Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Preliminary Geotechnical Investigation

Proposed Hotel Precinct
Royal Randwick Racecourse
Alison Road, Randwick

Prepared for
Australian Turf Club Ltd

Project 72973.04
May 2012

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Reviewer	BMcPherson.	16-5-12

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Executive Summary

Douglas Partners Pty Ltd (DP) was commissioned by the Australian Turf Club Ltd to carry out a preliminary geotechnical investigation for a proposed hotel precinct at the Royal Randwick Racecourse. The purpose of this preliminary geotechnical investigation was to identify the geotechnical issues for the development and to provide comments and parameters to allow preliminary design to proceed.

The proposed development involves the construction of an eight-storey building with a partial basement level. The basement will have a final floor level of RL 30.5 m and will require bulk excavation to depths of approximately 1 - 1.5 m. Localised lift pits will require excavation to RL 29.0 m, a further 1.5 m depth below the basement level. Subgrade preparation may also be required to similar depths below the basement.

The preliminary investigation included eight cone penetration tests which were taken to practical refusal at depths of between 3.3 m and 9.8 m. The practical refusal depths indicate the inferred top of weathered rock. The CPTs generally encountered filling up to 0.9 m depth, and then sand of variable density and a thin layer of residual clay overlying rock.

The groundwater level at the time of the investigation was measured at a depth of 3.9 m (RL 27.7 m) in CPT106. Historical data in this area indicates that long term fluctuations in groundwater levels of at least 1 m can occur.

The groundwater table is presently about 2.5 m below the depth of the proposed basement level and approximately 1 m below the lift pits, and therefore the development should not affect the regional groundwater table.

Excavations will be carried out through mostly filling and natural sands. All excavated materials will need to be disposed of in accordance with the provisions of the current legislation and guidelines including the Waste Classification Guidelines (DECC, April 2008; updated 2009). DP will be undertaking a Preliminary Waste Classification Assessment in conjunction with a Phase 2 Contamination Assessment for the hotel precinct.

Bulk excavation for the basement is expected to expose very loose and loose sands and therefore poor trafficability conditions are anticipated. The use of a layer of crushed rock or concrete of at least 300 mm thickness in conjunction with some initial heavy rolling may be required to improve trafficability for concrete trucks and other vehicles. Further analysis would be required to assess the required thickness of a working platform for piling rigs and outrigger cranes following receipt of specific loading conditions.

Dilapidation (building condition) reports should be undertaken, and as a minimum for the adjacent heritage wall to the north.

For excavation support, temporary batter slopes above the groundwater table should not exceed 1.5 Horizontal (H):1 Vertical (V) within the sandy soils, provided that no adjacent structure is founded above a 3:1 (H:V) imaginary line drawn up from the base of the excavation. Where space constraints prevent safe batter slopes, permanent support or temporary shoring could include contiguous piled walls or Geocast walls, or Soil-Mixed walls, such as the Cutter-Soil-Mix (CSM) technique.

The building loads could be supported on foundations of either cased bored piles, bored piles drilled with the use of a drilling fluid, or Continuous Flight Auger (CFA) concrete or grout-injected piles. All piled foundations should be founded uniformly in the underlying sandstone bedrock. A raft slab foundation system may also be considered to support the building at a higher level, although this would be highly dependent on the anticipated loads and the settlement tolerance of the structure. In order to provide suitable and more consistent bearing strata for this option, it would be necessary to remove and recompact at least 1 m depth below the basement level. The close proximity of the underlying water table could present issues for the earthworks associated with a raft slab option. Furthermore, the variable depth to rock below the raft slab could possibly give rise to significant differential settlement of the raft slab.

It is noted that at the time of this report, further geotechnical investigation including rock cored boreholes and groundwater monitoring is planned to provide more accurate geotechnical parameters for foundation and shoring design.

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Report on Preliminary Geotechnical Investigation
Proposed Hotel Precinct
Royal Randwick Racecourse, Alison Road, Randwick

1. Introduction

This report presents the results of a preliminary geotechnical investigation carried out for a proposed hotel precinct at Royal Randwick Racecourse, Alison Road, Randwick. The work was commissioned by Australian Turf Club Ltd.

The proposed development involves the construction of an eight-storey building with a partial basement level at RL 30.5 m. It is anticipated that the basement will require bulk excavation to depths of approximately 1 - 1.5 m below current surface levels. Investigation was carried out to provide information on the subsurface conditions for preliminary planning and submission with a development application (DA) to Randwick City Council.

The field work comprised eight cone penetration tests (CPTs) to assess the soil strength and infer the depth to bedrock. Details of the field work are provided in this report together with preliminary comments relating to design and construction practice.

A more detailed investigation including rock cored boreholes, installation of groundwater monitoring wells, and assessment of the founding conditions of the heritage wall along the front of the Racecourse will be undertaken by DP in the coming weeks, followed by an updated geotechnical report.

A separate Phase 1 Contamination Assessment has also been prepared by DP for the DA submission.

2. Site Description

The proposed hotel site occupies a roughly triangular shaped area located at the north-western corner of Royal Randwick Racecourse and has a 177 m northern frontage to Alison Road. The ground surface level undulates across the site between approximately RL 31.1 m and RL 32.1 m relative to Australian Height Datum (AHD).

At the time of the investigation, the southern portion of the site was predominantly occupied by marquees, with the remaining area either covered with grass or asphaltic concrete (AC) pavements. Some mature trees were present along the northern boundary and towards the western end of the site. A heritage brick wall approximately 3.4 m to 3.8 m high extends along part of the northern boundary, along the Alison Road frontage. The existing Members Grandstand is located to the west of the proposed hotel site and the race track extends along the southern boundary.

3. Geology

Reference to the Sydney 1:100,000 Geological Series Sheet indicates that the site is underlain by fine to medium grained 'marine' quartz sand overlying Hawkesbury Sandstone, which typically comprises medium to coarse grained quartz sandstone with minor shale and laminite lenses. The investigation on the site confirmed the presence of sandy soils overlying inferred bedrock.

4. Field Work Methods

The field work included eight cone penetration tests (CPT 101, 101A, 101B and 102 to 106 inclusive) which were taken to practical refusal at depths of between 3.3 m and 9.8 m. Following completion of testing, the CPT holes were 'dipped' with a measuring tape to measure the depth of the water table. The tests were generally located in areas accessible to the CPT truck at the time of the investigation and are shown on Drawing 1 in Appendix B.

Cone penetration testing (CPT) involves a ballasted truck-mounted test rig pushing a 35 mm diameter instrumented cone tipped probe into the soil using a hydraulic ram system. Continuous measurements are made of the end-bearing pressure on the cone tip and the friction on a 135 mm long sleeve located immediately behind the cone. The cone resistance (q_c) and friction (f_s) readings are displayed on a digital monitor and stored on computer for subsequent plotting of results and interpretation.

The ground surface levels at the test locations were interpolated from the spot levels shown on a survey plan by Rygate & Company Pty Ltd (Ref: 75363, dated 9 May 2012) and are understood to be relative to AHD.

5. Field Work Results

The results of the CPTs are included in Appendix A, together with Notes describing the test method and interpretation of CPT results. The inferred soil stratification based on the measured friction ratios (R_f) is given on each test report sheet, together with the interpreted density/consistency of the soil based on the measured cone resistance (q_c).

The general sequence of subsurface materials inferred from the CPTs, in increasing depth order, is summarised as follows:

FILLING:	Moderately to well compacted roadbase in CPT101, 101A, 101B and 104 extending up to 0.3 m depth. Variably poorly, moderately and moderately to well compacted filling in CPT102, 103, 105 and 106 extending up to 0.9 m depth.
SAND:	The underlying sand was typically loose to medium dense to depths of between 2 m and 3.5 m and then variably medium dense, dense and very dense to depths of between 3.2 m to 8.7 m depth, being deepest at the western-most (CPT105) and southern-most (CPT106) investigation points. Very loose and loose sand was encountered in CPT106 to 2.6 m depth.

CLAY:	A 0.5 m to 1.0 m thick layer of hard residual clay and sandy clay was encountered at depths of 8.7 m and 8.3 m in CPT105 and 106, respectively;
WEATHERED: ROCK	The CPTs encountered refusal on inferred weathered rock at depths ranging from 3.2 m (RL28.2 m) at CPT103 to 9.7 m (RL21.7 m) at CPT105.

It should be noted that CPT refusal can also occur on very dense cemented sands and therefore rock cored boreholes will generally be required (as planned) to confirm the depth to rock.

The groundwater level in CPT106 was measured at a depth of 3.9 m (RL 27.7 m) on completion. The holes collapsed in the remaining CPTs at depths of between 3.2 m and 3.9 m (RL 28.2 m to RL 27.5 m), with the exception of CPTs 101/A/B, which collapsed at depths of between 0.8 m to 1.1 m. The depth of hole collapse in CPT holes often occurs at or slightly above the water table, when the CPT rods are withdrawn.

6. Geotechnical Model

Two interpreted geotechnical cross-sections (Section A-A' and Section B-B') showing the interpreted subsurface profile between selected test locations are presented in Drawings 2 and 3 in Appendix B. The cross-sections show the interpreted geotechnical divisions of underlying soil and rock together with the extent of the proposed new basement excavation.

