Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Preliminary Geotechnical Investigation

Proposed Train Support Facility
Woodlands Close, Hexham

Prepared for
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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.

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Executive Summary

A preliminary geotechnical investigation has been carried out at the proposed Train Support Facility at Hexham. The investigation was undertaken at the request of QR National to provide geotechnical advice for the preliminary civil/structural design. The proposed development includes construction of a train support facility along the eastern boundary of the site.

The field investigation included test bores and cone penetration tests (CPT). Samples were collected for geotechnical and geo-chemical testing purposes.

The stratigraphy is characterised by filling mainly located over the southern parts of the site. The filling was typically less than 2 m thick and was associated with a former coal preparation plant and Hexham-Minmi Railway. The underlying natural soils include soft clay which is typically 15 m to 17 m thick but up to 25 m thick at the southern end of the site. The soft clay is underlain by sand with occasional gravel, usually loose to medium dense, becoming dense with depth. Clay (possibly residual in origin) was encountered beneath the sand. Based on previous investigations, the clay graded into weathered bedrock at depths in the range of 25 m to 33 m below the current site levels.

The regional groundwater level is typically shallow relative to the natural ground surface. The data indicate that ground water levels are typically around 0 m to about 2 m below ground level. The frequent irrigation of the northern part of the site, combined with the flooding in June 2007, could also have caused perched water levels within the fill and sometimes at the ground surface, above the regional water table level.

Geotechnical analysis indicated that the site is suitable for the proposed rail development provided that ground treatment is carried out to reduce post-construction settlements. The report presents several options for ground treatment but it is considered that preloading or deep soil mixing would be a suitable technique for the rail embankments, and piles would be appropriate for the support of building structures which are sensitive to settlement. The ground improvement method should be monitored by geotechnical instrumentation to measure and verify performance.

The report presents several pavement thickness options taking into consideration the poor trafficability across the northern low lying parts of the site and provides guidance on site preparation measures and bridging over the soft/wet low lying areas.

The report recommended further contamination assessment. Investigation has since been undertaken and results are in Report on Preliminary Contamination Assessment, 39798.06, September 2012.

Based on laboratory testing of the natural soils, potential acid sulphate soils were confirmed to be present. An ASSMP was prepared for the proposed development and presented in Report 39798.08-1, September 2012.

An investigation of the Tarro interchange was undertaken by DP in 2007/2008. The current alignment has changed since preparation of the original report. A copy of the revised 2008 report is presented in Appendix G.

Report on Preliminary Geotechnical Investigation
Proposed Train Support Facility
Woodlands Close, Hexham

1. Introduction

This report presents the results of a preliminary geotechnical investigation for a proposed train support facility (TSF) at Woodlands Close, Hexham. The report was prepared at the request of QR National and in consultation with ADW Johnson, GHD and Engenicom.

It is understood that the proposed development includes the construction of a train support facility, located adjacent to the Great Northern Railway Line, west of the Pacific Highway at Hexham.

A geotechnical investigation was required to provide the following information:

- Subsurface conditions, including depth to groundwater;
- Subgrade conditions along the proposed road alignment for the railway siding and the proposed access road;
- Pavement thickness design for the access road;
- Excavation conditions within the areas of proposed cut;
- Suitable footing types and geotechnical design parameters for the proposed locomotive provisioning shed, multi-cell stormwater culvert and embankments;
- Settlement estimates;
- Safe batter slopes for the proposed cuts and fills;
- Construction techniques and site preparation procedures;
- Drainage measures;
- Assessment of soil contamination and acid sulphate soil potential.

The investigation consisted of test bores and cone penetration tests (CPTs), in situ soil sampling and strength testing and laboratory and engineering analysis. The results are presented in the report, together with preliminary geotechnical advice on design and construction.

An additional investigation for the upgrade of the Tarro Interchange and the existing Woodland Close was completed by Douglas Partners in 2007/2008. The results from that investigation are presented in Appendix G. The current report, however, has been modified to reflect the current proposed development.

For the purpose of the investigation, the client supplied a concept plan of the site, overlaid on an aerial photograph, Ref MASTER_SENDOUT_C.dwg. QR National Limited also supplied co-ordinates for test locations.

This report supersedes Douglas Partners Pty Ltd (DP) previous preliminary geotechnical investigation report prepared for Queensland Rail (QR) in May 2011 (Project 39798.08 Rev 4) – Ref 1. The borehole logs, CPTs and laboratory testing from that investigation are attached.

The positions of the bores and CPTs were based on the development layout that was proposed in 2007.

2. Site Description

The site description is based on observations of the site in July 2007, during a walk-over survey by a geotechnical engineer from DP. A follow-up inspection of the site was undertaken by DP in March 2011.

The site is located at the southern end of Woodlands Close, Hexham and is bounded to the east by the Great Northern Railway which runs north-south parallel to the New England Highway and the Hunter River which is situated further to the east.

The proposed TSF development area is generally limited to a corridor about 150 m wide adjacent to the Great Northern Railway, due to the linear nature of the development. The ARTC Hexham Relief Roads Project which comprised five new train line (tracks) is located between the proposed TSF and the Great Northern Railway. The development generally only occupies a relatively narrow strip along the eastern side of the overall site, as shown on the Worley Parsons general arrangement figures in Appendix A.

The site can be divided into two distinctly different sections. The southern section has been heavily disturbed, with the site raised by filling. The northern part of the site is mostly low lying grazing land with only very localised areas of filling having been placed, associated with narrow access roads.

Each section of the site is described below.

Southern Side (Ch 174.170 km to Ch 175.800 km)

The southern part of the site contains the remains of former coal handling facilities, tailings ponds (mainly to the west) and part of the disused Hexham-Minmi Railway. The rail line is listed under the Newcastle LEP 2002 as a State significant item of heritage significance. A former rail loop was present on the southern part of the site which appears to have been connected onto the Great Northern Railway at approximately Ch 174.200 km.

An unsealed access road is situated along the eastern boundary of the site, immediately adjacent to the Great Northern Railway. The access road was used to gain access to Lot 312 DP 583724 further to the south. The access road was constructed in 1999.

Site levels have been modified by the placement of filling generally associated with the former coal handling plant facilities with site levels varying from RL 0.4 AHD to RL 3.7 AHD.

Filling was evident in the central and eastern portions of the site. Surface observations indicated that coal washery reject was the predominant filling type (refer Figure 1).

Figure 1: Filling stockpiles in the eastern portion of the site

Remnants of the previous coal handling facilities are present at the southern part of the site and include:

- A former storage tank was located in the central portion of the site near CPT TP15. Some minor surface staining was observed in the vicinity of the tank (refer Figure 2);
- Other stockpiles of filling observed onsite comprised terracotta roof tiles (refer Figure 3), fibro (possibly containing asbestos – Figure 4) and other deleterious material such as concrete, bricks and timber (Figure 5);
- Concrete slabs and piers, relating to the former building and conveyors, were observed across the southern parts of the site.

Figure 2: Storage tank observed in the central/eastern portion of the site

Figure 3: Scattered stockpile of terracotta roof tiles

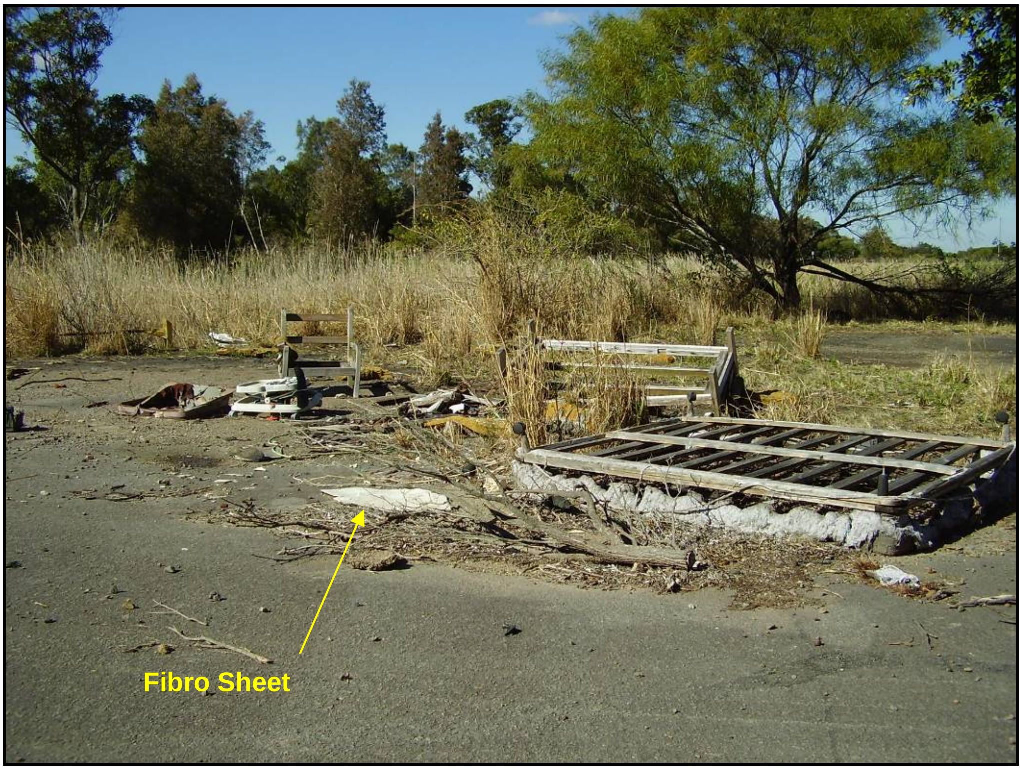

Figure 4: Scattered filling over a paved area in the central part of the site

Figure 5: Scattered stockpile of timber, tyres and 44 gallon drums

Site vegetation comprised grass, reeds (low lying parts) together with scattered trees. Some parts of the site are more densely vegetated such as the northern parts of the area.

Several drains and low lying areas are situated throughout the southern part of the site including a pond containing reeds between test locations Bore TP27 and Bore TP28 and adjacent to CPT 12.

A series of former tailings pond is located generally west of the proposed development layout. The tailings pond had been filled with coal fines and coal reject forming an elevated platform (stockpile) approximately 6 m (RL 8 AHD) above the surrounding site. At the time of the investigation, the stockpile was spray irrigated with treated effluent and was surfaced with grass. The overall dimensions of the tailings pond is about 0.5 km (east west) and up to 1.3 km long (north-south).

Northern Side (Ch 175.800 km to Ch 177.200 km)

The northern part of the site is generally located between the former Hexham-Mimi railway and the Tarro interchange along the New England Highway.

The northern 'Dairy Farmers' site is generally low lying with dense grass cover and scattered trees. The site levels typically range from RL 0.5 AHD to RL 1.5 AHD.

The site is accessed via a gravel access road which forms an extension to Woodlands Drive.

Surface water was ponding at the time of field investigations in July to September 2007 and was generally 0.1 m to 0.4 m in depth. The water was observed over the central low-lying areas of the site (ie CPT 2 to 10) and Bore TP35. The area was not accessible to standard vehicles and a specialised light weight "all terrain" vehicle was required to gain access to this section of the site (refer Figure 6).

Figure 6: General site figure showing low lying areas

Effluent treatment dams are situated within the grazing area to the west of the site. It is understood that effluent is treated to a secondary level and then spray irrigated on areas generally to the west of the site.

One major drain is situated at the northern part of the site. The drain flows from west to east via an unlined grassed channel which appears to have been excavated below former ground levels. The drain passes beneath the rail embankment at Ch 177.060 km via a concrete culvert (refer Figure 7). Water was ponding in the base of the drain.

Figure 7: Culvert beneath existing track at Ch 177.060 km

The western part of the site between Woodlands Close and the Tarro interchange where the access road is proposed comprises flat grassed paddocks (refer Figure 8).

The Chichester Pipeline passes through the site together with overhead power lines and drainage channels.

Figure 8: Western part of the site

3. Data Review

3.1 General

The data review had two main components: published information and in-house information from Douglas Partners files on previous investigations. The published information includes geological maps, soil landscape maps, acid sulphate risk maps and historical aerial photographs. These are described on Section 3.2 below.

The in-house information comprises data from several previous investigations both within the subject site and on adjacent or nearby sites, dating from 1959 to 2004. A summary of the data is presented in Appendix A and it is described in Section 3.3.

3.2 Published Data

3.2.1 Geological Map

The 1:100,000 scale Newcastle Coalfield Regional Geology map (Sheet 9321), published by the Department of Mineral Resources, indicates that the site is underlain by Quaternary Alluvium. The alluvium typically comprises unconsolidated sediments deposited in a fluvial or estuarine environment, and includes gravel, sand, silt and clay.

3.2.2 Landscape Map

The soil landscape map for Newcastle (Sheet 9232), published by the Soil Conservation Service, shows that the majority of the southern part of the site is categorised as "disturbed terrain", being extensively disturbed by human activity. The soils and hence the potential limitations are highly variable, and may include foundation hazard, unconsolidated low wet bearing strength materials, potential acid sulphate soils, impermeable soils, poor drainage, erosion hazard, very low fertility.

The northern part of the site is shown to be part of the Millers Forest landscape, described as comprising extensive alluvial flood plain / delta on recent sediments with elevation below 3 m to 6 m AHD. Limitations, as listed, include flood hazard, permanently high water table, seasonal water-logging, foundation hazard. This landscape would also be expected to underlie the disturbed terrain of the remainder of the site.

3.2.3 Acid Sulphate Soil Risk Map

The Acid Sulphate Soil Risk Map for Beresfield (Sheet 9232 N3), published by the Department of Land and Water Conservation, indicates that the entire site has a high probability of acid sulphate soils within one metre of the (natural) ground surface. There would be an environmental risk if acid sulphate materials were disturbed without appropriate management procedures in place.

3.2.4 Aerial Photographs

The following historical aerial photos were reviewed for the assessment:

Table 1: Aerial Photo Review

Year	Approximate Scale	Black and White/Colour
1954	1: 30,000	B & W
1966	1: 30,000	B & W
1975	1:40,000	B & W
1986	1:4,000	B & W
2004	1:10,000	Colour

These are listed below with relevant comments on the site condition.

