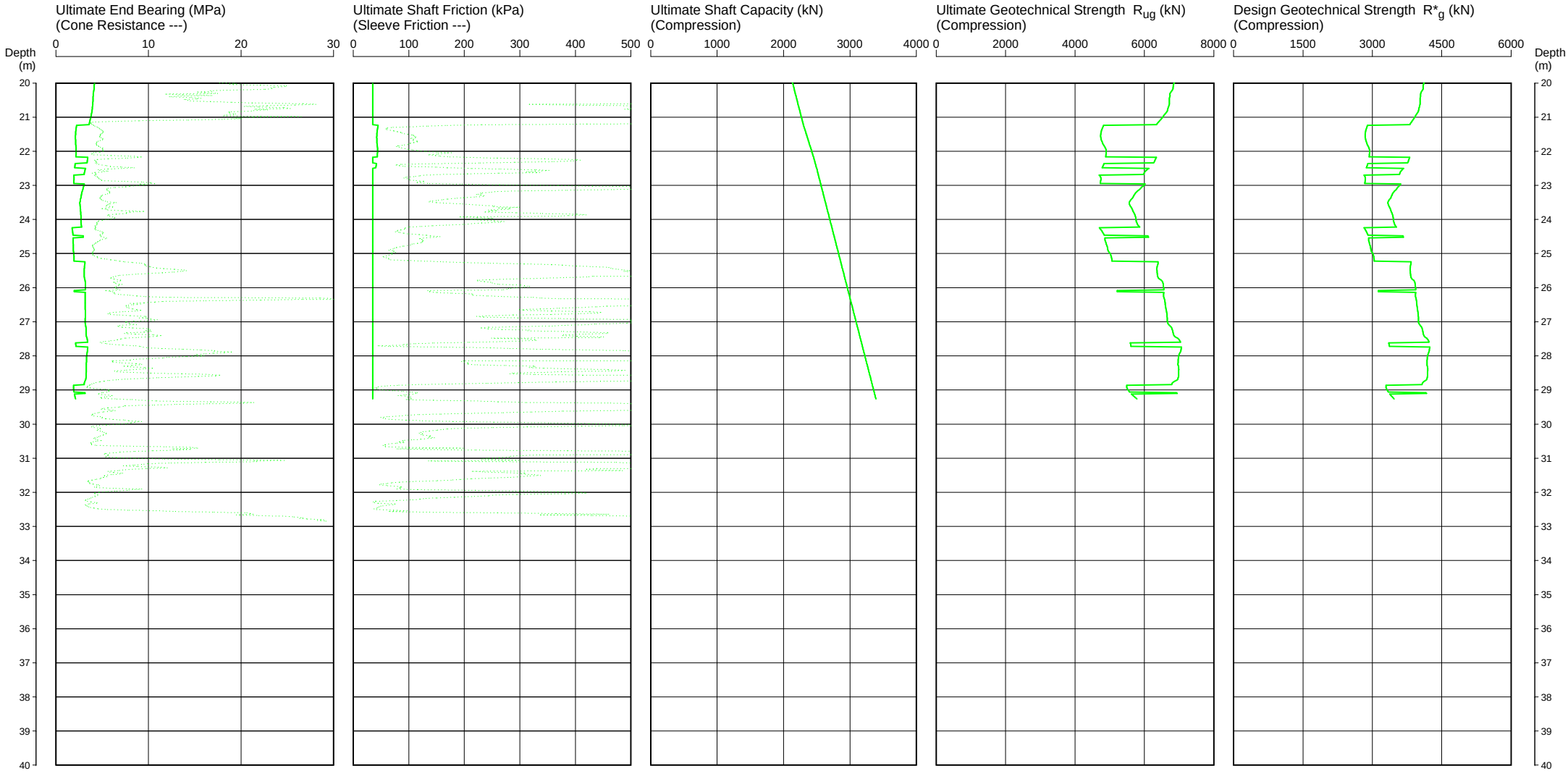
**PROJECT:** WAGGA WAGGA BASE HOSPITAL REDEVELOPMENT, STAGE 2

**LOCATION:** EDWARD STREET, WAGGA WAGGA

**CLIENT:** HEALTH INFRASTRUCTURE

**307**


**DATE** 9/11/2012
**PROJECT No:** 72320.06
**SURFACE RL:** 182.2

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**Water depth after test: 6.00m depth**

**File:** P:\72320.06 WAGGA WAGGA, Base Hospital Supplementary Geotech PMO\Field\72320307.CP5
**Cone ID:** CONE-H4 **Type:** 2 Standard

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