The subsurface profile consists of sand of variable density overlying Hawkesbury Sandstone. The sandstone surface dips down towards the south-west from depths of approximately 3.2 m (RL28.2 m) to 9.7 m (RL21.7 m). As shown on Drawings 2 and 3, it is possible that the rock surface will step down in a series of near-vertical benches or buried cliffs, typically about 1 m to 2 m high. For example, the interpreted top of rock surface varied by about one metre between closely spaced tests CPT101B and CPTs 101 and 101A. Further detailed investigation involving rock cored boreholes are planned to be carried out to confirm the depth and strength of the rock across the site.

The groundwater level at the time of the investigation was measured at a depth of 3.9 m (RL 27.7 m) in CPT106. This water level is relatively consistent with groundwater monitoring recently being undertaken by DP on the nearby Spectator Precinct, which is south-west of the Hotel Precinct. Near-high water levels at the Spectator Precinct fall to the south-west from approximately RL 27.6 m to about RL 26.0 m. Short term fluctuations/rises of up to 0.7 m have been measured at the Spectator Precinct after periods of heavy rainfall. Historical data in this area indicates that long term fluctuations in groundwater levels of at least 1 m can occur.

Further groundwater monitoring is planned to confirm the level of the water table at this site to assess the potential influence it may have on the construction of the basement for the Hotel Precinct.

7. Comments

7.1 Proposed Development

Based on architectural drawings by Tonkin Zulaikha Greer Architects Pty Ltd (dated May 2012), it is understood that the proposed development involves the construction of an eight-storey building (plus roof level) with a partial basement level. The basement will have a final floor level of RL 30.5 m and will require bulk excavation to depths of approximately 1 - 1.5 m. Localised lift pits will require excavation to RL 29.0 m, a further 1.5 m depth below the basement level.

It is understood from Brown Consulting (NSW) Pty Ltd that the maximum estimated column working loads are in the order of 7000 kN.

7.2 Site Preparation and Earthworks

Excavations will be carried out through mostly filling and natural sands which should be readily removed using conventional earthmoving equipment such as tracked hydraulic excavators.

The groundwater table measured during the investigation was approximately 2.5 m below the depth of the proposed basement level and approximately 1 m below the lift pits. The groundwater table may fluctuate/rise to shallower levels over time.

Bulk excavation for the basement is expected to expose very loose and loose sands and therefore poor trafficability conditions are anticipated. The use of a layer of crushed rock or concrete of at least 300 mm thickness in conjunction with some initial heavy rolling may be required to improve trafficability for concrete trucks and other vehicles. For support of tracked piling rigs and outriggers for mobile cranes, thicker working platforms comprising compacted crushed rockfill are likely to be required. Where appropriate, rockfill platforms or running surfaces may be incorporated to the subgrade for the design of the basement floor slab.

All excavated materials will need to be disposed of in accordance with the provisions of the current legislation and guidelines including the Waste Classification Guidelines (DECC, April 2008; updated 2009). This includes filling and natural materials that may be removed from site. DP will be undertaking a Preliminary Waste Classification Assessment in conjunction with a Phase 2 Contamination Assessment.

7.3 Dilapidation Surveys

Dilapidation (building condition) reports should be undertaken on surrounding structures prior to commencing work on the site to document any existing defects so that any claims for damage due to construction related activities can be accurately assessed. As a minimum this should include the adjacent heritage wall to the north.

7.4 Excavation and Retaining Walls

7.4.1 Temporary Batter Slopes

During the bulk excavation phase, it is recommended that temporary batter slopes above the groundwater table do not exceed 1.5 Horizontal (H):1 Vertical (V) within the sandy soils, provided that no adjacent structure is founded above a 3:1 (H:V) imaginary line drawn up from the base of the excavation. Although temporary batter slopes may be possible along some sections of the eastern and western sides of the basement, the extent of batter slopes on this site may be limited due to the relatively close proximity of the basement excavation to the existing heritage wall (setback up to 6 m) to the north and the course proper (setback 2 m to 3 m) to the south.

Where there is potential for groundwater to rise into the excavation (possibly in areas where rock is at shallow depths or within deeper lift pits), batter slopes should not exceed 2.5H:1V.

7.4.2 Suitable Retaining Wall Systems

In areas where the proximity of the excavation does not allow safe batter slopes to be formed, a contiguous pile wall comprising closely spaced Continuous Flight Auger (CFA), grout or concrete-injected piles, is one option to form a shoring system. A contiguous pile wall may be considered where there are no adjacent buildings or structures within a distance equal to the height of the excavation from the shoring wall. Such walls require the progressive ‘plugging’ during excavation of the gaps between the piles. The piles could also support vertical loads and can generally form part of the basement structure.

Sheet piles may not be suitable for this site due to noise and risks associated with vibrations during installation. The use of sheet piles would largely depend on the depth of footings and founding conditions for adjacent structures (i.e. founded on deep piled footings in rock or shallow footings in loose sandy soils). Sheet piles are also likely to refuse on low strength rock which is expected at relatively shallow depths at the northern and eastern ends of the basement footprint.

Another shoring/support system that may be appropriate for relatively minor excavations that are predominantly above the water table, is the Geocast retaining wall system. This system is a light-duty diaphragm wall that involves continuously digging a 300 mm wide trench and simultaneously casting a steel-reinforced concrete wall in a series of panels. Geocast walls can be readily incorporated to the final basement structure.

Soil mixed wall systems, such as the Cutter-Soil-Mix (CSM) technique, may also be considered as an alternative to the more conventional contiguous pile wall. These walls are constructed using specialised equipment to blend cement or other additives with the in-situ soils to create a soil-cement mix. Universal Column sections are usually installed into the wet soil-cement mix at regular intervals along the wall to provide additional stiffness and to act as load-bearing columns. There are several different systems available and further advice should be obtained from the specialist piling contractor regarding the suitability of the wall system to this site. In particular, confirmation should be sought in relation to the consistency/strength of the soil mixed wall and its long term durability.

A secant pile wall comprising interlocking CFA piles are typically used where basement excavations extend below the groundwater in sandy soils. As the water table is expected to be below the basement level, a secant pile wall is not necessarily expected for this site, other than for localised deeper excavations (e.g. lift pits).

7.4.3 Retaining Wall Design

In some areas, vertical excavations within the sand are likely to require retaining structures, both during construction and as part of the final structure.

It is suggested that the design of cantilevered shoring systems are based on an average unit weight of 20 kN/m^3 for the retained soil, with a triangular earth pressure distribution calculated using an ‘active’ earth pressure coefficient (k_a) value of 0.35 where some wall movement is acceptable. An ‘at-rest’ earth pressure coefficient (k_o) value of 0.5 should be used where wall movement needs to be limited, such as where there are adjacent structures. Cantilevered pile walls should not be used where there are adjacent structures which are sensitive to movement.

A coefficient of passive earth pressure (K_p) equal to 3.0 may be assumed within at least loose sand below the bulk excavation level, to which a factor of safety must be applied in recognition of the significant wall movement needed to mobilise full passive pressure. The top of the passive pressure distribution must be deemed to be below the base of any nearby disturbance (such as detailed excavation for lift pits and services etc). For sockets in rock, an ultimate passive pressure of 1000 kPa in low strength rock and 4000 kPa in medium strength rock may be adopted (rock strengths to be confirmed by detailed investigation/cored boreholes).

The pressure distribution given above does not include hydrostatic pressure due to groundwater behind retaining walls. It is expected that the groundwater level will be below the bulk excavation level. It is noted that the groundwater level will be confirmed within groundwater monitoring wells which have been recently installed at the site.

In design of the retaining walls, due allowance should be made for surcharge loads including adjacent footings and plant operating above the excavation during construction.

7.5 Foundations

Due to the relatively shallow depth to rock expected below the north-west and north-east sides of the building, and the high column loads, it is recommended that the building be should be uniformly supported on the underlying rock. Based on DP’s experience in the area, it is expected that the rock profile will comprise a relatively thin layer of weathered rock over competent medium to high strength sandstone (subject to confirmation by rock cored boreholes).

With respect to suitable pile types, bored (uncased) ‘piers’ are not considered to be appropriate for this site due to the sandy soils and relatively shallow water table present. Cased bored piles or bored piles drilled with the use of a drilling fluid could, however, be considered but would generally require bentonite (or polymer mud) support and proper tremie pour methods of concrete placement under a head of fluid (e.g. water/mud).

Driven precast concrete piles are also unlikely to be suitable for this site due to noise and vibrations induced during installation of such piles and the potential for adverse impact on nearby vibration sensitive structures, such as the heritage wall.

Continuous Flight Auger (CFA), grout or concrete-injected piles socketed into sandstone would be suitable for this site.

For the preliminary design of rock-socket CFA or (cased) bored piles, recommended maximum allowable pressures and modulus values for two possible foundation materials which are expected at the site are presented in Table 1. These parameters (and possibly higher parameters) will be confirmed by rock core drilling and point-load strength testing.