1954 Aerial Photograph

- The Hexham-Minmi Railway runs parallel and to the west of the Main Northern railway along the southern part of the site before heading west about midway along the site (south of Dairy Farmers boundary);
- The Pacific Highway and Great Northern Railway are present east of the site;
- The rail line / road following the Hexham-Minmi railway appears to have been recently constructed;
- Water appears to be ponding in the area of the Dairy Farmers property (eastern part) with pastures / crops to the west.

1966 Aerial Photograph

- Buildings (coal preparation plant) situated at the southern part of the site between Great Northern Railway and Hexham Minmi railway at about Ch 174.65 km to 174.850 km;
- Rail crossing on southern part of the site at about Ch 175.450 km.

1975 Aerial Photograph

- Coal Preparation Plant buildings, stockpiles, tailings ponds, conveyors and the rail loop are present on the southern half of the site.

1986 OrthoPhotomap

- Coal Preparation Plant buildings, stockpiles, tailings ponds, conveyors and the rail loop are present, and in operation;
- Rail carriages appear to be present on the rail loop, the rail lines / sidings adjacent to the Hexham Minmi railway;
- Buildings were observed north of the Hexham Minmi Rail line;
- Several trucks were present across the site;
- Gravel access tracks were constructed within the Dairy Farmers (northern) part of the site.

2004 Aerial Photograph

- Operations associated with the Coal Preparation Plant have ceased;
- Buildings and other structures associated with the Coal Preparation Plant have been demolished and trees now growing over rail line;
- The stockpile and tailings ponds to the west of the Coal Preparation Plant are vegetated with grass;
- The Dairy Farmers Treatment ponds/plant is present.

It is noted that the review of aerial photos was limited by the relatively small scale and poor resolutions.

3.3 Data from Previous DP Investigations

The archive search revealed a number of relevant previous investigations by DP (and its predecessors). Some of these were carried out within the subject site, and the others were on adjacent or nearby sites. These assist in building a geotechnical model of the site. The reports are listed in Table 2 in chronological order, identified by a letter prefix, and the sites associated with these projects are shown on Drawing 1-1, Appendix H.

A brief summary of each report, including the work done and predominant findings is contained in Appendix A.

Table 2: Previous Investigations Undertaken on the Site and Surrounding Area by DP

Reference Prefix**	Project Number	Date	Report Title	Field Tests
A	00083	February 1959	Subsoil Investigation, Hexham	3 Bores (location uncertain)
B	02961	March 1971	Foundation Investigation, Ironbark Colliery, Hexham	13 Bores
C	03389	March 1972	Foundation Conditions, Proposed Coal Preparation Plant Hexham	4 Bores
D	06109	June 1978	Foundation Conditions Proposed Road and Rail Interchange Station, Hexham	5 Bores, 2 CPTs
E	16781	August 1993	Geotechnical Investigation, Proposed Depot Redevelopment, Australian Co-Operative Foods Ltd, New England Highway Hexham	4 Bores, 3 CPTs
F	17163, 17163A	August 1995	Geotechnical Investigation and Building Preload, Proposed Service Station Redevelopment, Pacific Highway Hexham	8 Wells*
G	18419, 18419A, 18419B	November 1995	Geotechnical and Acid Sulphate Soil Investigation, Proposed Effluent Ponds, ACF, New England Highway Hexham	6 Test Pits
H	18419C	November 1995	Geotechnical And Acid Sulphate Soil Investigation, Proposed Effluent Ponds, ACF, New England Highway Hexham	2 Bores
I	18457	February 1996	Geotechnical Investigation, Proposed Industrial Development, Lots 1 and 2 Old Maitland Road Hexham	3 CPTs
J	18603	November 1996	Geotechnical Investigation, Proposed Extensions to Club and Car park, Hexham Bowling Club, Hexham	6 Bores, 2 CPTs
K	18891	September 1998	Geotechnical Investigation, Proposed Access Road Hexham	12 Test Pits
L	18891A	January 1999	Geotechnical Investigation, Power Poles, Access Road and Smithy's Crossing, Hexham	5 Bores
M	18944, 18944A, 18944B	February 1999 to November 2000	Groundwater Monitoring, Dairy Farmers, 189 Maitland Road Hexham	10 Wells*
N	31773	July 2003	Geotechnical Investigation, Augmentation Of Hexham Bowling Club Wastewater Facilities, Hexham Bowling Club Hexham	2 Bores
O	39033	September 2004	Geotechnical Investigation, Proposed Weighbridge, Sparke Street Hexham	3 Test Pits, 1 CPT
P	39052	September 2004	Preliminary Site Assessment, Maitland Road, Hexham	Desktop review of geotechnical and geo-environmental data
Q	39159	June 2005	Report on Water Balance Assessment for Disposal of Treated Waste Water	NA
R	39798	October 2007	Preliminary Geotechnical Investigation, Proposed Maintenance Facility, Woodlands Close, Hexham	15 CPTs, 12 Bores, 11 hand augers
S	39798.01	March 2008	Geotechnical Assessment Proposed Rail Siding, Hexham	Desktop review of geotechnical data
T	39798.05	February 2012	Groundwater Assessment, Proposed Hexham Redevelopment, Maitland Road and Woodlands Close, Hexham	12 Wells*

Notes to Table 2:
* Wells – Groundwater monitoring wells
** - Refer Drawing 1-1 Appendix H for reference Prefix location
CPT – Cone Penetration Test
NA – Not Applicable

It should be noted that the locations of the tests are quite approximate in most cases, particularly for the older investigations where site plans are unclear or open to interpretation.

4. Field Work

4.1 Methods

General

The field work for the 2007 study was undertaken in the period 30 July 2007 to 19 September 2007, and comprised bores, hand auger bores, cone penetration tests (CPT / CPTu). The field work methods and results for the investigation of the upgrade of the Tarro Interchange is presented in Appendix G.

The bores and CPT locations were generally set out at pegged locations nominated by QR with consideration given to potential access issues at a number of locations. The numbering system at test locations was based on QR numbering system, except that Bores 2 to 12 were renamed CPT 2 to 12 to account for the type of testing that was undertaken. CPTs were also undertaken at locations proposed as test pit locations TP13, TP15, TP17 and TP19. The bores and CPTs were positioned for the development layout that was proposed in 2007.

Bore 1 was not undertaken as this test was located within the ARTC corridor and it was agreed by QR that the test could be deleted from the scope of work.

Test 20 was also not undertaken as this test was situated within swampy ground and testing could not be undertaken due to access constraints.

The tests were located to ISG co-ordinates and AHD datum. The test locations are presented on Drawing 1-2 in Appendix H. The recorded test co-ordinates and levels are shown on the respective CPT charts and borehole logs.

Cone Penetration Testing

A total of 15 cone penetration tests were carried out comprising six standard cone penetration tests and nine piezocone tests. The standard tests are numbered CPT 11 and 12, TP13, 15, 17 and 19 (standard cones) and CPT 2 to 9 (piezocones).

The standard tests were carried out using a custom-built, truck-mounted CPT rig, with centrally located hydraulic rams. The piezocones were carried out with an ‘all terrain’ CPT rig capable of accessing the soft / wet areas of the site (refer Figure 9 below). The cones were advanced at a constant rate of approximately 20 mm / second and a digital data acquisition system recorded cone tip resistance, friction sleeve resistance, dynamic pore pressure (only in piezocone), inclination from vertical and encoded depth at measurement intervals of 20 mm.

Figure 9: CPTu testing within low lying parts of the site using "all terrain" rig (2007)

The tests were generally carried out to depths ranging between 20 m and 32.9 m. The piezocone tests were limited to depths of 17 m to 27 m as the rig was lighter in weight and refusal was encountered generally within the medium dense sands.

Test Bores

4WD-Mounted Bores

A total of 12 bores (Bores 14, 16, 18, 21, 25, 27 to 30, 34, 36 and 37) were drilled across the site. The bores were drilled to depths ranging from 4 m to 4.95 m.

The bores were drilled using a 4WD mounted rotary drilling rig equipped with solid flight augers.

Sampling and testing included standard penetration testing (SPT) at depth intervals of about 1.5 m.

Hand Augers

A total of 11 hand-augered test bores (Bores TP22 to 24, 26, 31 to 33, 35, 38 to 40) were drilled in areas where the drilling rig could not gain access due to wet and boggy conditions. It should be noted that the field work was undertaken following a period of unusually high rainfall and part of the site had become flooded.

The bores were drilled to depths ranging between 1.1 m and 2.5 m depth.

The subsurface profile in each bore was logged by a geotechnical engineer or environmental scientist from DP who also collected samples for subsequent laboratory testing and identification purposes.

The bores and hand augers were augmented by dynamic penetrometer testing at each location together with pocket penetrometer tests at selected depths and locations.

Samples for environmental purposes were generally collected from the near surface, and at regular depth intervals or changes in strata within each bore. Soil samples were collected directly from the solid flight augers using stainless steel sampling equipment. Augers were screwed into the ground at discrete depths and retracted without rotation to minimise sample disturbance. Care was taken to remove any extraneous material deposited on the outer auger flights as the auger was withdrawn from the borehole.

Disturbed samples of the underlying natural soils were also collected for the purpose of acid sulphate screening tests. The samples were double wrapped in plastic and stored in an iced cooler for transport to DP's Newcastle laboratory for testing.

All environmental sampling data was recorded on DP chain of custody sheets, and the general sampling procedure comprised:

- Decontamination of all sampling equipment using a 3% solution of phosphate free detergent (Decon 90) and tap water prior to collecting each sample;
- The use of disposable gloves for each sampling event;
- Transfer of samples into laboratory-prepared glass jars, and capping immediately;
- Collection of 10% replicate samples for QA/QC purposes;
- Collection of replicate soil samples in zip-lock plastic bags at each depth for PID screening;
- Labelling of sample containers with individual and unique identification, including project number, sample location and sample depth;
- Placement of the sample jars and replicate sample bags into a cooled, insulated and sealed container for transport to the laboratory;
- Use of chain of custody (C-O-C) documentation ensuring that sample tracking and custody could be cross-checked at any point in the transfer of samples from the field to the laboratory. Copies of completed forms are contained in Appendix D.

Replicate samples for each sample were screened for the presence of volatile organic compounds (VOC’s), using a Microtip HL-2000 Photo-ionisation detector (PID) with a 10.6 eV lamp, calibrated to 100 ppm Isobutylene. The PID is capable of detecting over 300 VOC’s.

Samples for contamination testing were selected for analysis from filling material at bore locations which were nominated by QR.

4.2 Results

The subsurface conditions encountered in the testing undertaken in 2007 are presented in detail in the attached test bore logs and CPT charts in Appendix A. The CPT charts show the measured parameters, together with an inferred strata description, based on published correlations. The charts and report sheets should be read in conjunction with the accompanying notes preceding them, which explain the descriptive terms and classification methods used in the logs.

The following is a summary of the subsurface conditions encountered in the bores / CPT together with previous investigations undertaken in the vicinity of the site:

Table 3: Summary of Subsurface Profile

Stratum	Description
FILL	Predominantly comprising coarse coal reject (chitter), and intermixed with sand and clays where spread elsewhere particularly on the southern half of the site in the area of a former Coal Handling Preparation Plant. Over the southern half of the site the fill depth is typically 0.5 m to 1.5 m depth, but up to about 2 m.
CLAY (alluvial)	Soft to firm silty clays / clays and clayey silts are present beneath the fill at all CPT test locations. The clay layer is typically 15 m to 17 m thick but up to 25m thick at the southern end of the site. It is this layer which presents issues of poor bearing capacity for footings and pavements, as well as potential long term settlements under load due to its compressibility. The clay profile is interbedded by silty sand / clayey sand, particularly in the upper profile of the unit.
SAND	Sand, clayey sand or silty sand, with occasional gravel, usually loose to medium dense, becoming dense with depth. The thickness and distribution of this layer is quite variable and it is not present at all locations.
CLAY (residual)	The deeper clays are generally stiff to very stiff sandy clay, grading to hard clays and weathered rock although weathered rock was not encountered during the current investigation.
BEDROCK	Sandstone, siltstone, shale and coal were encountered in previous bores that were taken to rock. The depth to rock varies considerably, from about 25 m (below natural surface) in the south-eastern area (former colliery facilities) to 33 m near the former rail loop, west of the southern end of the site. More generally, it appears that the depth to rock is round 30 m to 35 m over most of the site, probably increasing to the west towards Hexham Swamp.

A geological section along the rail line is provided in Drawing 1-3, Appendix H.

The regional groundwater level is typically shallow relative to the natural ground surface. The data indicates that ground water levels are typically around 0 m to about 2 m below ground level. The frequent irrigation of the northern part of the site, combined with the flooding in June 2007 could also have caused perched water levels within the fill and sometimes at the ground surface, above the regional water table level.

Due to the above features, and with climatic variations, water levels within the site will be transient and also vary across the site. Further discussions on groundwater is presented in Douglas Partners report Ref 13.

4.3 Contaminant Observations

Fill materials generally comprised coal reject materials with no visual or olfactory evidence of contamination (ie no staining or odour).

The following observations of potential contamination were observed during the walkover and subsurface investigation:

- Presence of building materials (rubble) within filling (possible asbestos) in the southern part of the site (former coal preparation plant);
- Presence of fuel storage area (Figure 2) with some minor staining of adjacent ground surface;
- Presence of coal chitter and filling covering generally the southern parts (Figures 4 and 5) of the site;
- Scattered stockpiles of rubbish including fuel drums generally adjacent to access tracks;
- The results of PID Screening on soil samples are shown on some borehole logs in Appendix B and generally suggest the absence of gross volatile hydro-carbon impact;
- Groundwater was observed in the boreholes; observation of the water suggested the absence of visual or olfactory contamination (ie visible staining and odour). It is noted that groundwater was not sampled or analysed to confirm chemical condition.

Further discussions on contamination observations and results are presented in Ref 12.

5. Laboratory Results

5.1 Geotechnical Testing

Samples of expected subgrade material were submitted to the DP Newcastle laboratory for California bearing ratio (CBR), standard compaction, Atterberg limits and linear shrinkage testing. Detailed results are attached (Appendix C) and are summarised in Table 4.

Table 4: Results of Laboratory Testing

Test Location	Depth (m)	Description	FMC (%)	MDD (t/m^3)	OMC (%)	CBR (%)	LL (%)	PL (%)	PI (%)	LS (%)
TP16	2.3	Silty Clay – dark brown	41.9	-	-	-	56	25	31	14.0
TP18	0.0-1.0	Coal Reject (chitter)	11.7	1.58	13.5	9	-	-	-	-
TP21	1.5-1.95	Silty Clay – brown	41.1	-	-	-	44	23	21	12
TP27	1.0-1.5	Gravelly clay – dark grey (chitter)	20.7	1.48	15.0	14	-	-	-	-
TP34	0.7-1.0	Silty Clay – dark grey / brown	51.4	1.32	34.5	1.0	-	-	-	-
TP36	0.1-1.0	Sandy Clay – dark brown	28.5	1.50	25.5	2.0	-	-	-	-
TP37	3.9	Sandy Silt – grey black	37.0	-	-	-	-	-	NP	-

Notes to Table 4:

FMC – Field Moisture Content
MDD – Maximum Dry Density
OMC – Optimum Moisture Content
CBR – California Bearing Ratio
LL – Liquid Limit
PL – Plastic Limit
PI – Plasticity Index
LS – Linear Shrinkage
NP – Non-Plastic

5.2 Chemical Testing

5.2.1 Analytical Programme

Laboratory testing was undertaken by SGS Pty Limited, a National Association of Testing Authorities, Australia (NATA) registered laboratory. Analytical methods used are shown on the laboratory sheets in Appendix D.

Five samples of filling were selected to provide a preliminary assessment of fill materials. QR specified the laboratory testing schedule. The samples were analysed for pH, sulphate and phosphorus as well as the following potential contaminants:

- Total Recoverable Hydrocarbons (TRH);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Organochlorine Pesticides (OCP);
- Organophosphorus Pesticides (OPP);

- Polychlorinated Biphenyls (PCB);
- Benzene, Toluene, Ethyl Benzene, Xylene (BTEX);
- Metals: Arsenic (As); Cadmium (Cd); Chromium (Cr); Copper (Cu); Lead (Pb); Mercury (Hg); Nickel (Ni); Zinc (Zn).

Quality Control/Quality Assurance (QA/QC) testing comprised one soil replicate (sample D1), the results of which are detailed in Appendix D.

5.2.2 Analytical Results

The results of chemical analysis of soil samples are presented in the laboratory report sheets (Appendix D), and are summarised in Tables 5, 6 and 7 below.

Table 5: Laboratory Results for Metals in Soil

Test	Depth (m)	PID (ppm)	Metal							
			As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
TP14	0.8	<1	<3	<0.1	2.1	5.9	15	<0.05	3.5	24
TP18	1.0	<1	20	0.3	2.2	17	16	0.13	3.5	33
TP28	0.1	<1	7	0.3	8.0	18	20	0.06	13	140
D1	-	<1	4	0.1	14.0	11	9	0.05	13	36
TP28	1.0	<1	<3	<0.1	3.5	5.0	5	<0.05	3.8	110
TP29	0.4	<1	<3	0.2	4.0	6.7	23	<0.05	8	81
Laboratory PQL			3	0.1	0.3	0.5	1	0.05	0.5	0.3
NSW EPA - NEHF F [1] (Ref 5)			500	100	500	5000	1500	75	3000	35000
NSW EPA –General Solid Waste Guidelines – CT1 (Ref 7)			100	20	100	NC	100	4	40	NC
NSW EPA – Restricted Solid Waste Guidelines – CT2 (Ref 7)			400	80	400	NC	400	16	160	NC

Notes to Table 5:
All results in mg/kg on a dry weight basis
NC - No Criteria
CT - Concentration Threshold
D1 - Replicate of TP 28/0.1 m
PQL - Practical Quantification Limits
1 - Health Based Criteria for Commercial / Industrial Land Use
PID - Photoionisation Detector

Table 6: Laboratory Results for TRH and BTEX in Soil

Pit	Depth (m)	PID (ppm)	TRH				BTEX			
			C_6 - C_9	C_{10} - C_{14}	C_{15} - C_{28}	C_{29} - C_{36}	Benzene	Toluene	Ethyl Benzene	Xylene
TP14	0.8	<1	<20	<20	<50	<50	<0.50	<0.50	<0.50	<1.5
TP18	1.0	<1	<20	<20	100	<50	<0.50	<0.50	<0.50	<1.5
TP28	0.1	<1	<20	23	290	170	<0.50	<0.50	<0.50	<1.5
D1		<1	<20	<20	250	170	<0.50	<0.50	<0.50	<1.5
TP28	1.0	<1	<20	<20	<50	<50	<0.50	<0.50	<0.50	<1.5
TP29	0.4	<1	<20	110	**2600**	**1900**	<0.50	<0.50	<0.50	<1.5
Laboratory PQL			20	20	50	50	0.5	0.5	0.5	1.5
NSW EPA Criteria for Service Station Sites[2] (Ref 6)			65	1000 total			1	1.4[1]	3.1[1]	14[1]
NSW EPA – General Solid Waste Guidelines - CT1 (Ref 7)			650 SCC1	10000 total SCC1			10	288	600	1000
NSW EPA - Restricted Solid Waste Guidelines - CT2 (Ref 7)			650 SCC2	40000 total SCC2			40	1152	2400	4000

Notes to Table 6:

All results in mg/kg on a dry weight basis

PQL - Practical Quantification Limits

1 - Human Health Based Protection Level

2 - Threshold Concentration for Sensitive Land Use

SCC - Specific Contaminant Concentration

CT - Concentration Threshold

PID - Photoionisation Detector

D1 - Replicate of Pit 28/0.1 m

Bold results exceed “Threshold Concentrations for Sensitive Land Use”

Table 7: Laboratory Results for OCP, PCB and PAH in Soil

Pit	Depth (m)	PID (ppm)	Total PAHs	Benzo(a) Pyrene	Total OCPs	Aldrin + Dieldrin	PCBs
TP14	0.8	<1	0.57	0.07	<0.1	<0.1	<0.90
TP18	1.0	<1	0.86	0.06	<0.1	<0.1	<0.90
TP28	0.1	<1	1.69	0.09	<0.1	<0.1	<0.90
D1		<1	1.68	0.08	<0.1	<0.1	<0.90
TP28	1.0	<1	0.1	<0.05	<0.1	<0.1	<0.90
TP29	0.4	<1	13.92	0.62	<0.1	<0.1	<0.90
Laboratory PQL			0.05	0.05	0.1	0.1	0.9
NSW EPA - NEHF F [1] (Ref 5)			100	5	NC	50	50
NSW EPA - General Solid Waste Guidelines - CT1 (Ref 7)			200 SCC1	0.8	NC	NC	50 SCC1
NSW EPA - Restricted Solid Waste Guidelines - CT2 (Ref 7)			800 SCC2	3.2	NC	NC	50 SCC2

Notes to Table 7:
All results in mg/kg on a dry weight basis
PQL - Practical Quantification Limits
NC - No Criteria
PID - Photoionisation Detector
1 - Health Based Criteria for Various Land Uses
SCC - Specific Contaminant Concentration
CT - Concentration Threshold
Total PAH - Sum of positive PAH species
D1 - Replicate of Pit 28/0.1 m

The results of the preliminary assessment of contamination are discussed in Section 8 of this report.

5.3 Acid Sulphate Soil Testing

A total of 55 acid sulphate screening tests were undertaken on selected soil samples. The testing was undertaken in accordance with the ASSMAC “Acid Sulphate Soils Manual” (Ref 3). The soil samples were tested at the DP laboratory for pH in water (H_2O), and pH following oxidation with hydrogen peroxide (H_2O_2), using a calibrated pH meter. Samples were selected to test the acid forming potential of each material encountered that will potentially be disturbed by the excavation works. The results of the screening tests are presented in Table 8 below.

Table 8: Acid Sulphate Soil Screening Tests

Bore / Test Pit	Sample Depth [a] (m)	Sample RL (m AHD)	Sample Description	Screening Test Results			
				pH			Strength of Reaction [b]
				pH_F	pH_{FOX}	$pH_F - pH_{FOX}$	
14	2.4	-0.9	Silty Sand – grey	7.2	2.6	4.6	3FH
14	2.9	-1.4	Silty Sand – grey	7.4	5.2	2.2	1
16	2.3	0.0	Silty Clay – grey / brown	7.3	6.1	1.2	1-2
16	2.8	-0.5	Sandy Silty Clay - grey	7.6	6.5	1.1	1
16	3.0 - 3.45	-0.7 to -1.1	Sandy Silty Clay - grey	7.6	2.3	5.3	1-2
21	0.5 - 0.95	0.6 to 1.0	Silty Clay – grey brown	7.4	6.2	1.2	1-2
21	1.5 - 1.95	0.0 to -0.4	Silty Clay – grey brown	7.6	6.9	0.7	1
21	2.4	-0.9	Sandy Silt – grey	7.5	6.9	0.6	1
21	3.0 - 3.45	-1.5 to -1.9	Clayey Sand - grey	7.6	6.2	1.4	1
22	0.4	0.3	Silty Clay – grey	6.8	5.9	0.9	1H
22	0.9	-0.2	Silty Clay – grey	6.8	6.7	0.1	1H
22	1.4	-0.7	Clayey Silty Sand – grey mottled orange	7.0	6.8	0.2	1
22	1.7	-1.0	Clayey Silty Sand – grey mottled orange	7.1	6.9	0.2	1
22	2.4	-1.7	Clayey Silty Sand – grey mottled orange	7.1	6.9	0.2	1
23	0.7	0.4	Silty Clay – grey	7.4	6.6	0.8	1H
23	0.9	0.2	Silty Clay – grey	7.2	6.6	0.6	1H
23	1.2	-0.1	Clayey Silty Sand – grey	7.1	7.0	0.1	1H
24	0.4	3.1	Silty Clay – grey brown	7.3	6.0	1.3	1
24	0.7	2.8	Silty Sand – grey	6.7	6.3	0.4	1
24	0.9	2.6	Silty Sand – grey	6.7	6.2	0.5	1
24	1.6	1.8	Silty Sand – grey	6.5	5.5	1.0	1
Guideline			Sands to Loamy Sands Sandy Loams to Light Clays Medium to Heavy Clays and Silty Clays	<4[c]	<3.5[d]	>1[d]	-

Table 8: Acid Sulphate Soil Screening Tests (continued)

Bore / Test Pit	Sample Depth ^{a} (m)	Sample RL (m AHD)	Sample Description	Screening Test Results			
				pH			Strength of Reaction ^{b}
				pH_F	pH_{FOX}	$pH_F - pH_{FOX}$	
25	0.8 - 0.95	0.4 to 0.5	Silty Sand – grey	8.4	7.2	1.2	1
25	1.4	-0.1	Silty Sand - brown	8.0	7.5	0.5	1
25	1.5 - 1.95	-0.2 to -0.6	Silty Sand - brown	8.0	6.4	1.6	1
25	2.4	-1.1	Silty Sand – brown (shells)	8.5	6.9	1.6	1-2
25	3.9	-2.6	Silty Sand - brown	8.3	6.3	2.0	1-2
27	1.5 - 1.95	0.3 to -0.2	Silty Clay – grey	8.1	5.5	2.6	1
27	2.4	-0.6	Clayey Silty Sand - grey	8.1	6.3	1.7	1
27	2.9	-1.1	Clayey Silty Sand - grey	8.0	6.0	2.0	1-2
27	3.0 - 3.45	-1.2 to -1.7	Clayey Silty Sand - grey	8.2	7.2	1.0	1-2
28	3.3	-0.3	Silty Clay – grey	7.8	3.9	3.9	1-2
28	4.5 - 4.95	-1.5 to -1.9	Sandy Silt – grey	7.6	5.6	2.0	1-2
30	0.4	1.4	Sandy Clay - brown	5.9	4.4	1.5	2
30	0.5 - 0.95	0.8 to 1.3	Sandy Clay - brown	6.3	6.3	0.0	1-2
30	1.4	0.4	Clay – grey	7.2	6.6	0.6	1-2
30	1.5 - 1.95	0.3 to -0.2	Clay – grey	7.1	6.5	0.6	1
30	2.4	-0.6	Silty Sand – grey mottled orange	7.0	6.6	0.4	1
30	3.0 - 3.45	-1.2 to -1.7	Clayey Silt – grey (shells)	7.7	2.4	5.3	1-2
30	4.5 - 4.95	-2.7 to -3.2	Clayey Silt – grey (shells)	7.5	2.6	4.9	4HF
31	1.3	0.0	Silty Clay – grey mottled orange	7.4	6.1	1.3	1H
31	1.5	-0.2	Silty Clay – grey mottled orange	7.0	6.9	0.1	1H
31	1.8	-0.5	Silty Clay – grey mottled orange	7.7	7.6	0.1	1H
Guideline			Sands to Loamy Sands	<4^c	<3.5^d	>1^d	-
			Sandy Loams to Light Clays				
			Medium to Heavy Clays and Silty Clays				

Table 8: Acid Sulphate Soil Screening Tests (continued)

Bore / Test Pit	Sample Depth [a] (m)	Sample RL (m AHD)	Sample Description	Screening Test Results			
				pH			Strength of Reaction [b]
				pH_F	pH_{FOX}	pH_F - pH_{FOX}	
34	1.3	-0.7	Silty clay - grey	7.2	6.4	0.8	1
34	1.4 - 1.95	-0.8 to -1.35	Silty clay - grey	7.1	6.5	0.6	1
34	2.4	-1.8	Silty clay - grey	7.0	6.1	0.9	1
34	3.0 - 3.45	-2.4 to -2.8	Silty clay - grey	7.2	4.5	2.7	1
36	0.4	0.8	Silty sand - brown	6.9	5.4	1.5	1-2
36	0.5 - 0.95	0.3 to 0.7	Sandy clay - brown	7.6	7.6	0.0	1
36	1.4	-0.2	Sand - brown	8.0	7.8	0.2	1
36	1.5 - 1.95	-0.3 to -0.7	Sand - brown	8.1	7.8	0.3	1
36	2.5	-1.3	Silty sand - grey	8.1	6.6	1.5	1
36	3.0 - 3.45	-1.8 to -2.2	Silty sand - grey	8.1	4.8	3.3	1-2
36	4.0	-2.8	Silty sand - grey	8.2	6.8	1.4	1-2
37	1.4	-0.1	Clay - grey	7.3	5.2	2.1	1
37	2.4	-1.1	Clayey silt - grey	7.3	2.9	4.4	1
Guideline			Sands to loamy sands Sandy loams to light clays Medium to heavy clays and silty clays	<4[c]	<3.5[d]	>1[d]	-

Notes to Table 8:

a Depth below ground surface

b Strength of Reaction

- 1 denotes no or slight reaction
- 2 denotes moderate reaction
- 3 denotes high reaction
- 4 denotes very vigorous reaction
- F denotes bubbling/frothy reaction indicative of organics
- H denotes heat generated

c For actual acid sulphate soils (ASS)

d Indicative value only for Potential Acid Sulphate Soils (PASS)

Shaded results indicate potential for acid generation upon oxidation (ie PASS)

pH_F - Soil pH Test (1:5 soil:distilled water)

pH_{FOX} - Soil Peroxide pH Test (1:4 soil:distilled water following oxidation of soil with 30% hydrogen peroxide (H_20_2))

Based on the above screening results, three samples were selected and submitted to ALS Environmental Pty Ltd for detailed laboratory testing as follows:

- Total potential acidity (TPA);
- Total actual acidity (TAA);
- Chromium reducible sulphur (S_{cr}).