Table 1 – Recommended Preliminary Design Parameters and Moduli for Foundation Design

Rock Description	Limit State Condition		Working Stress Condition		Field Elastic Modulus (MPa)
	Ultimate End Bearing (kPa)	Ultimate Shaft Adhesion(1)(2) (kPa)	Allowable End Bearing (kPa)	Allowable Shaft Adhesion(1)(2) (kPa)	
Low to Medium Strength	8000	600	2000	150	300
Medium Strength or stronger	20000	800	3500	300	500

Notes:
1. Shaft adhesion applicable for the design of bored piers, uncased over rock socket length, where adequate sidewall cleanliness and roughness is achieved.
2. Reduce by 30% for uplift loads and ensure 'cone pull-out' failure mechanism is checked.

Piled foundations proportioned on the basis of the above Serviceability parameters alone would be expected to experience total settlements of less than 1% of the pile diameter under the applied Working (i.e. Serviceability) Load, with differential settlements between adjacent columns expected to be less than half of this value.

A raft slab foundation system founded on at least medium dense sand may also be considered to support the building, although this would be highly dependent on the anticipated loads and the settlement tolerance of the structure. At some locations, very loose to loose sand extends approximately 1 - 2 m below the proposed basement level. In order to provide suitable and more consistent bearing strata for this option, it would be necessary to remove and recompact at least 1 m depth below the basement level. The close proximity of the underlying water table could present issues for the earthworks associated with a raft slab option. Furthermore, the variable depth to rock below the raft slab could possibly give rise to significant differential settlement of the raft slab.

Preliminary design of a raft slab could be based on a modulus of subgrade reaction of 3 - 5 kPa/mm. It is noted that the modulus of subgrade reaction is dependent on the size of the area subject to loading and founding conditions. The above recommended modulus of subgrade reaction is based on a slab section of 10 m x 10 m (100 m^2) in area, founded on a 1 m thick layer of engineered sand filling overlying at least loose to medium dense sand and supporting a uniform pressure of 50 kPa.

Alternatively, preliminary design could be based on a maximum allowable bearing pressure of 200 kPa and an average elastic modulus (E) of 15 MPa.

7.6 Groundwater

As the proposed basement level (RL 30.5 m) and lift pits (RL 29.0 m) are likely to be above the water table, it is unlikely that dewatering will be required for their construction. Furthermore, the building may be founded on piled foundations which intersect the water table, although piled foundations are typically spaced approximately 8 m apart. Therefore, it is considered that the proposed development would not affect the depth or flow path of the regional groundwater table.

8. Further Investigation

The purpose of this preliminary geotechnical investigation was to provide information for DA and preliminary design. For detailed design, a comprehensive geotechnical investigation (including rock cored boreholes and groundwater monitoring) is planned to provide more accurate geotechnical parameters for foundation and shoring design.

9. Limitations

Douglas Partners (DP) has prepared this report for the proposed hotel precinct at Royal Randwick Racecourse, Alison Road, Randwick in accordance with the proposal dated 16 April 2012. This report is provided for the exclusive use of Australian Turf Club Ltd for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results provided in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. DP's advice is based on observations, measurements, tests or derived interpretations. The accuracy of the advice provided by DP in this report is limited by unobserved features and variations in ground conditions across the site in areas between test locations and beyond the site boundaries or by variations with time. The advice may be limited by restrictions in the sampling and testing which was able to be carried out, as well as by the amount of data that could be collected given the project and site constraints.

This report must be read in conjunction with the attached "About This Report" and any other attached explanatory 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, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report, or sections of this report, should not be used as part of a specification for a project without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report
Cone Penetration Test Results
Notes on Cone Penetration Testing

About this Report

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.

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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.

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

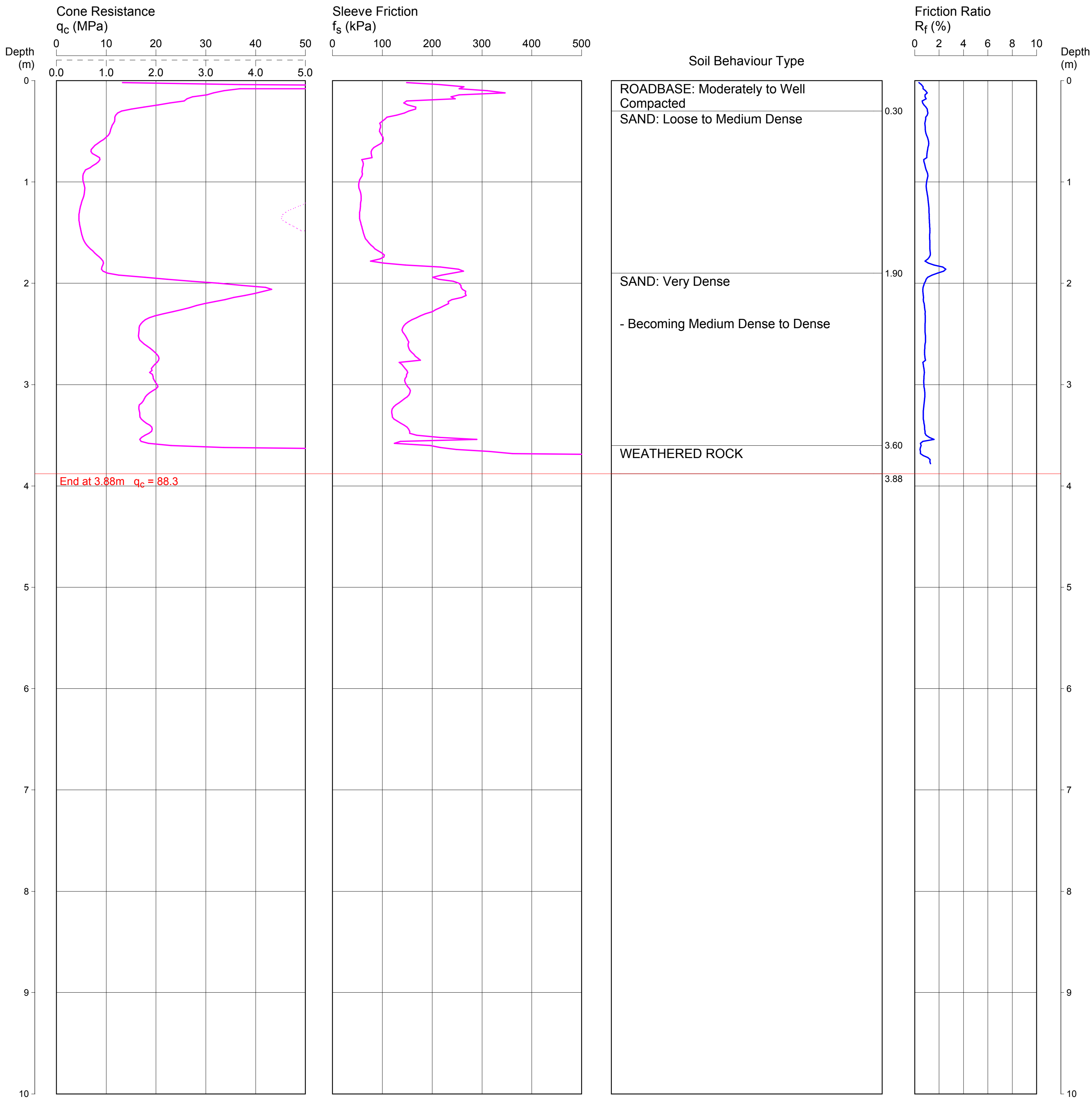
REDUCED LEVEL: 31.2 AHD

COORDINATES:

CPT 101

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: HOLE COLLAPSED AT 1.0 m AFTER WITHDRAWAL OF RODS

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Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