The results of the acid sulphate soil testing are presented in Appendix D and are summarised in Table 9 below.

Table 9: Acid Sulphate Soil – Detailed Laboratory Testing

Bore / Test Pit	Sample Depth [a] (m)	Sample RL (m AHD)	Sample Description	Laboratory Results			
				pH_{KCL}	Scr %S	TAA (mole H+/t)	TPA (mole H+/t)
14	2.4	-0.9	Silty Sand - grey	5.6	0.65	6	359
16	3.0 - 3.45	-0.7 to -1.1	Sandy Silty Clay - grey	6.8	0.08	<2	388
27	1.5 - 1.95	0.3 to -0.2	Silty Clay - grey	5.5	<0.02	21	184
28	3.3	-0.3	Silty Clay - grey	5.9	<0.02	4	<2
30	0.4	1.4	Sandy Clay - brown	5.4	0.04	16	230
Guideline			Sands to Loamy Sands	-	0.03	18	18
			Sandy Loams to Light Clays		0.06[b]/0.03[c]	36[b]/18[c]	36[b]/18[c]
			Medium to Heavy Clays and Silty Clays		0.1[b]/0.03[c]	62[b]/18[c]	62[b]/18[c]

Notes to Table 9:
a – depth below ground surface
b – ASSMAC Action Criteria for disturbance of 1-1000 tonnes of material
c – ASSMAC Action Criteria for disturbance of more than 1000 tonnes of material
Shaded results indicate an exceedence of ASSMAC action criteria for 1-1000 tonnes of ASS soil (Ref 3)

The results of the acid sulphate testing are discussed in Section 9 of this report.

6. Proposed Development

It is understood that the proposed development includes the construction of a rolling stock maintenance facility, located adjacent to the Great Northern Railway Line. The proposed development will include the following aspects:

Stage 1:

- Construction of a connection to the Tarro Interchange and main vehicle access road to the site;
- Construction of earthworks, drainage, circulating roadwork and the construction of one provisioning track, a train examination road, two cut out roads and two wagon maintenance roads;
- Filling and grading of the TSF area (approximately 380,000 m^3 of suitable fill to be imported) so that site levels can match the adjoining rail network;
- Associated signalling and connections to the down coal road on the Great Northern Line;
- Construction of a Provisioning Facility;
- 2 x Provisioning roads and UTM road;
- 2 x Wagon Maintenance roads;
- Wagon storage road;
- Construction of a Wagon Maintenance Building;
- 1 x Wagon storage road;
- Fuel storage area to initially accommodate 2 x 100,000 litre tanks and to be constructed in such a manner as to allow for future expansion of up to 4 x 100,000 litre tanks of diesel fuel.

Stage 2:

- Locomotive Maintenance Building;
- Locomotive Wash Building;
- Locomotive Turntable;
- Locomotive Maintenance roads.

The proposed TSF development is shown in Worley Parsons Proposed Arrangement Figure 2 in Appendix H.

Filling

The majority of filling is proposed to be along the rail formation with the depth of filling in the range 0.2 m to 0.4 m on the southern parts of the site where the site is already filled and from 1.4 m to 1.8 m on the northern parts of the site, where the site is at low lying natural grades.

Localised areas of filling are also proposed as follows:

- 0.3 m high access road on northern parts of site;
- 0.3 m perimeter road around overall southern site, mostly on existing filled areas;
- 0.5 m high temporary construction compound on northern low lying part of site.

Approximate areas of proposed filling are shown on the GHD Areas of Disturbance – Fill plan in Appendix H.

Excavations

Excavations on site are proposed to comprise the following:

- Proposed Basins 1 to 3, with cut ranging from 0.1 m for Basins 1 and 2 on the northern part of the site which are expected to be through natural clay soils to 2.6 m for the Basin 3 at the southern part of the site, which is expected to be mostly through existing filling;
- Proposed cess drains leading to the various basins with depths of cut ranging from 1.6 m though existing filling on the southern site to 1.0 m or less on the northern site;
- Site preparation for proposed access roads and associated culverts with depths of cut typically 0.3 m or less and in places up to 1.5 m;
- Temporary trench excavations for buried services, to depths of up to about 0.8 m.

Approximate areas of proposed cut (excavations) are shown on the GHD Area of Disturbance – Cut plan in Appendix H.

Preliminary column loads provided by the client indicate that the main portal frame structures will be in the range of 40 to 50 tonne and between 20 and 40 tonne for the service platform. It has been assumed that these loads are working loads.

Based on information provided by ADW Johnson, it is understood that about 13 freight trains will be refuelled each day which will require three B-double tankers to service the facility each day. It is further understood that other delivery trucks will service the facility but on an infrequent basis.

It is expected that a multi cell culvert will be required at the northern end of the project to connect into the existing culvert which runs beneath the Great Northern Railway.

7. Geotechnical Assessment

7.1 Summary of Geotechnical Factors

A number of geotechnical factors require consideration as listed below:

- Consolidation settlement in areas of soft clay, due to imported fill, structural loads and dewatering; this is discussed in Section 7.2;
- Acid Sulphate Soil:
  - There is a high probability that the site is underlain by potential acid sulphate soil. Disturbance of those soils, therefore, will require the implementation of a management plan;
  - This matter is discussed further in Section 9.
- Some of the existing granular filling at the site could be used as a bridging layer for the support of pavements such as access roads but may need to be removed and replaced with engineered fill for areas beneath buildings and proposed rail lines;

- Excavation and disturbance of existing coal fines and coal chitter would need to consider the risks associated with spontaneous combustion. These risks have not been assessed as part of the preliminary investigation;
- Ground improvement methods for areas where structures and services will be affected by settlement.

Notwithstanding the above, the southern part of the site has successfully been used as a rail facility for loading coal and the adjacent Great Northern Railway confirms the development at this site is feasible from a geotechnical perspective.

7.2 Ground Conditions

Soft soils are present beneath the fill over most of the site, as described in the Section 4.2, typically comprising soft to firm alluvial silty clay, sometimes described as organic. These soils have low permeability and are highly compressible, leading to long-term consolidation when subject to load.

Based on the field and laboratory tests conducted during previous investigations within the site, the typical range of engineering parameters for the soft silty clays is shown in Table 10.

Table 10: Typical Engineering Properties of the Soft to Firm Alluvial Silty Clay

Parameter	Symbol	Unit	Range	Typical Value
Moisture Content	W	%	41.2 – 75.0	60
Unit Weight	γ_b	kN/m^3	15.5 – 18.9	17
Undrained Shear Strength	c_u	kPa	5– 50	25
Drained Shear Strength	c’	kPa	5 – 6	5
Drained Friction Angle	ϕ’	°	30 – 31	30
Coefficient of Consolidation	c_v	m^2/yr	0.2 – 2.0	0.8
Coefficient of Volume Change	m_v	m^2/MN	0.22 – 2.40	1.0
Coefficient of Creep	c_α	-	0.005 – 0.040	0.020*
Coefficient of Permeability	k_v	m/s	2 x10^{-9} - <1 x10^{-10}	5 x 10^{-9}

Notes to Table 10:
* could differ widely

Long-term settlements would be expected for heavily loaded slabs, or any area where new fill is placed, thereby increasing the load on the soil. The magnitude of the settlement will depend on the load, the dimensions of the loaded area and the thickness of the compressible clay layer. As a guide, the settlement induced by placing 1 m of compacted fill (about 20 kPa) over an area with 16 m of soft to firm clay beneath would be in the order of 500 mm (primary settlement plus creep), taking many years to occur. This settlement depends on the preconsolidation pressure (load history) and also the staging of construction.

The time for the settlement of clay layers to occur can be difficult to predict, and will vary with the thickness of the clay, the coefficient of consolidation and whether there are any intermediate drainage layers (eg sandy layers). The theoretical time for 95% primary consolidation to occur is shown in Figure 10 plotted against clay thickness and the c_v values given in Table 10.

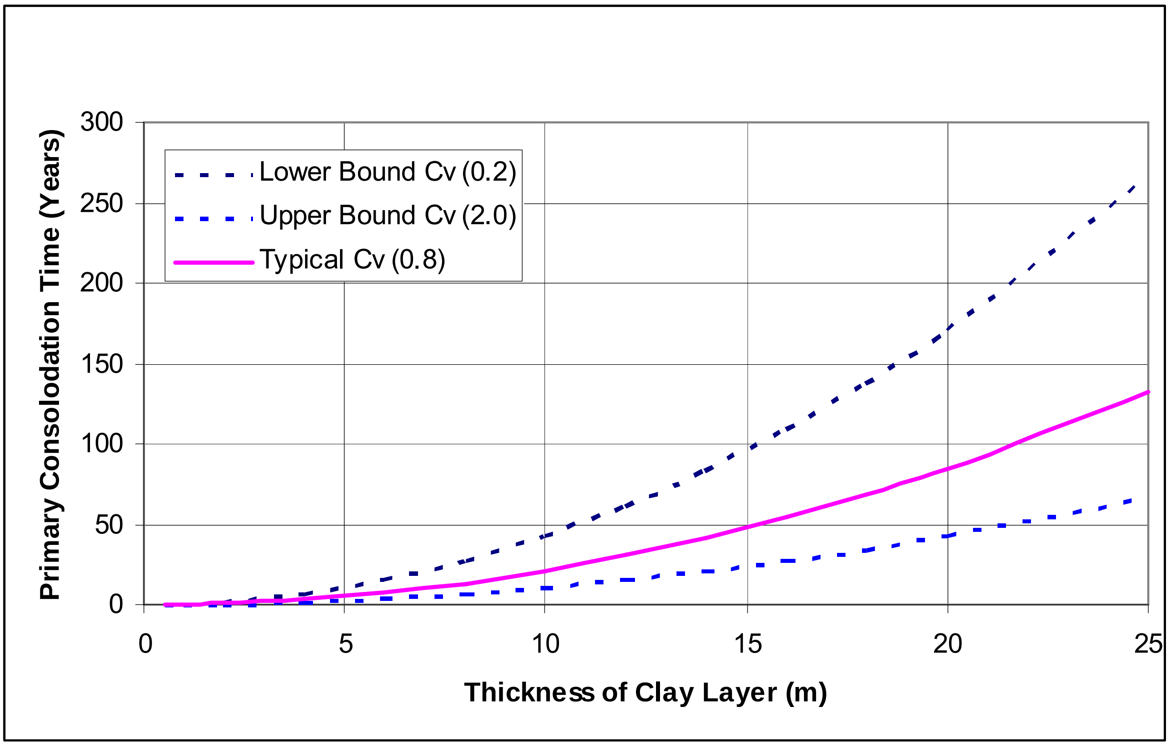

Figure 10: Primary Consolidation

It may be seen that the time for primary consolidation of a 15 m layer would be expected to take somewhere between 24 and 95 years, and probably around 50 years, in the absence of any intervening drainage layers.

The above is supported by monitoring undertaken by the RTA (Ref 9) for the Hexham bridge approach ramps (east of the site). The monitoring recorded settlements in the order of about 700 mm under a 65 kPa embankment load. Additional post construction settlements, also observed at the approaches, are probably associated with secondary (creep) settlements. The original estimated consolidation time was 15 years, which was reduced to about 1.5 years by using wick drains to accelerate consolidation. The thickness of the soft to firm clays at the Hexham bridge site were typically less than those at the QR site.

7.3 Foundation Conditions

7.3.1 Buildings

Due to the relatively low strength of the soft to firm clays, the use of high level foundations would not generally be feasible for any heavily loaded structure, particularly where the structure is sensitive to settlement.

The site is classified as Class P in accordance with AS 2870-2011 (Ref 10) due to the presence of the soft to firm clays and the associated long term total and differential settlements. Footings, therefore, will need to be designed in accordance with engineering principles.

Based on the results of the testing, it is considered that the applied bearing pressure beneath pad footings, strip footings or raft edge beams should not exceed 40 kPa and the width of pad and strip footings should not exceed 1 m and 0.5 m respectively. The actual bearing capacity would be a function of the strength of the natural clays, thickness of filling over the clay and dimensions of the footing and therefore should be confirmed during detailed design. Furthermore, as the ground conditions generally decrease with depth, footings should be founded as shallow as practicable. Notwithstanding the above, footings as designed above are expected to undergo settlements in the range of 20 mm to 50 mm in addition to settlement associated with any filling placed over the site (refer Section 7.2 above).

Heavily loaded structures, or settlement – sensitive structures, will need to be founded on piled foundations, with the foundations taken to the underlying sand or bedrock. Further comments on piles are presented in Section 7.6.

As an alternative to piled structures, ground improvement could be considered to improve the shear strength of the underlying clay with the aim of increasing the bearing capacity of the upper soil profile and reduce the magnitude of total and differential settlements. Further comments on ground improvement are presented in Section 7.4

7.3.2 Rail Embankment

Due to the presence of soft clay at the site, it is recommended that a slope stability assessment and analysis is undertaken once embankment heights and train loads are finalised. A preliminary geotechnical assessment on the expected track settlement for an unimproved site and slope stability of the rail embankment is presented in Appendix F. The results of the analysis was based on the elevation of the previous development and therefore should be confirmed during detailed design.