REDUCED LEVEL: 31.2 AHD

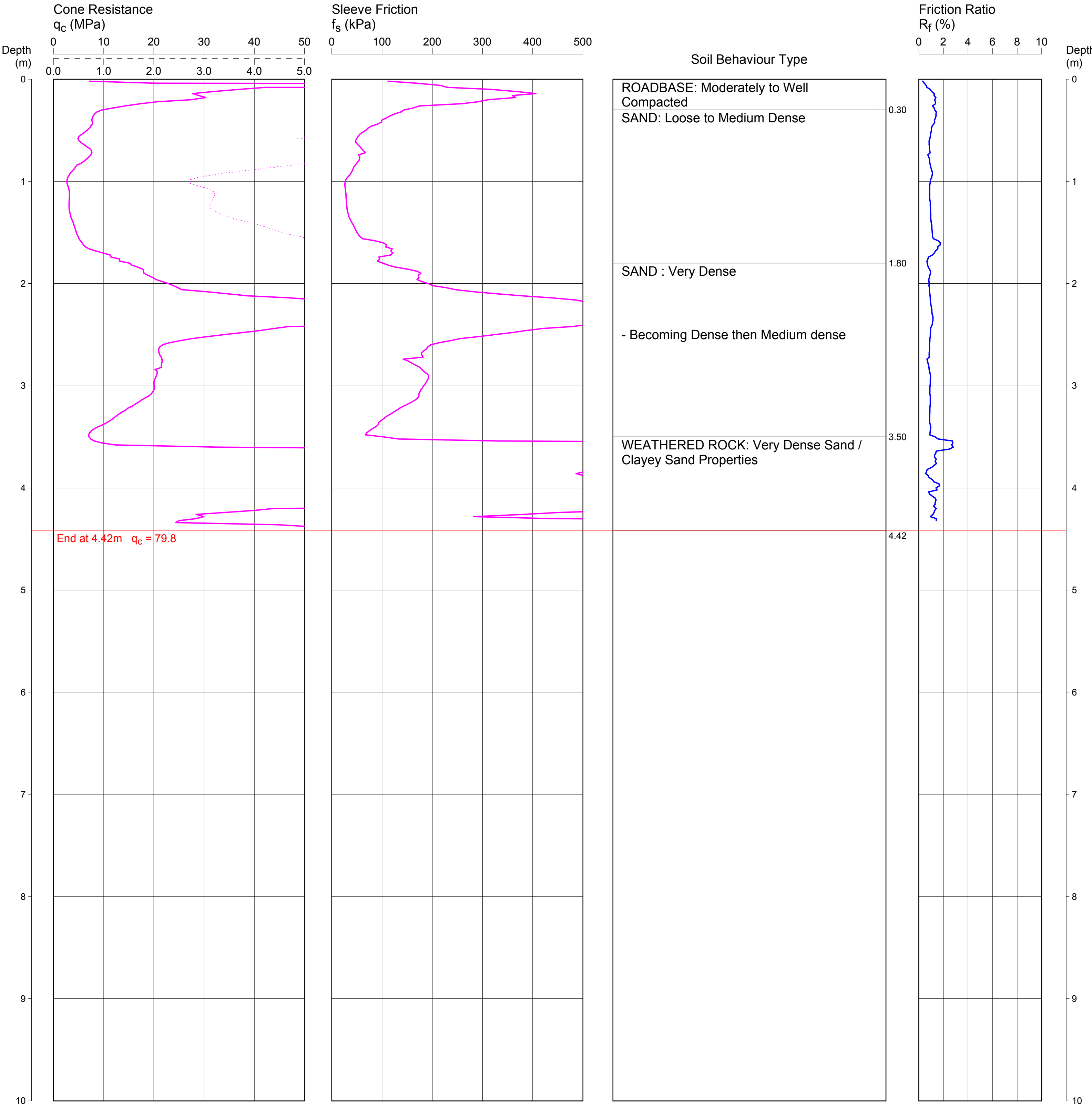
COORDINATES:

CPT 101A

Page 1 of 1

DATE 10/05/2012

PROJECT No: 72973.00



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Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

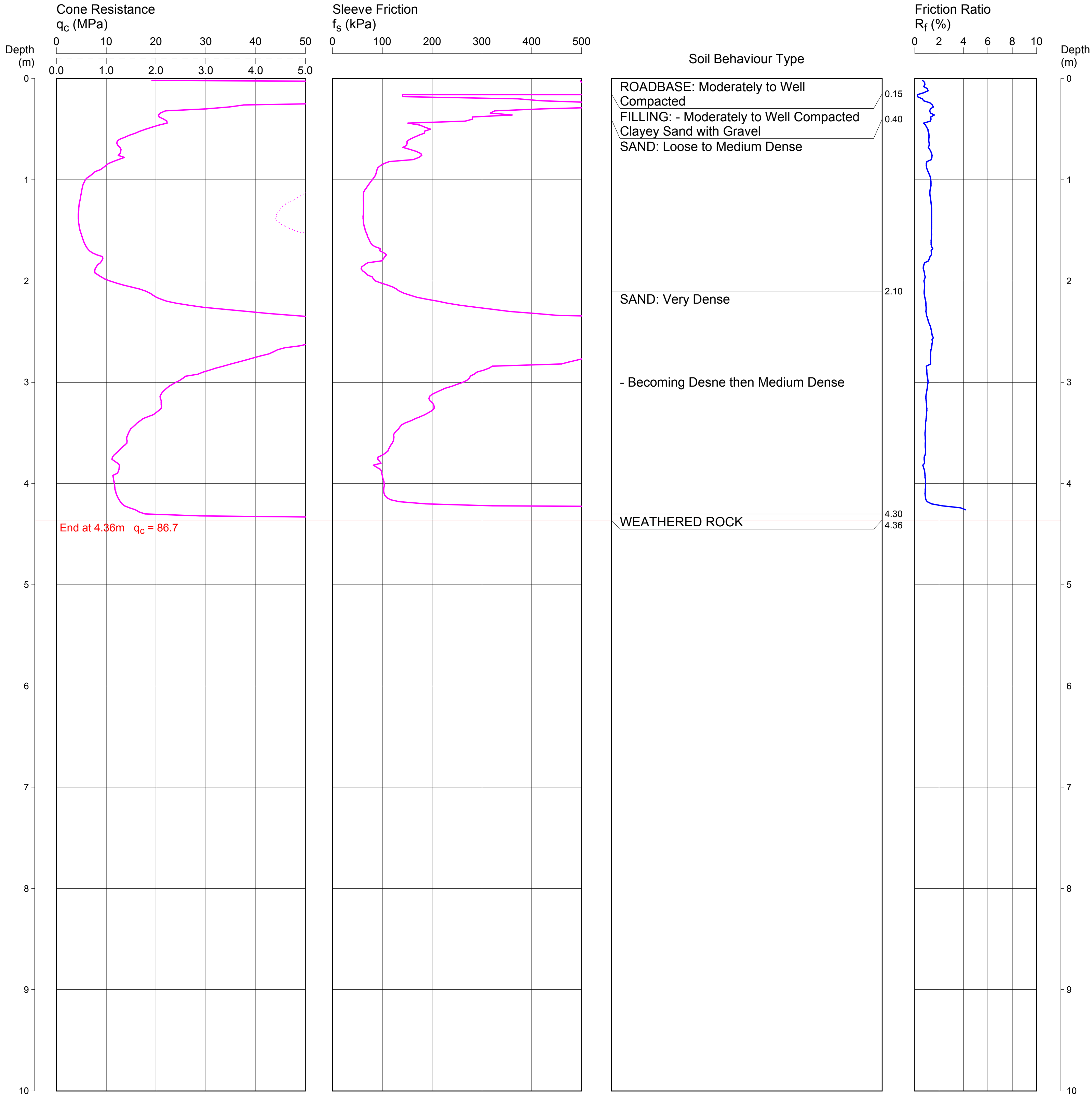
REDUCED LEVEL: 31.2 AHD

COORDINATES:

CPT 101B

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: HOLE COLLAPSED AT 0.8 m AFTER WITHDRAWAL OF RODS.

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Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

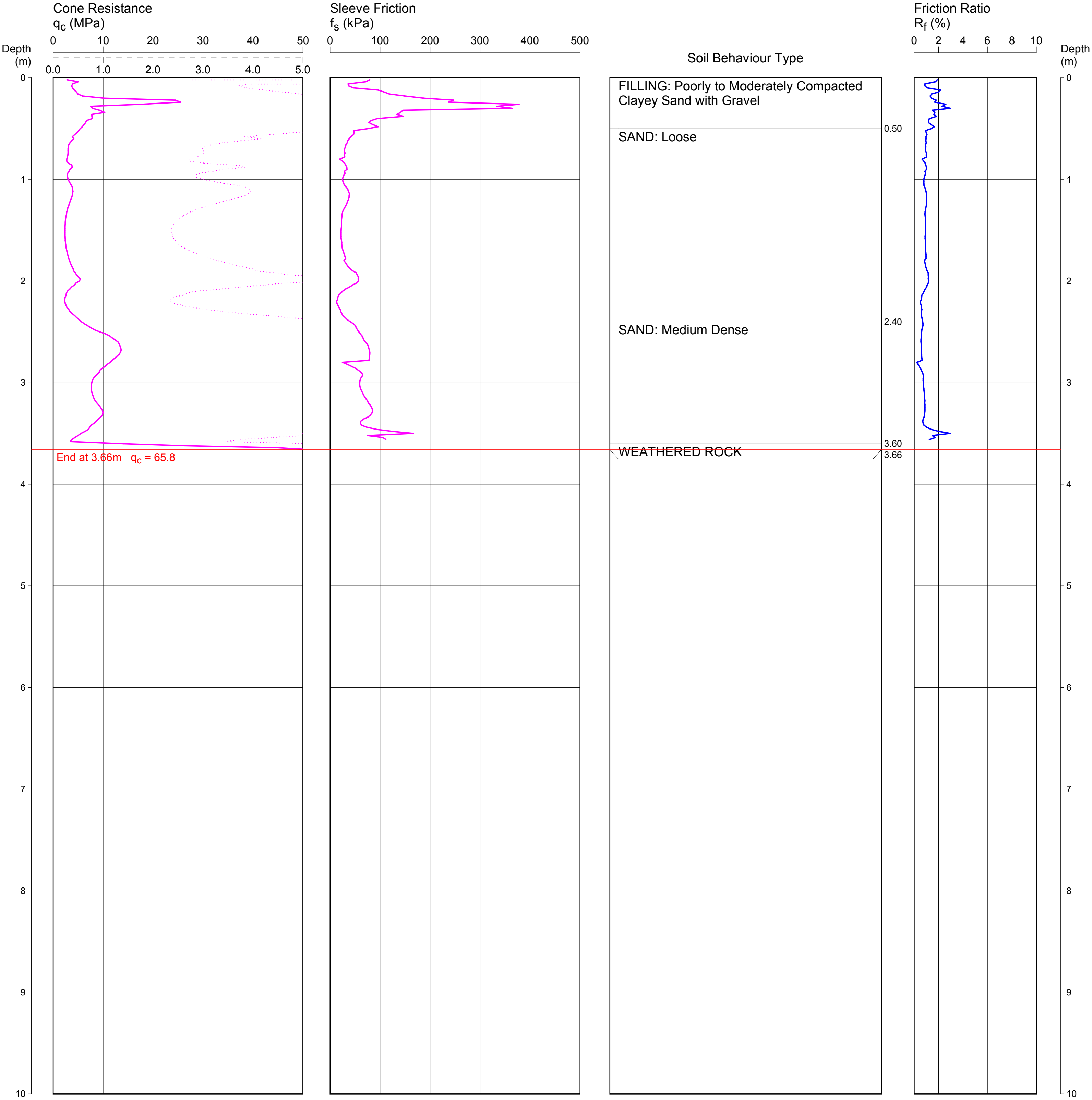
REDUCED LEVEL: 31.4 AHD

COORDINATES:

CPT 102

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: HOLE COLLAPSED AT 3.5 m AFTER WITHDRAWAL OF RODS.

File: P:\72973.04 RANDWICK RACECOURSE, Hotel Precinct, Geotechnical Desktop Study PAV\Field\72973-102.CP5
Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

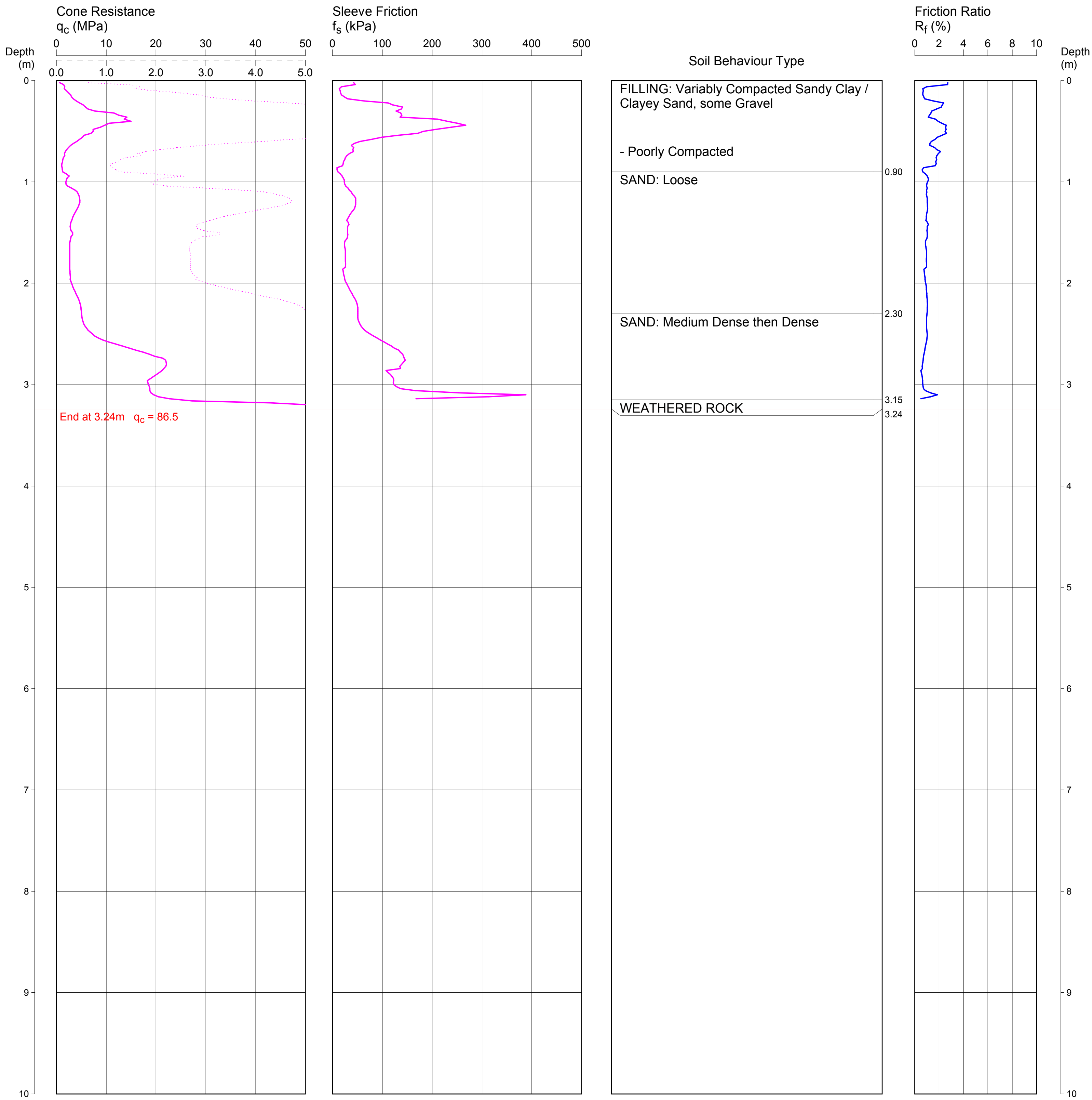
REDUCED LEVEL: 31.4 AHD

COORDINATES:

CPT 103

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: HOLE COLLAPSED AT 3.2 m AFTER WITHDRAWAL OF RODS.

File: P:\72973.04 RANDWICK RACECOURSE, Hotel Precinct, Geotechnical Desktop Study PAV\Field\72973-103.CP5
Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

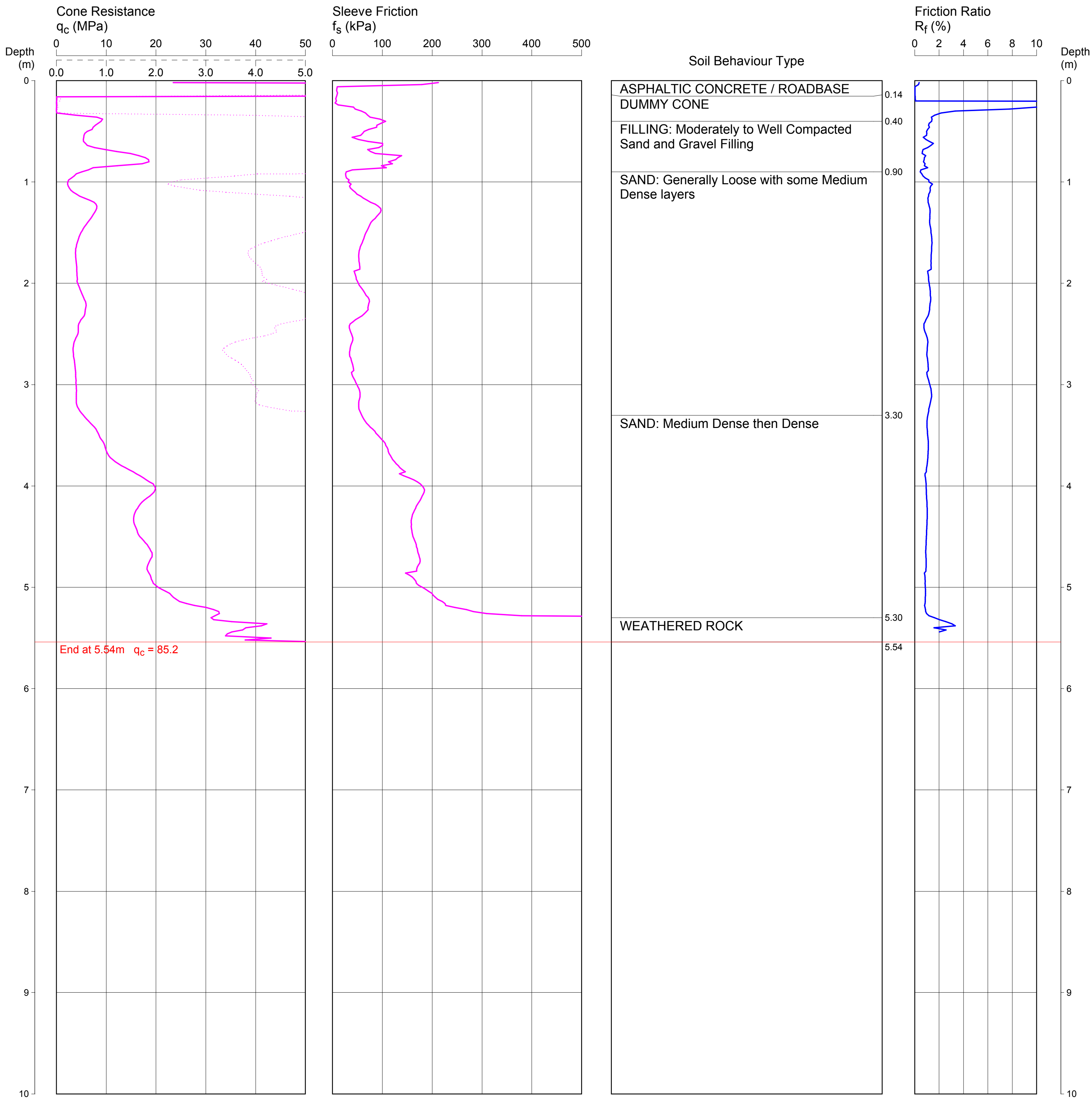
REDUCED LEVEL: 31.7 AHD

COORDINATES:

CPT 104

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: DUMMY CONE USED FROM 0.14 m TO 0.4 m DEPTH. HOLE COLLAPSED AT 3.6 m AFTER WITHDRAWAL OF RODS.

File: P:\72973.04 RANDWICK RACECOURSE, Hotel Precinct, Geotechnical Desktop Study PAV\Field\72973-104.CP5
Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

REDUCED LEVEL: 31.4 AHD

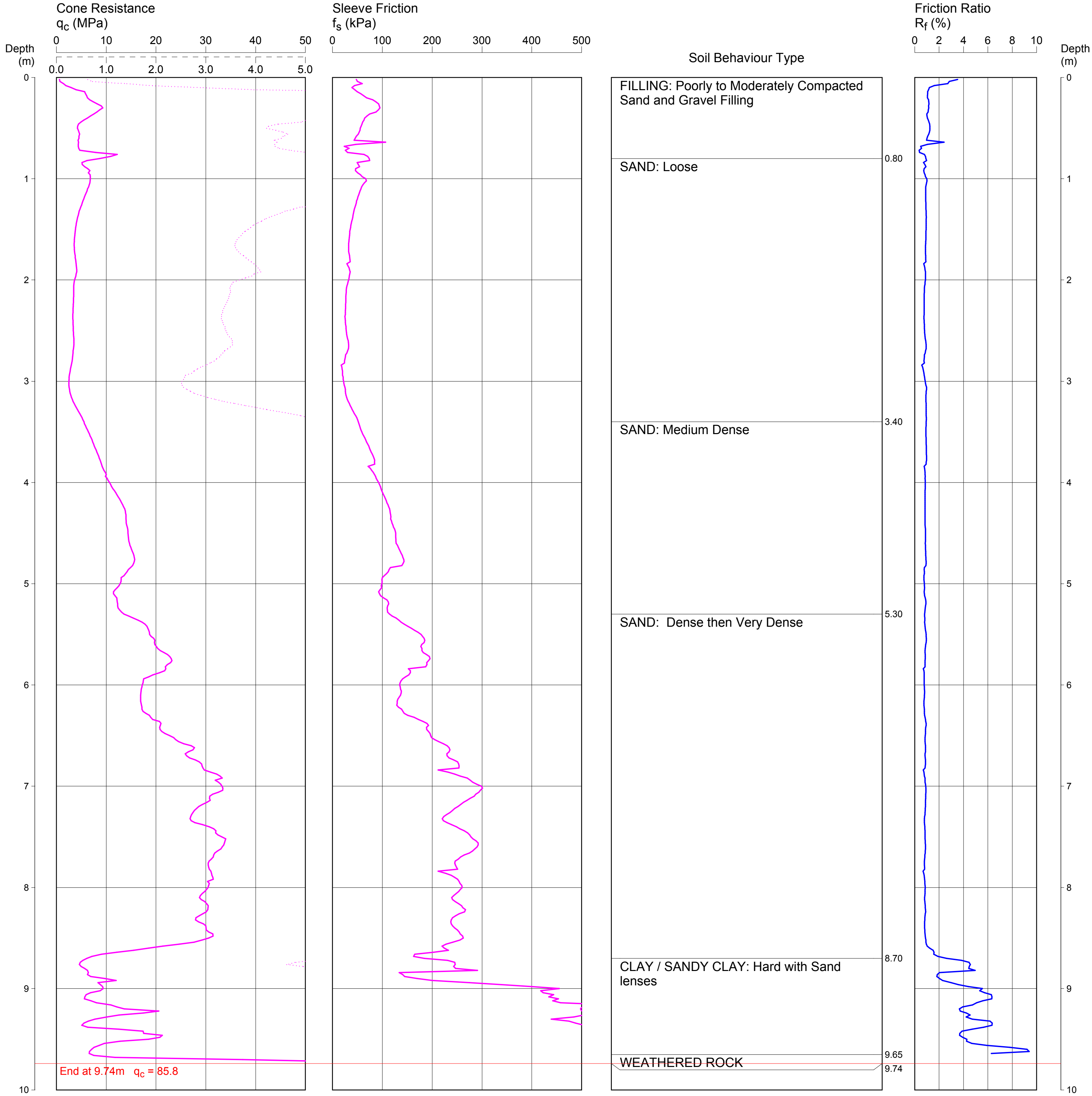
COORDINATES:

CPT 105

Page 1 of 1

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: HOLE COLLAPSED AT 3.9 m AFTER WITHDRAWAL OF RODS.

File: P:\72973.04 RANDWICK RACECOURSE, Hotel Precinct, Geotechnical Desktop Study PAV\Field\72973-105.CP5
Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: AUSTRALIAN TURF CLUB LTD

PROJECT: PROPOSED HOTEL PRECINCT

LOCATION: ALISON ROAD, RANDWICK RACECOURSE

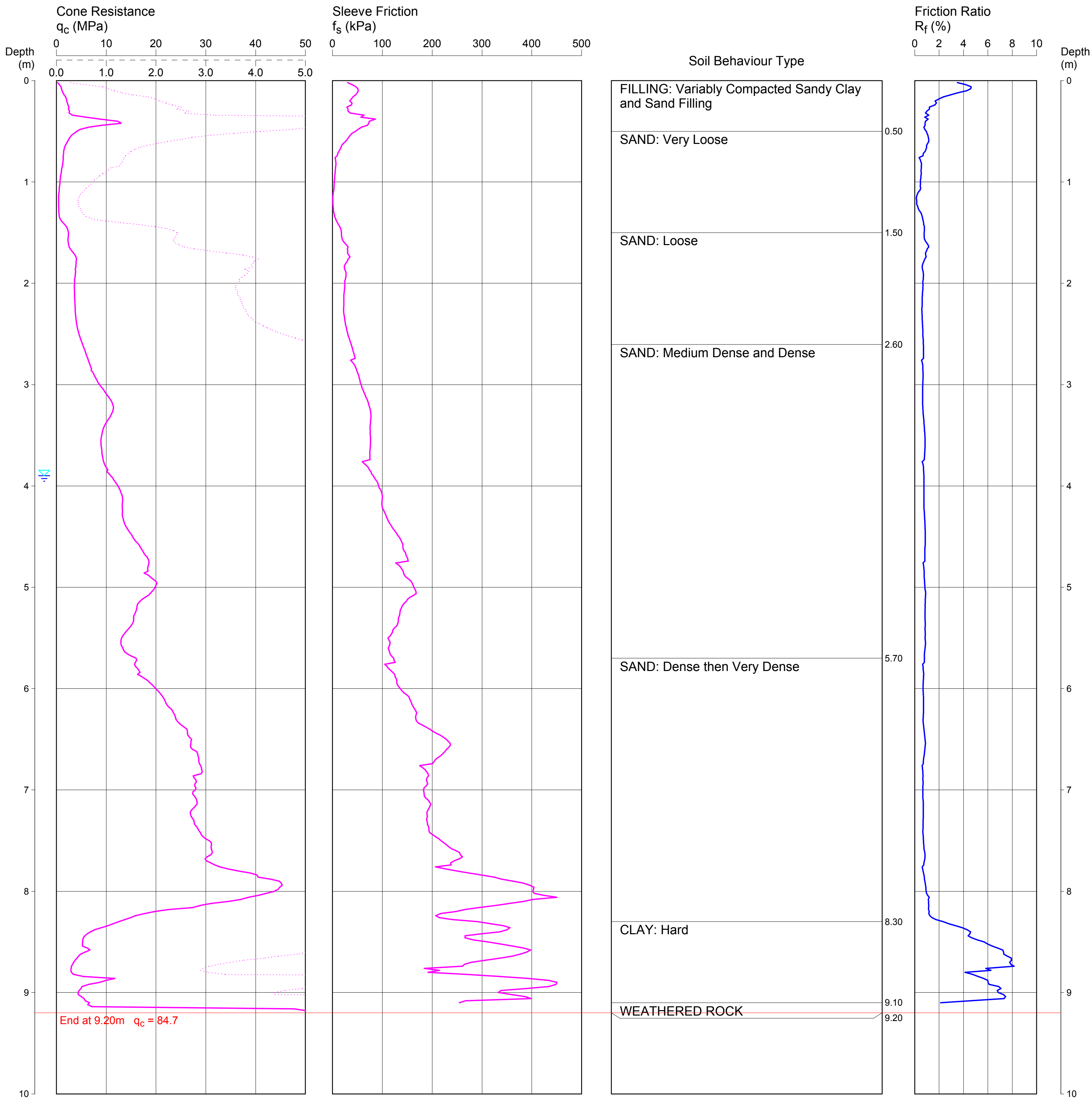
REDUCED LEVEL: 31.6 AHD

COORDINATES:

CPT 106

DATE 10/05/2012

PROJECT No: 72973.00



REMARKS: WATER LEVEL OBSERVED AT 3.9 m AFTER WITHDRAWAL OF RODS.