Ground improvement may be required to increase the shear strength of the underlying clays and thereby increase the factor of safety against failure.

Based on previous assessments at the site, a preliminary batter slope of 1V:3H should be adopted until more rigorous analysis is undertaken.

7.4 Ground Improvement Options

A number of possible ground improvement options may be considered, including:

- Preloading: this involves applying a load to the foundation which is equal to or greater than the final loads after construction. The load is usually applied in the form of additional fill material which is later removed. This method is one of the most straightforward and effective ground improvement techniques, but can require significant time. The proximity of the existing rail infrastructure and existing major services should be considered with preloading as preloading can induce settlements beyond the footprint of the surcharge and such settlements would need to be assessed and managed;
- Wick drains: carried out in conjunction with preloading in order to accelerate the consolidation process by providing a shorter drainage path for the expulsion of water. This method has been used with success for the approaches to the Hexham Bridge;
- Deep Soil Mixing: columns are formed by mixing lime and / or cement with the soft clay to form a column of treated soil. They reduce the plasticity and compressibility of the soil. Typical column diameters are 0.5 m to 0.8 m, spaced at 1.5 m to 2.5 m centres. The thickness of the clay may preclude full penetration of the clay but partial penetration would improve the shear strength of the upper clay stratum and provide increased shear resistance to improve stability of embankments and provide higher bearing capacities for shallow footings. This method has also been used with success for limiting differential settlements beneath embankments and light weight buildings;
- Vacuum consolidation involves extraction of pore water under vacuum, thereby causing consolidation without the need for any surcharge loading. It thereby replicates the effect of preloading without the need to bring in (and subsequently remove) large quantities of fill. A closely spaced series of vertical drains and pumps is installed. A limitation is that the maximum pressure that can be generated is around 80 kPa (limited by atmospheric pressure). Some surcharge fill may still be required depending on the final embankment height and loads applied. The surcharge would be applied simultaneously to the vacuum. The proximity of existing services and rail infrastructure may preclude this ground improvement option;
- Stone columns: this involves the installation of many stone piers to a stable stratum (such as the lower sand), which then support the ‘earth raft’ of compacted sand which forms the immediate foundation for the development; also known as ‘vibro – replacement’. The columns are typically 0.8 m to 1.2 m in diameter, spaced on a 1.5 m to 3 m grid. The thickness of the clay however, may preclude this method.

It should be noted that the above techniques do not eliminate post-construction settlement: they merely aim to reduce settlement to manageable/tolerable levels.

7.5 Preload

7.5.1 Preload Times

It is considered that preloading would be a suitable technique for this site taking into account existing services and infrastructure, however it should be recognised that in the areas of thick soft clay, the preload times will be excessive unless additional measures are taken such as the installation of wick drains (discussed further below). The preload should aim to achieve 90% primary consolidation, and the time for this to occur is related to the soft clay thickness and the coefficient of consolidation (c_v).

Areas where the very soft to soft clay is the maximum of about 15 m thickness would require preload times of up to about 25 to 50 years.

Vertical Wick drains installed at optimum spacing of probably about 1.5 m to 2 m would reduce the preload time for the thickest clay to about 1.5 years based on the RTA experience at the Hexham Bridge (Ref 9).

Further subsurface investigations and detailed analysis would be required to delineate the areal extent, strength and thickness of the soft clays in order to optimise the construction preloading times and spacing of wick drains.

7.5.2 Preload Design

Preliminary comments are presented on the use of sand as a preload material, but the use of on-site filling such as chitter could be utilised subject to further assessment.

The preload should cover areas where strength gain is required for stability/bearing capacity and long term settlements are needed to be reduced to acceptable levels. Such areas may include building areas, rail embankments, roads and services.

The height of preload required depends on the final loads, on the density of the preload material and on slope stability considerations. For example an embankment of 2 m may require a preload height of 4 m; that is 2 m height of sand fill placed temporarily above the general site finished level and removed after 90% primary consolidation is complete.

The stability of the preload mound at the edges of the fill embankment will require assessment and design to ensure batter slope stability. It is commonly found in the Hunter River estuary areas that batter slopes of 1V:3H are suitable for the general fill (or stability berm at the toe of the preload mound) and 1V:1.5H for the preload fill.

7.5.3 Preload Construction and Monitoring

The magnitude and rates of settlement are estimated from the results of geotechnical investigation and analysis. Preliminary estimates are included in this report on the basis of a few tests only.

Even after more detailed investigation and design, the preload performance must be monitored by geotechnical instrumentation and survey.

The instruments normally include settlement monitoring plates to measure surface settlement, inclinometers to measure lateral deflections, and piezometers to measure pore water response in the soft clay. Survey of the settlement monitoring plates and the preload mound height and location would be carried out by project surveyors.

The results of monitoring should be compared with settlement predictions so that the soil settlement model can be refined, and predictions updated, as the preload consolidation proceeds on the site.

7.6 Piles

Heavily loaded structures, or settlement–sensitive structures, which include overhead cranes, could be supported on separate piled foundations.

Preliminary column loads provided by the client indicate that the main portal fame will be in the range of 40 tonne to 50 tonne (about 400 kN to 500 kN) and between 20 tonne and 40 tonne (about 200 kN to 400 kN) for the service platform. The loads are assumed to be working loads.

Various pile types have been considered for this project and are discussed below.

Driven piles such as timber, concrete or steel will require splicing to achieve a suitable founding stratum which is typically encountered at depths of 17 m to 23 m. Noise and the potential for vibration should be also be considered with these piles types.

G-piles could also be used at the site which would minimise noise and vibration. The G-pile is a concrete precast pile which is pushed into the ground until the pile achieves a particular load capacity. The piles are easily spliced together until a suitable founding stratum is encountered.

Steel screw piles are not considered suitable due to the applied loads and the depth to a suitable founding stratum as these piles only gain load capacity from end bearing and therefore rely solely on a suitable end bearing stratum.

Uncased bored piles are not considered suitable as bore hole collapse would be expected upon withdrawal of the augers within the saturated alluvial sands that underlie the site.

Screw cast concrete piles were considered but the depth to a suitable founding stratum is expected to be beyond the reach of such piling equipment.

Continuous flight auger (CFA or grout injected) piles could be used provided the depth of reach of such piling equipment is suited for this site. The disadvantage with these pile types is that the capacity cannot be estimated during augering and accordingly additional CPT would be required to assess the variability in ground conditions across the site. Furthermore, spoil is generated from piling activities which could expose potential acid sulphate soils. In this regard the layout of the proposed developed has changed since the previous investigation in 2007 and additional investigation is recommended at proposed building locations.

Pile capacity plots are provided in Appendix E for single 350 mm square concrete driven pile and 0.25 m diameter timber pile, in vertical down-thrust. The pile capacities have been estimated based on the profile at CPT 4 and CPT 11 which are considered typical of the tests that were undertaken.

These plots suggest that a Geotechnical Strength (R_{dg}) in the order of 270 kN to 600 kN (working load of 200 kN to 440 kN) could be gained within the sand layer encountered at depths in the range of about 18 m to 24 m for both driven timber and concrete piles. Higher capacities may be achieved if the piles are driven further but additional deeper investigations would be required to confirm the deeper stratum.

The ground around pile – supported structures would continue to consolidate over the years and the design of services and pavements would need to take this into account.

A suitably designed bridging layer would be required over the existing soils to enable access for piling rigs and construction equipment, particularly in the northern parts of the site.

7.7 Pavements

7.7.1 Subgrade Conditions

Based on the subsurface conditions encountered at the test locations, the subgrade conditions across the site are expected to comprise silty clay or filling (generally southern parts of the site). Coal tailings which are very soft / soft inconsistency could also be encountered on the western parts of the site (ie west of CPT 12).

The success of the earthworks and site preparation will depend on the experience of the contractor, on the equipment, techniques and materials used, and on the prevailing weather conditions. In this regard, it is suggested that a field trial pavement be undertaken at the commencement of earthworks to address and revise the subgrade preparation measures presented below.

Laboratory testing on clay subgrade indicated a CBR (4 day soaked) of 1.0% and 2.0% with field moisture contents of up to 15.9% above optimum moisture content. This is consistent with previous investigations undertaken in the Hexham area.

The dynamic penetrometer results suggest that a crust is present over the site which is generally about 0.5 m to 1 m thick. The subgrade significantly reduces in strength below this level. It is recommended (where possible) that pavements are constructed with minimal excavation into the surface crust to avoid exposing the underlying soft and wet soils.

The low strength of the soils is expected to require a bridging material to enable compaction of pavement layers. The thickness of the bridging material will depend on the location of the pavement, weather conditions at the time of construction, the type of bridging material to be used and the earthworks contractor's experience.

Based on the results of field work together with previous laboratory testing, a CBR value of 1% was adopted for the on-site clay soils for pavement design purposes. Where existing pavements are present and trafficability is reasonable, a bridging layer may not be required.

7.7.2 Traffic Loading

It is understood that three B-double tanker trucks will service the facility each day together with other delivery trucks on an infrequent basis. As provided by GHD, the estimated traffic design load adopted for preliminary design for the access road is 5 x 10^5 ESA (based on anticipated traffic loading) or 1 x 10^7 ESA (based on industrial road classification). The design for both loading scenarios is provided below. The pavement thickness design is preliminary and subject to detailed design. The design should be reviewed if more detailed traffic information becomes available and/or concentrated wheel loads such as those imposed by forklifts are proposed.

7.7.3 Pavement Thickness

Two pavement options have been considered for the proposed road which include the following:

- Option 1 - Unbound granular pavement;
- Option 2 – Bound pavement.

These options are for vehicular movements along the alignment with the exception of drains and creek crossings.

A third option has also been presented for the construction of temporary access roads that do not require sealing.

Options 1 and 2: Bound or Unbound Pavement

The poor strength of the natural clay may result in construction problems associated with compaction of the overlying pavement material and poor trafficability over the site.

For the reasons provided above, it is suggested that a geofabric be placed over the surface in some areas followed by a select subgrade to provide a working platform. The thickness of the select material would depend on moisture conditions at the time of construction. The use of a 300 mm to 500 mm select material would improve constructability of the pavement. A thicker layer would be required if the upper crust is removed. The required thickness of the select layer will depend also on the properties of the material. It may be necessary to use sand as a select subgrade particularly in areas where water is ponding to improve drainage of the base material. The use of an open ballast material could also be considered but would require a geofabric separator to reduce migration of fines into the ballast. Alternatively, self-cementing material would be preferred to bridge the underlying softer ground.

The following pavement thickness designs have been based on Austroads (Ref 11). It should be noted that the pavement provided below could be locally thicker in poorer subgrade areas.

Table 11: Preliminary Pavement Thickness Design: (Options 1 and 2) – 5 x 10^5 ESA

Pavement Layer	Thickness (mm) CBR = 1% (clay)	
	Unbound (Option 1)	Bound (Option 2)
Asphalt and Primer Seal	40	40
Basecourse / Subbase	580	340
Select Subgrade	300 - 500	300 - 500
Total	**620 plus select**	**380 plus select**

Table 12: Preliminary Pavement Thickness Design: (Options 1 and 2) – 1 x 10^7 ESA

Pavement Layer	Thickness (mm) CBR = 1% (clay)	
	Unbound (Option 1)	Bound (Option 2)
Asphalt and Primer Seal	40	100
Basecourse / Subbase	800	360
Select Subgrade	300 – 500	300 – 500
Total	**840 plus select**	**550 plus select**

Option 3: Recycled Truck Tyres

An alternative system for the use as a temporary access road involves the use of recycled truck tyres (Ecocflex), which are laid over a geofabric layer placed directly on the existing ground surface. The tyres are then filled with granular material. A second layer of tyres can be placed if necessary. This system is a recent innovation and there is little data available on the performance of such systems and no formal design method has been developed for this system. Douglas Partners experience with this system for a temporary access road, however, suggests such systems have performed well in similar situations.

7.7.4 Subgrade Preparation

Based on the results of the investigation, soft to firm or wet clay soils are expected for the majority of the alignment.

Preparation of the natural subgrade should include the following:

- Remove large vegetation (trees and shrubs) or deleterious materials. The grass could be retained for temporary roads;
- Rubber tyre vehicles should not travel on the exposed subgrade;
- Due to the high moisture condition of the subgrade soils, it will be necessary to place the select layer (Options 1 and 2) immediately over the subgrade (ie without compaction of the subgrade). The thickness of the select subgrade should be confirmed by geotechnical inspection and dynamic penetrometer testing but is expected to range between 300 mm and about 500 mm. A suitable bridging material, would comprise sand, crushed recycled concrete (if suitable), ballast or similar (CBR≥15%, PI≤5%). Where open graded material is used as a bridging layer or as a pavement, a geotextile should be used over the bridging layer, to prevent subsequent filling from migrating into the rock fill voids. Compaction of the bridging layer should involve surface rolling (about 6 to 8 passes) initially with a tracked excavator and possibly with a medium size roller of non-vibration mode;
- If heaving occurs, leave the select subgrade for one or two days to allow pore pressures to dissipate or increase the layer thickness;
- For Option 3, place the geofabric over the surface following removal of trees, grass and shrubs followed by the truck tyre system;
- Place and spread granular fill from the layer of existing fill in such a manner that the need to traffic the exposed surface of the weak material is avoided. Compaction of the pavement should involve surface rolling (about 6 to 8 passes) with a roller of at least 8 tonnes capacity operating in non-vibration mode.

Geotechnical inspections and testing should be undertaken by DP during construction to confirm the above requirements. Additional assessment is required to confirm the properties and site preparation measures associated with the coal tailings stockpile in the area west of CPT12.

7.8 Drains

There are numerous drains along the alignment, many of which will require crossing. The majority of these drains are expected to encounter very soft clay to below the drain invert level. Additional testing would be required to establish the depth of soft clay.

For drains containing significant thicknesses of very soft soil it is expected that any filling material placed in these drains will displace and sink into the very soft clay. This displacement can be reduced by the placement of a geo-fabric material in conjunction with coarse cobble filling, however the depth and extent of clay displacement is difficult to predict. In addition, the displacement of the softer clay would also depend on the thickness of the filling and placement methods. It is suggested that a trial be undertaken to assess whether it will be feasible to use a fill bridging layer, as discussed above, to found the culverts and overlying pavement.