Water depth after test: 3.90m depth (assumed)

File: P:\72973.04 RANDWICK RACECOURSE, Hotel Precinct, Geotechnical Desktop Study PAV\Field\72973-106.CP5

Cone ID: CONE-H5 **Type:** 2 Standard

ConePlot Version 5.9.2

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

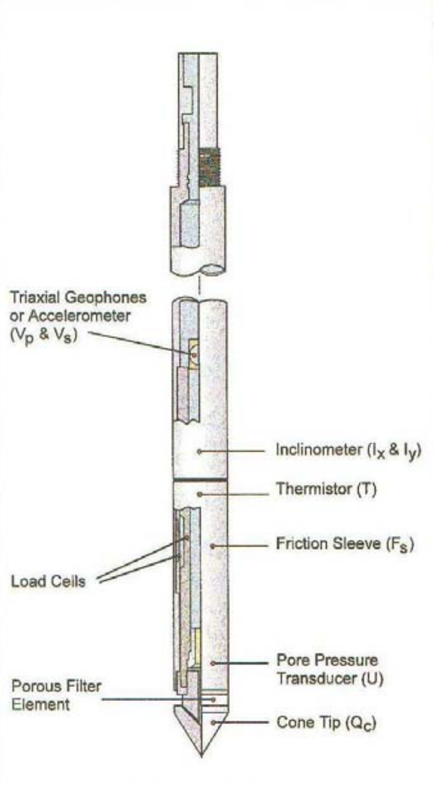


Figure 1: Cone Diagram

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 (σ) 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

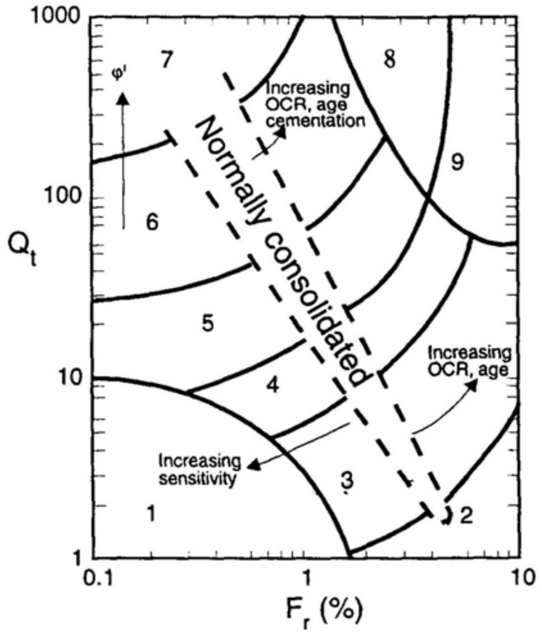


Figure 3: Soil Classification Chart

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.

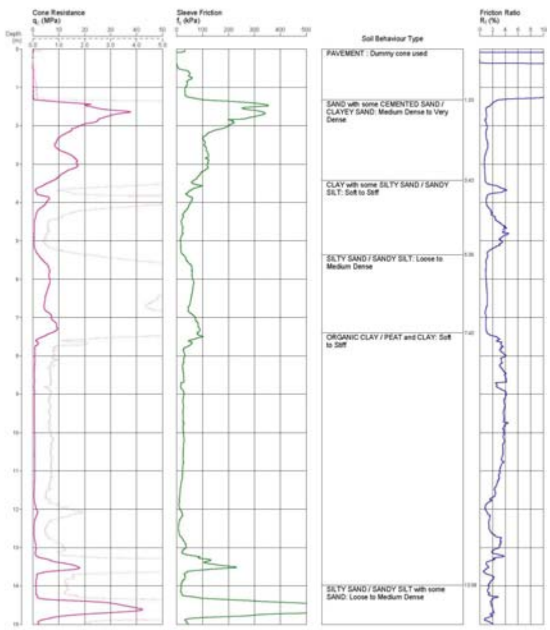
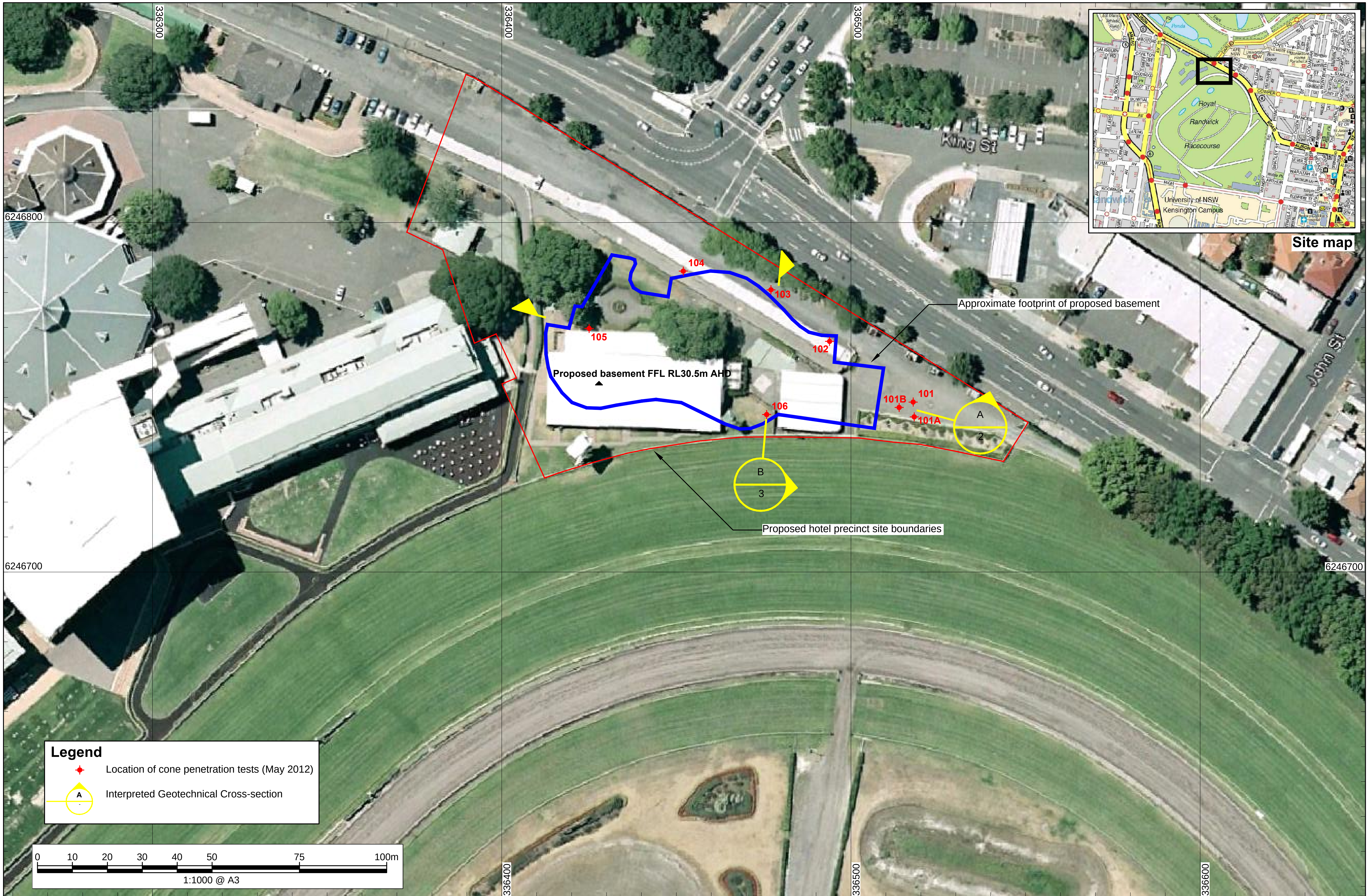


Figure 4: Sample Cone Plot

Appendix B

Drawing 1 – Locations of Cone Penetration Tests
Drawing 2 – Interpreted Geotechnical Cross-Section A-A’
Drawing 3 – Interpreted Geotechnical Cross-Section B-B’