7.9 Proposed Excavations

It is understood that excavations are proposed for the site for a possible underfloor, detention basins and service trenches. Subsurface conditions are expected to comprise filling, firm to stiff clays overlying saturated silty sands and soft to firm clays.

Based on the results of the investigation potentially collapsing conditions are expected where excavation is proposed through soft to firm clays and saturated silty sand / sand. These soil conditions were encountered at the majority of test locations beneath the filling and upper ‘crust’ of the natural soil.

Groundwater was encountered at or near the surface and accordingly groundwater seepage is also expected in proposed excavations.

Temporary excavations (less than about 1 m below natural ground levels) could be undertaken provided the excavation is battered at 1H:1V and groundwater is managed. If saturated sands or granular fill are encountered during excavation, the batter will need to be reduced to at least 2.5H:1V or potentially flatter.

There is a risk that base heave and accompanying large settlements of the ground surface could occur where excavations are proposed through the soft clay. Preliminary calculations indicate that, for excavations of about 3 m with no surcharge load, the factor of safety against base heave is about unity and less if surcharge pressure (such as excavator or spoil) is applied to the adjacent ground surface.

Based on the above, if it is essential to have equipment at the surface which applies surcharge pressure or if excavations are required to be greater than say 2.5 m depth (without surcharge), the excavation will need to be supported by sheet piling, braced internally as the excavation proceeds. The sheet piling will need to be driven to a sufficient depth below the excavation base to ensure stability and prevent base heave.

Due to the variability of the depth and strength of the soft clay at the site, it is recommended that detailed geotechnical analysis is undertaken to refine the requirements at the site specific locations following completion of detailed design and confirmation of construction methods.

Excavation into the soft clays or saturated silty sand/sand will probably require granular bedding material, such as ballast, slag or rock spalls at the base of the excavation, to assist with construction.

Based on the shallow groundwater levels at site it is anticipated that most excavations will intersect groundwater. Temporary dewatering may be required to allow construction activities, especially for the access road, culvert and buried service excavations. For the proposed cess drains and detention ponds it may be possible to excavate these without dewatering.

Excavations on the southern parts of the site will be predominantly through existing filling which is typically granular and can be expected to be relatively permeable. Dewatering is likely to be achieved by a combination of sump and pump methods for localised excavations with the possibility of spear point dewatering in some areas.

On the northern parts of the site excavations will be through the natural clay soils, which are generally of low permeability with the exception of local sandy or silty layers. Sump and pump dewatering is expected to be used and due to the low permeability of these soils flow rates are expected to be relatively low if they are not under surface water.

The detailed design should consider the subsurface conditions for excavation and dewatering requirements.

8. Contamination Assessment

8.1 Assessment Criteria

Selected existing fill materials encountered during the geotechnical assessment were assessed for potential contamination. The results of the chemical analyses were compared to the following NSW EPA recommended guidelines:

- NSW EPA (1994). Contaminated Sites – Guidelines for Assessing Service Station Sites, December 1994, (Ref 6);
- NSW DECCW, "Waste Classification Guidelines, Part 1: Classifying Waste," December 2009 (Ref 7);
- NSW EPA, Guidelines for the NSW Site Auditor Scheme, (2nd Edition) April 2006. (Ref 5).

The NSW EPA Guidelines for Assessing Service Station Sites (Ref 6) were used to assess total recoverable hydrocarbons (TRH) and BTEX contamination across the site. The criteria used are threshold concentrations for sensitive land use.

The NSW EPA Guidelines for the Site Auditor Scheme (Ref 5) contain National Environmental Health Forum (NEHF) health-based investigation levels for various beneficial use scenarios including: low density residential (A), medium/high density residential (D), recreational (E) and commercial/industrial (F). These criteria are applicable where aesthetic and ecological concerns are not an issue. The criteria for commercial/industrial land use (NEHF F) are considered appropriate for assessing contamination within soil over the site due to the proposed industrial development.

Classification of fill materials were conducted with reference to the NSW DECCW, "Waste Classification Guidelines, Part 1: Classifying Waste," December 2009 (Ref 7).

8.2 Assessment of Contamination

The results of chemical analysis on the two fill samples indicated the following:

- Soil chemical analysis results were generally within the health based criteria for commercial/industrial land use (ie NEHF F), and NSW EPA sensitive land use criteria for TRH and BTEX with the exception of elevated TRH detected in TP29/0.4 m;
- The samples tested are classified 'General Solid Waste', with respect to potential chemical contaminants.

If the fibro sheeting observed at the site (Figure 4) is found to contain bonded asbestos, testing of the soil matrix for asbestos is required, in order to confirm waste classification. Asbestos materials or asbestos impacted materials are classified as ‘Special Waste’ in accordance with Ref 7.

Dumped fill materials observed within the site are likely to be variable, and may contain further bonded asbestos (fibro) materials. Additional investigation is recommended to confirm the condition of fill materials with respect to potential chemical contamination and the potential for bonded asbestos fragments.

Investigation, remediation and validation of fill materials with respect to asbestos waste should be conducted by a qualified asbestos consultant.

Due to the presence and variability of extensive fill materials within the site, this assessment cannot be considered to be exhaustive and as such there may be areas within the site that have not been identified that may require remediation. Further detailed investigation should be carried out as the development proceeds. In this regard based on site observations and preliminary site history, the areas comprising potential contamination could include:

- Former above ground fuel storage tanks (ASTs) and bowsers (hydrocarbons);
- Truck wash bay (hydrocarbons);
- Railway lines: rail loop, rail line north of site, internal rail line 100m from east boundary running north-south (1986 orthophoto), and associated buildings on the northern boundary (servicing of locomotives) (herbicides, pesticides, heavy metals, hydrocarbons, asbestos);
- Ash from steam locomotives may have been deposited on site (metals, hydrocarbons);
- Fill materials of unknown origin – topsoil capping material and building rubble deposited across the site (metals, hydrocarbons, asbestos). Potential for further illegal dumping activities;
- Irrigation of treated effluent across northern half of site from Dairy Farmers (biological contaminants, nutrients, hydrocarbons etc);
- Acid drainage from former coal stockpiles (Acidic run-off, heavy metals);
- Leached salts from coal fine stockpiles (salinity in surface water and groundwater).

The additional assessment should include the following:

- Additional subsurface investigation, soil sampling and laboratory testing to assess potential soil contamination across the site;
- Installation of groundwater wells within the site, sampling and analysis.

If remedial works are required on the basis of further investigations, they should be conducted in accordance with an appropriate remediation action plan (RAP) with reference to relevant NSW EPA guidelines and regulatory requirements.

Please note, further details of contamination analysis and testing can be found within DP Report titled “Preliminary Contamination Assessment, Proposed Train Support Facility, Maitland Road and Woodlands Close, Hexham”, Project 39798.06, September 2012 (Ref 12)

9. Acid Sulphate Soil Assessment

The ASSMAC guidelines suggest that a soil pH<4 in water is an indicator of actual acid sulphate soils. The results of screening tests therefore suggest the absence of actual acid sulphate soils at the locations and depths tested.

The ASSMAC guidelines also suggest that indicators of potential acid sulphate soils (PASS) include the following:

- Soil pH <3.5 in H_2O_2 (ie. pH_{FOX});
- Drop of 1 pH unit or more between pH_F and pH_{FOX}.

A total of 29 of the samples tested exhibited a pH drop of greater than one pH unit and of these, five samples also exhibited a soil pH following oxidation below 3.5.

It is noted that the above test method is a qualitative method only and gives an indication of the intensity of total acidification (pH). The ASSMAC guidelines indicate that peroxide may also oxidise organic matter (in addition to pyrite) to produce acids which are unlikely to form under natural conditions, thus giving falsely high indication of acid sulphate potential.

Detailed (laboratory) testing was undertaken to more accurately determine the presence or absence of acid sulphate soil forming conditions at the site. The results of detailed analysis confirmed that there are potential acid sulphate soil conditions on the site.
The result of the chromium reducible sulphur testing and / or TPA testing for samples 14/2.4 m, 16/3.0-3.45 m, 27/1.5-1.95 and 30/0.4 m was above the ASSMAC action criteria for disturbance of soils (regardless of volume excavated) above and below. This means that an Acid Sulphate Soil Management Plan (ASSMP) will be required for any activities which are likely to disturb PASS (ie excavations which expose the natural clay / sand or when dewatering is required).

The ASSMP is presented in Report 39798.08-1, September 2012.

10. References

1. Douglas Partners Pty Ltd, “Report on Preliminary Geotechnical Investigation, Proposed Maintenance Facility, Woodlands Close, Hexham”, Project 39798 (Rev A), August 2008.
2. AS 2159-2009, “Piling Design and Installation”, Standards Australia.
3. ASSMAC Acid Sulfate Soil Manual”, New South Wales Acid Sulfate Soil Management Advisory Committee, August 1998.
4. NSW EPA Contaminated Sites. “Guidelines for Consultants Reporting on Contaminated Sites”, September 2000.
5. NSW EPA Contaminated Sites. “Guidelines for NSW Site Auditor Scheme”, (2^{nd} Edition) April 2006.
6. NSW EPA Contaminated Sites, “Guidelines for Assessing Service Station Sites”, December 1994.

7. NSW DECCW, “Waste Classification Guidelines, Part 1: Classifying Waste”, December 2009.

8. NSW EPA Contaminated Sites, “Sampling Design Guidelines”, 1995.

9. Coleman, R.A (1986) “Hexham embankment, Case study, Wick drains, Predictions”.

10. Australian Standard AS 2870-2011 “Residential Slabs and Footings”, Standards Australia.

11. Austroads 2012, “Guide to Pavement Technology Part 2: Pavement Structural Design”, Austroads Publication No AGPT02-12.

12. Douglas Partners Pty Ltd, “Preliminary Contamination Assessment, Proposed Train Support Facility, Maitland Road and Woodlands Close, Hexham”, Project 39798.06, September 2012.

13. Douglas Partners Pty Ltd, “Report on Groundwater Assessment, Proposed Hexham Redevelopment, Maitland Road and Woodlands Close, Hexham, Project 39798.05, February 2012.

11. Limitations

DP has prepared this report for a project at Woodlands Close, Hexham in accordance with DP's Proposal No P7771 dated 16 March 2007 and subsequent proposal NCL120293 dated 29 June 2012 and acceptance received by QR National. The report is provided for the exclusive use of QR National for this project only and 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. Subsurface 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.

It is noted that this report does not represent a preliminary contamination assessment in accordance with NSW EPA guidelines (Ref 4).

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

Summary of Previous Douglas Partners Reports

Douglas Partners
Geotechnics / Environment / Groundwater

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39798.08 – Preliminary Geotechnical Investigation, Hexham Summary of DP Projects

3389
Foundation Conditions Proposed Coal Preparation Plant
Hexham, May 1972

Client: J&A Brown, Abermain and Seaham Collieries Ltd

Purpose: Assessment of foundation conditions for proposed coal preparation plant.

Comments:
Four bores were drilled to between 24 m to 31 m depth. Insitu vane shear tests were carried out in soft clays in Bores 2 and 4. Rock coring was undertaken in Bores 1 and 2.

Subsurface conditions generally comprised filling (loose coal wash and soft to firm clays) up to maximum depth of 6 m underlain by soft to firm silty clays and shells to 12 m to 18 m depth; silty and sandy clays and silty sands with occasional gravel (medium dense in Bores 1 and 2, very loose to loose becoming medium dense from 22.5 m to 23m in Bores 3 and 4). Bores 1 and 2 were underlain by very stiff silty and shaley clays from 29 m depth, and soft shales from 29.5/33 m underlain by medium hard shale.

Groundwater was encountered in all bores between 0.5 m to 3.6 m depth during the investigation.

Undrained shear strength tests were performed on nine soft to firm clay samples from Bores 2 to 4. Triaxial testing was performed on two samples from Bore 2, and indicate an angle of shear resistance of 30^{o} to 31^{o}, and cohesion intercepts of 110 and 115 bs/ft^{2}.

Odometer testing of two samples from Bore 4 indicate the clays to be of high compressibility.

Permeability tests (in a triaxial cell) were conducted on three samples from Bore 2 (silty clay at 2.1 m and 4.5 m, and silty sand at 3.3 m). Results indicate very low clay permeability (10^{-7} to 10^{-8} cm/s) and relatively low permeability for sand (2.4×10^{-5} cm/s).

6109
Foundation Conditions
Proposed Road and Rail Interchange Station
Hexham, June 1978

Client: CMPS Consulting Engineers for RW Miller and Co

Purpose: Investigation for proposed road and rail interchange station.

Comments:
Five bores (including two CPTs) were drilled to between 3 m and 26.5 m depth. Subsurface conditions generally comprised alluvial soils (generally soft organic silty clays with some shells) to about 25 m depth underlain by coal and shale.

Laboratory shear strength testing of clays indicate an undrained cohesion of 19 kPa to 25 kPa. Odometer testing was performed on four clay samples and indicated the clays to be highly compressible.

16781
Geotechnical Investigation
Proposed Depot Redevelopment, Australian Co-Operative Foods Ltd
New England Highway, Hexham, August 1993

Client: Meinhardt (NSW) Pty Ltd

Purpose: Proposed redevelopment (new buildings). Estimate settlements for proposed high level footings, estimate pile capacities for proposed deep footings, comment on site preparation and general construction practice.

Comments:
High Level Footings: Lightly loaded structures may be supported on high level footings such as raft slabs, pad footings or strip footings, provided the estimated settlements (given in Table 1, 16781) are acceptable. As ground conditions generally decrease in strength with depth, footings should be founded as shallow as practicable (about 300 mm below finished surface level). The applied bearing pressure beneath pad footings, strip footings or raft slab edge beams should not exceed 50 kPa. Overall distributed raft slab loads should not exceed 25 kPa. Width of pad and strip footings should not exceed 1.0 m and 0.5 m respectively. Edge to edge distance between footings should be at least 3 m.

Deep Footings: Heavily loaded structures (such as silos) should be supported on piled foundations. Piles should be founded in the very dense sand encountered between approx. 8.7 m to 10.3 m depth. Refer to table below for estimated pile capacities.

Table: Estimated Pile Capacities

Pile Type	Approx Founding Depth (m)	Allowable Load (kN)
Driven Timber (300 mm toe)	10 - 12	500 – 700
	13 - 15	800 – 900
Driven Steel Tube 450 mm diameter (closed end or soil plug)	10 - 12	1000 – 1200
Grout Injected 500 mm diameter 600 mm diameter	11 - 13	350 – 400
	11 - 13	650 – 700

Site Preparation: For structures on shallow footings, remove 1m of soil and replace with granular filling such as sand or granulated slag compacted to 75% density index or 100% Standard dry density ratio. Note groundwater flow may be expected where excavating to over 0.5 m depth. Hence ground improvement may require dewatering etc.

17163 and 17163A
Geotechnical Investigation and Building Preload
Proposed Service Station Redevelopment
Pacific Highway, Hexham, August 1995

Client: Shell Company of Australia Ltd

Purpose: Provide footing design parameters, settlement estimation, subgrade evaluation and pavement thickness design, soil chemical aggressiveness, and comment on slope instability and mine subsidence for proposed new service station building and pavements. Settlement monitoring of preload beneath proposed building area.

Comments:
8 bores drilled to 5.5 m/8.5 m depth, and wells installed (see 17163/1 below). Ground conditions generally comprised fill to 0.5 m/1.25 m underlain by soft to firm silty clay to 1.4 m/2.0 m, very loose clayey sand to 5.5+/6.0, and very soft to soft silty clay to >8.5 m depth. Groundwater was observed in wells between 0.25 m to 0.95 m AHD on 25/7/95.

CBR of sandy gravel filling (coal refuse) was 35%. Total settlement for a ‘L’ shaped 450 m^2 raft slab with overall site surcharge load of 12 kPa, uniformly distributed building load of 5 kPa to 13 kPa, total load in building area (including fill under slab) of 10 kPa to 17.6 kPa, and internal and edge beam width of 0.4 m – average spacing of 4 m was estimated to be 80 mm to 130 mm.

17163A – The building area was preloaded with 1.5 m select granular material. Monitoring recorded 56 mm to 82 mm settlement after 45 days under load (primary consolidation was still in progress when preload was removed). Following preload, new settlement estimates were 20 mm to 50 mm.

17163/1
Preliminary Contamination Assessment
Proposed Service Station Redevelopment
Pacific Highway, Hexham, August 1995

Client: Shell Company of Australia Ltd

Purpose: Investigate existing contamination onsite resulting from ongoing use as a service station.

Comments:
8 wells installed to 5.5 m/8.5 m depth. Ground conditions generally comprised fill to 0.5 m/1.25 m underlain by soft to firm silty clay to 1.4 m/2.0 m, very loose clayey sand to 5.5+/6.0, and very soft to soft silty clay to >8.5 m depth. Groundwater was observed in wells between 0.25 m to 0.95 m AHD on 25/7/95. Local groundwater contours indicate general north-easterly flow toward the Hunter River at a gradient of 0.7%.

Elevated PID in soil was observed in Well 2 at 0.5 and 2.0m depth (465 ppm and 148 ppm respectively). Elevated PID in groundwater observed in Bores 2, 3 and 6 (230 ppm to 2500 ppm). No floating product detected with oil-water interface meter.

No chemical testing of soil conducted. Results of chemical testing of groundwater indicated Wells 2 and 3 exceed “EPA Service Station Sites” for BTEX (maximum benzene was 32 mg/L and xylenes 18 mg/L). Wells 4, 6, 7, 8 exceed “EPA Service Station Sites” for lead (0.05 mg/L to 0.08 mg/L).

18419, 18419A, 18419B
Geotechnical and Acid Sulphate soil Investigation
Proposed Effluent Ponds
ACF, New England Highway, Hexham, November 1995

Client: Meinhardt (NSW) Pty Ltd

Purpose: Geotechnical and acid sulphate soil investigation for two proposed effluent ponds.

Comments:
Subsurface conditions generally comprised filling to 0.3 m/0.75 m underlain by firm to stiff clay to 1.1 m/1.3 m, soft to firm/loose sandy clay/clayey sand to 2.3 m/2.6 m, loose/soft clayey sand to 3.1 m/3.5 m, and very soft clay and shells to termination at 3.6m /4.2 m. Groundwater seepage was observed between 1.1 m and 3.8 m depth in the test pits. Testing of silty clays between 0.3 m/1.3 m indicated a field moisture content between 24% to 41%, Plasticity Index of 56% to 58% and Emerson Class Number 5.

Acid sulphate soil laboratory testing of two soil samples at 0.5 m and 1.0 m depth indicated a Total Actual Acidity of 0 mol/kg, and a maximum Total Potential Acidity of 0.03 mol/kg, which indicates low acid sulphate potential.

18457

Geotechnical Investigation, Proposed Industrial Development Lots 1 and 2, Old Maitland Road, Hexham, February 1996

Client: Stephen H Savage, Consulting Engineer

Purpose: Estimation of settlements, consolidation rates, site improvement options and footing / pile design parameters for a proposed steel clad portal frame workshop, brick veneer office and amenities and 2.1 m to 2.4 m fill pad (with retaining walls).

Comments:
Two CPTs to 15 m depth and pore pressure dissipation tests in clay strata were conducted on the site. Soil profile comprised fill to about 1 m, interbedded firm clays and loose sand to about 4.5 m, soft to firm silty clay to 17.7 m/18.1 m, underlain by very stiff clay and medium dense sand to >22 m. Groundwater was observed from 1-1.5 m. Settlement estimates for a 45 kPa to 60 kPa load ranged between 240 mm to 365 mm.

For comparison it was noted that at the Hexham bridge approach embankment settlements of 530 mm to 615 mm were recorded under an applied load of 65 kPa. The soil profile included an 11-16 m thick layer of very soft silty clay. Laboratory testing of samples from the Hexham bridge approach indicated an average c_v of 0.5 m^2/yr for very soft silty clay (range of 0.1 m^2/yr to 2.5 m^2/yr). (Ref: Coleman RA (1985) “Hexham Embankment Case Study, Wick Drains, Predictions”).

18603

Geotechnical Investigation Proposed Extensions to Club and Carpark Hexham Bowling Club, Hexham, November 1996

Client: Michael Fitzgerald Consulting Engineers Pty Ltd

Purpose: Geotechnical investigation for a proposed one to two storey building extension and pavements.

Comments:
The investigation comprised two CPTs including dissipation testing to 20 m, and six test bores to 1.2 m to 1.9 m depth. Soil profiles comprised filling to 0.5 m/1.3 m depth, soft to firm silty clay to 15.0 m/15.6 m, medium dense sand with interbedded sandy clay to 18.3 m, underlain by firm to stiff silty clay becoming sandier with depth to >20 m. Groundwater was observed from 0.9 m depth during the investigation. Refer to report for settlement estimates and coefficients of consolidation.

18891
Geotechnical Investigation, Proposed Access Road
Hexham, September 1998

Client: GHD Pty Ltd

Purpose: Assess subsurface conditions and provide pavement thickness design and subgrade preparation measures for a proposed 3 km long access road alongside the main northern railway line.

Comments:
Subsurface conditions generally comprised filling to 0.7 m/1.0 m depth, (sand in some locations 0.2 m/0.3 m thick), clay generally firm to stiff (soft in TP5) with shear strength generally decreasing with depth. Groundwater seepage was observed at most locations between 0.5 m to 1.0m depth.

18891A

Geotechnical Investigation, Power Poles
Access Road Smithy's Crossing, Hexham, January 1999

Client: GHD Pty Ltd

Purpose: Assess subsurface conditions and provide comments on lateral stability of existing and proposed power poles adjacent to the Great Northern railway line at Hexham.

Comments:
Subsurface conditions generally comprised fill (railway ballast) to 0.2 m/0.6 m underlain by generally firm silty clay (very soft in Bore 2) to 1.2m depth becoming sandy and very soft from 1.2 m/1.4 m depth. Bore 5 encountered filling to 1.7 m. Groundwater was observed between 0.55 m and 1.0 m depth during the investigation.

18944, 18944A, 18944B
Groundwater Monitoring, Dairy Farmers, 189 Maitland Road, Hexham, February 1999 to November 2000

Client: Dairy Farmers

Purpose: Installation of 10 groundwater monitoring wells and subsequent groundwater monitoring to assess potential groundwater impacts resulting from operation of a liquid waste disposal system utilising spray irrigation (under EPA licence).

Comments:
The bores generally comprised topsoil or fill to 0.2 m/0.5 m, underlain by silty clays to 0.5 m/2.8 m, underlain by sandy clays to termination between 2.8 m/4.3 m. Clayey sand layers were encountered in Bores 5, 8 and 10.

Groundwater levels ranged between 0.36 m to 1.26 m AHD on 9/04/99, 0.12 m to 0.96 m AHD on 28/9/99, and –0.43 m to 1.49 m AHD on 4/10/00. Groundwater contours generally indicate groundwater associated with the factory complex (east of the railway) generally flows east toward the Hunter River with a hydraulic gradient of 0.015 to 0.017. Groundwater associated with effluent irrigation areas west of the railway line generally flow north and north-west toward the tidal drain, with a relatively flat hydraulic gradient (0/0005-0.003). Note groundwater levels were measured following an above average period of rainfall.

Results from installation of piezometric data loggers in wells 3, 6 and 9 suggest minimal tidal influence on groundwater from the Hunter River.

Rising Head (Slug) tests in wells 3, 5, 7 and 10 estimated hydraulic conductivities of sandy clays / clayey sands to be between 2 x 10^{-6} m/s and 7 x 10^{-6} m/s. Assuming an aquifer porosity of 0.4, the groundwater seepage velocity beneath the factory complex was estimated to be 4m to 5 m/year towards the Hunter River. West of the railway line, groundwater seepage flows were estimated to be 0.5 m to 2 m/year north toward the tidal drain.

Groundwater Quality: EC testing indicates very high to extremely high salinity. Elevated concentrations of faecal coliforms (FC) and TKN were encountered in wells 3, 9 and 10 (and well 7 for TKN). Comparison of GC in irrigation effluent and the groundwater concentrations indicate significant dilution and attenuation has occurred.

31773
Geotechnical Investigation
Augmentation of Hexham Bowling Club Wastewater Facilities
Hexham Bowling Club, Hexham

Client: Hunter Water Australia

Purpose: Geotechnical and acid sulphate soil investigation for the upgrade of an onsite wastewater facility within club grounds.

Comments:
Investigation comprised drilling of two bores to 7.3 m depth. Subsurface conditions comprised filling to 0.4 m/1.0 m, underlain by very soft to firm (typically soft) clay / sandy clay to >5.0 m. Groundwater was encountered between 0.8 m to 1.2 m during the investigation, and from 1.85 m within piezometer B101 on 11/7/03 (3 days after drilling).

Acid sulphate soil screening, TPA and chromium reducible sulphur testing indicate the presence of Potential Acid Sulphate Soils below 2.8 m depth.

39033

Geotechnical Investigation, Proposed Weighbridge Sparke Street, Hexham, September 2004

Client: Ridge Group

Purpose: Comment on suitable footing types and expected settlements for a proposed weighbridge.

Comments:
Ground conditions comprised filling to about 2.2 m to 2.5m underlain by compressible clays with medium dense to dense sand from about 12.4 m depth. Groundwater was observed from about 1 m during the investigation.

Expected settlement estimates are based on a working load of 550 kN and placement of 0.5 m of additional filling. Pad footings: for 3 strip footings 3.5 m by 1 m, total settlements are in the order 35 mm to 50 mm. Stiffened raft: of dimensions 3.5 m by 25 m, estimated total settlement is 20 mm to 30 mm.

Site preparation for shallow footings include replacing existing filling to 0.5m below existing ground level, before placing additional bridging material up to 0.5m (total bridging layer of 1.0 m).

Piled footings founded on medium dense to dense sand encountered from about 13 m depth may be necessary if the expected settlements of the proposed structure exceed acceptable limits.

Appendix B

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.

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.

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.

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

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

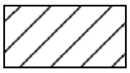
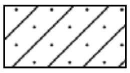
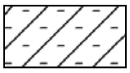
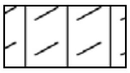
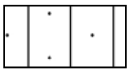
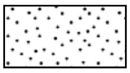
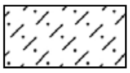
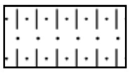
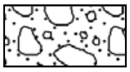
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

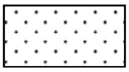
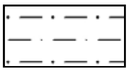
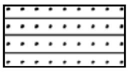
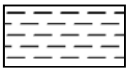
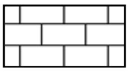
General

■	Asphalt
	Road base
	Concrete
	Filling

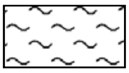
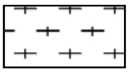
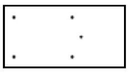
Soils

	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

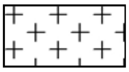
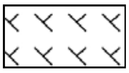
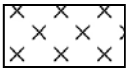
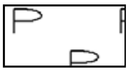
Sedimentary Rocks

	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

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

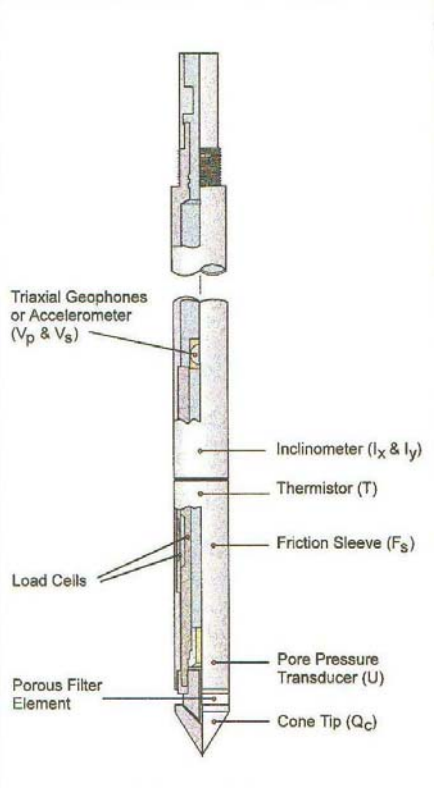


Figure 1: Cone Diagram

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)

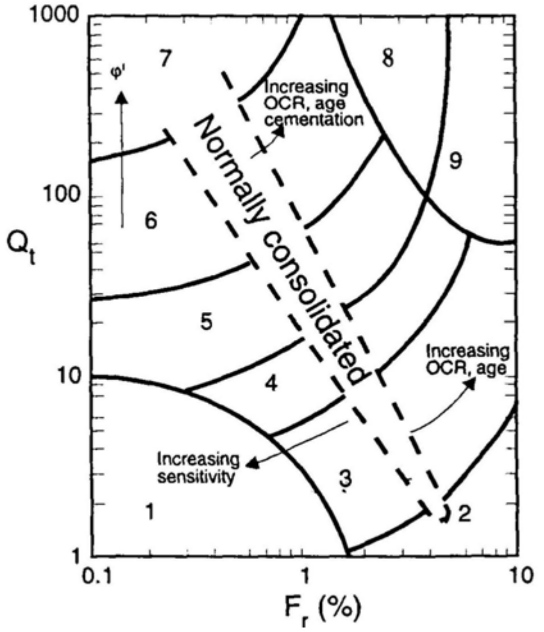


Figure 3: Soil Classification Chart

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.