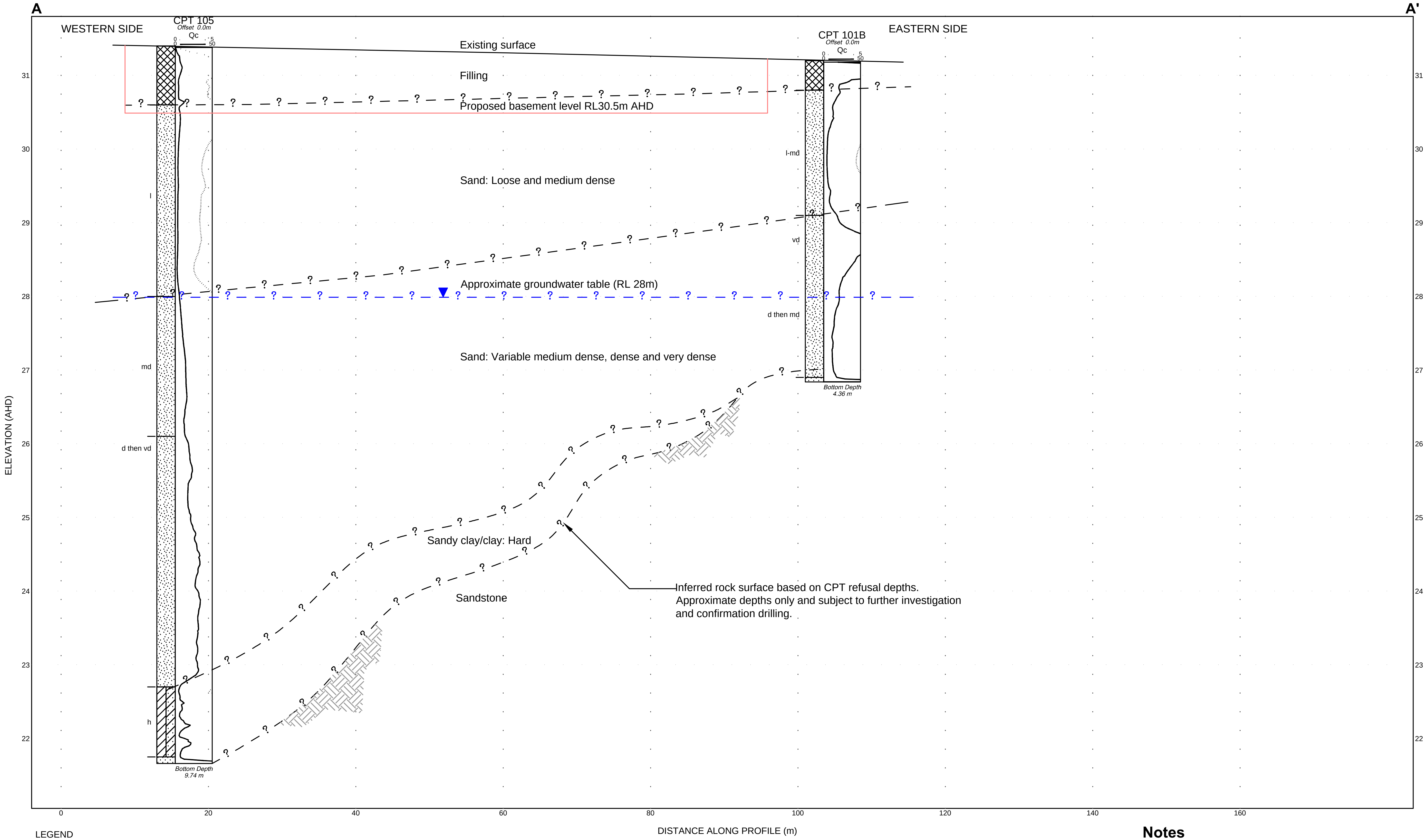


Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Australian Turf Club Ltd		
OFFICE: Sydney	DRAWN BY: JCP	
SCALE: As shown	DATE: 9.05.2012	

TITLE: **Locations of Cone Penetration Tests**
Preliminary Geotechnical Investigation - Proposed Hotel Precinct
Alison Road, Royal Randwick Racecourse

PROJECT No:	72973.04
DRAWING No:	1
REVISION:	0



LEGEND

- Filling
- Sand
- Sandstone fine grained
- Clay
- Sandy Clay

ROCK STRENGTH
EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High

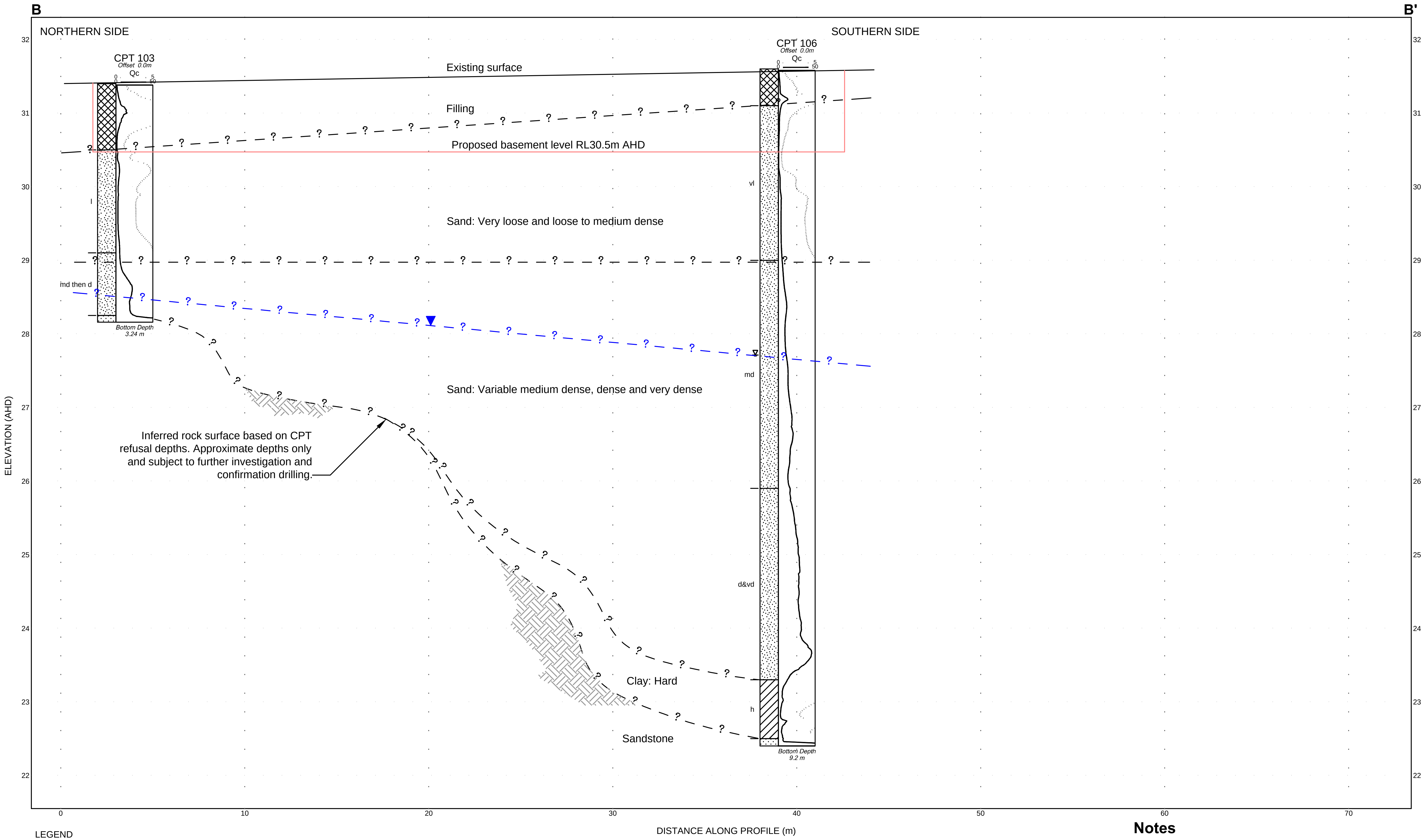
SOIL CONSISTENCY
st - stiff
vst - very stiff
h - hard
vl - very loose
l - loose
md - medium dense
d - dense
vd - very dense

TESTS / OTHER
- Water level

Notes

1. Subsurface profiles are accurate at CPT locations only and should be expected to vary in between and away from test locations.
2. Vertical exaggeration = 10x.
3. Summary logs only. Should be read in conjunction with detailed logs.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Australian Turf Club Ltd		TITLE: **Interpreted Geotechnical Cross-Section A-A'**	PROJECT No: 72973.04
	OFFICE: Sydney	DRAWN BY: JCP	**Preliminary Geotechnical Investigation - Proposed Hotel Precinct**	DRAWING No: 2
	SCALE: 1:500 (H) 1:50 (V)	DATE: 9.05.2012	**Alison Road, Royal Randwick Racecourse**	REVISION: 0



LEGEND

- Filling
- Sand
- Sandstone fine grained
- Clay

ROCK STRENGTH
EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High

SOIL CONSISTENCY
st - stiff
vst - very stiff
h - hard
vl - very loose
l - loose
md - medium dense
d - dense
vd - very dense

TESTS / OTHER
Water level

Notes

1. Subsurface profiles are accurate at CPT locations only and should be expected to vary in between and away from test locations.
2. Vertical exaggeration = 4x.
3. Summary logs only. Should be read in conjunction with detailed logs.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Australian Turf Club Ltd	
	OFFICE: Sydney	DRAWN BY: JCP
	SCALE: 1:200 (H) 1:50 (V)	DATE: 9.05.2012

TITLE: **Interpreted Geotechnical Cross-Section B-B'**
Preliminary Geotechnical Investigation - Proposed Hotel Precinct
Alison Road, Royal Randwick Racecourse

PROJECT No: 72973.04
DRAWING No: 3
REVISION: 0