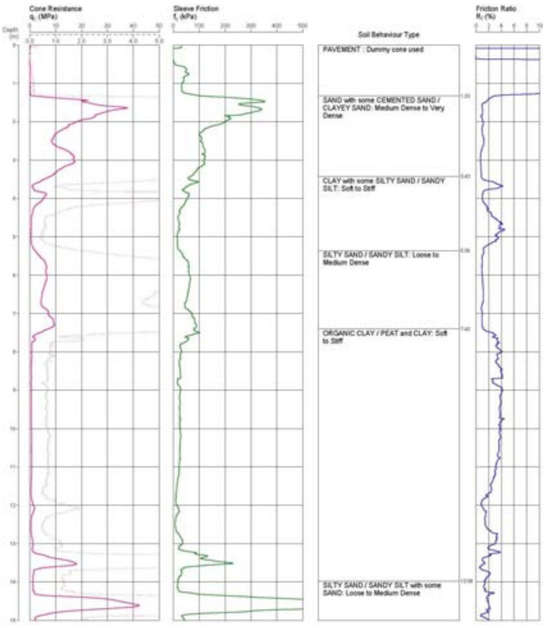


Figure 4: Sample Cone Plot

CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

PROJECT No: 39798

CPT 2

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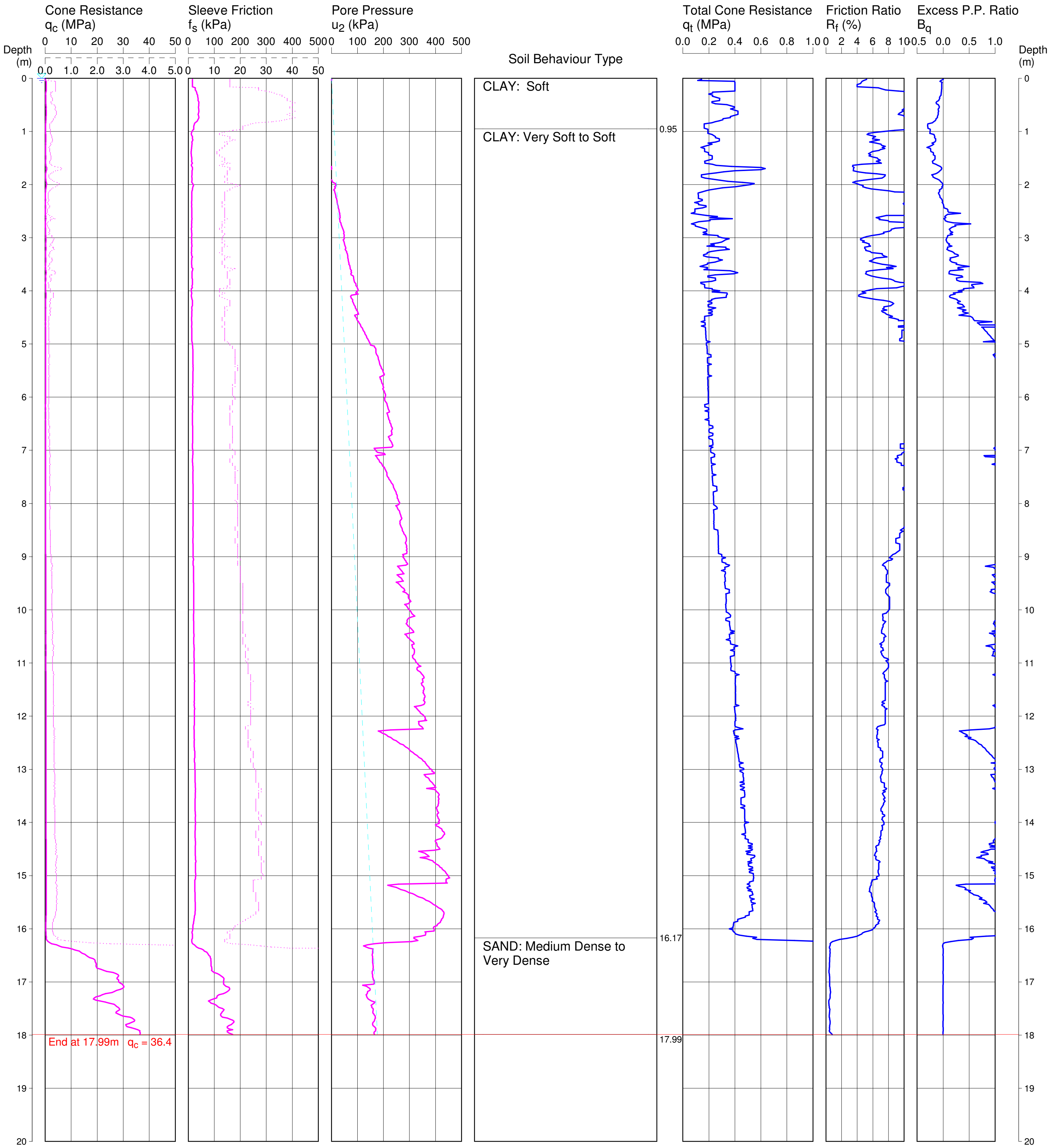
DATE 17/08/2007

SURFACE RL: 0.69 AHD



REMARKS: DEPTH TO WATER AT SURFACE
E 363744 N 1366402

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT02.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.8.1

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CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

PROJECT No: 39798

CPT 3

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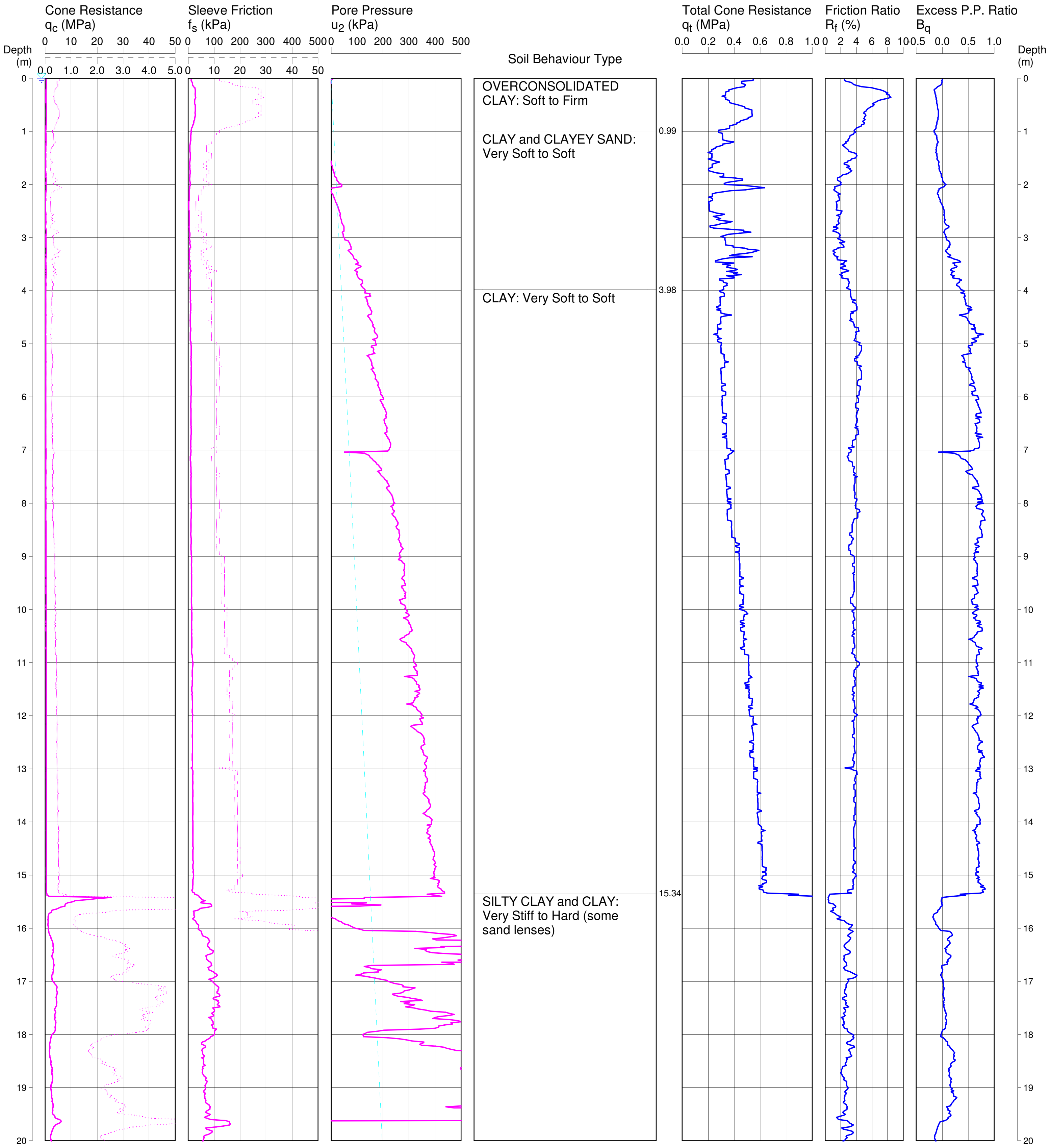
DATE 20/08/2007

SURFACE RL: 0.68 AHD



REMARKS: DEPTH TO WATER AT SURFACE
E:363762 N:1366349

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT03.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.8.1

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CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

PROJECT No: 39798

CPT 3

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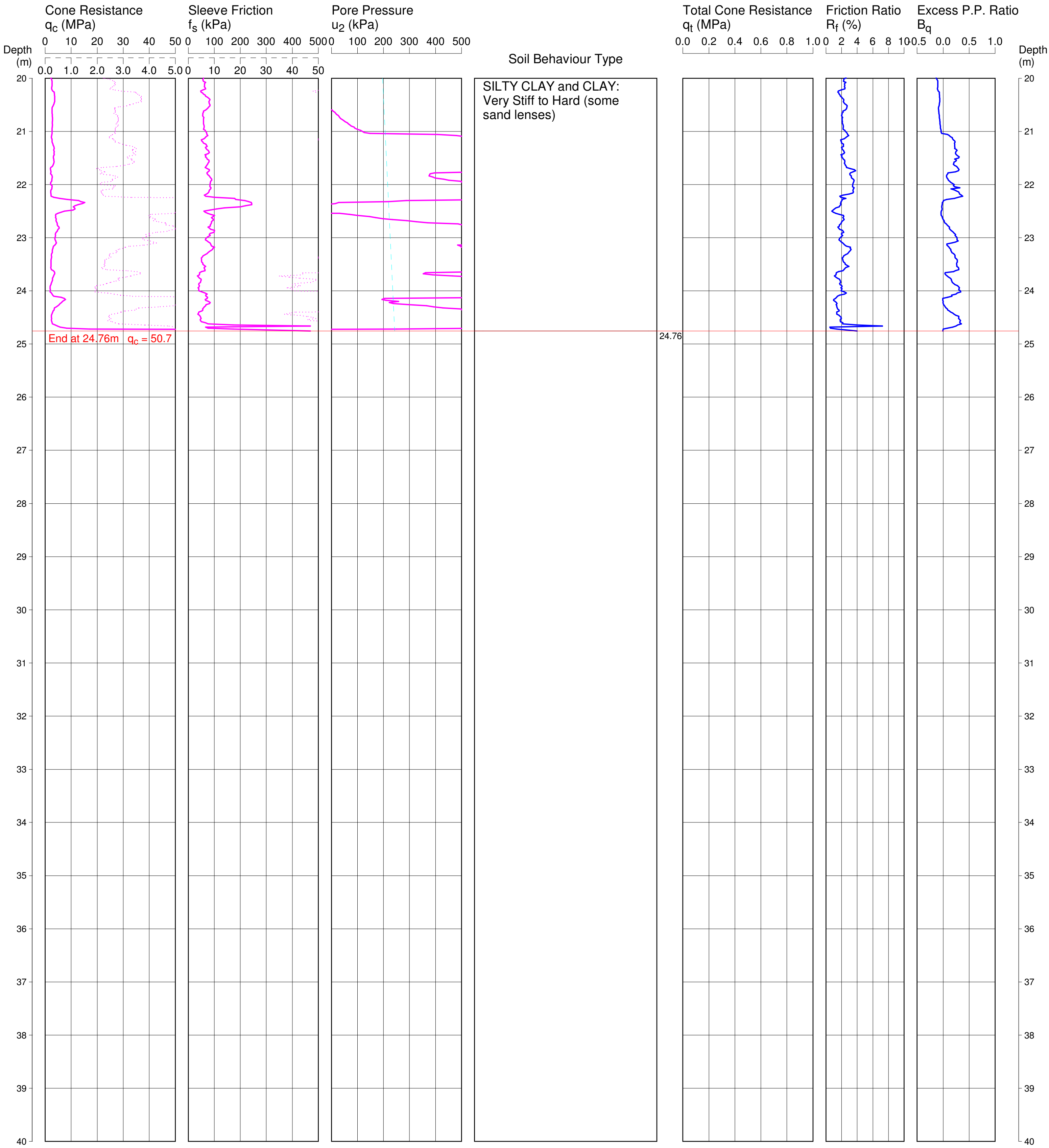
DATE 20/08/2007

SURFACE RL: 0.68 AHD



REMARKS: DEPTH TO WATER AT SURFACE
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Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\CPT03.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.8.1

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CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

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CPT 4

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DATE 20/08/2007

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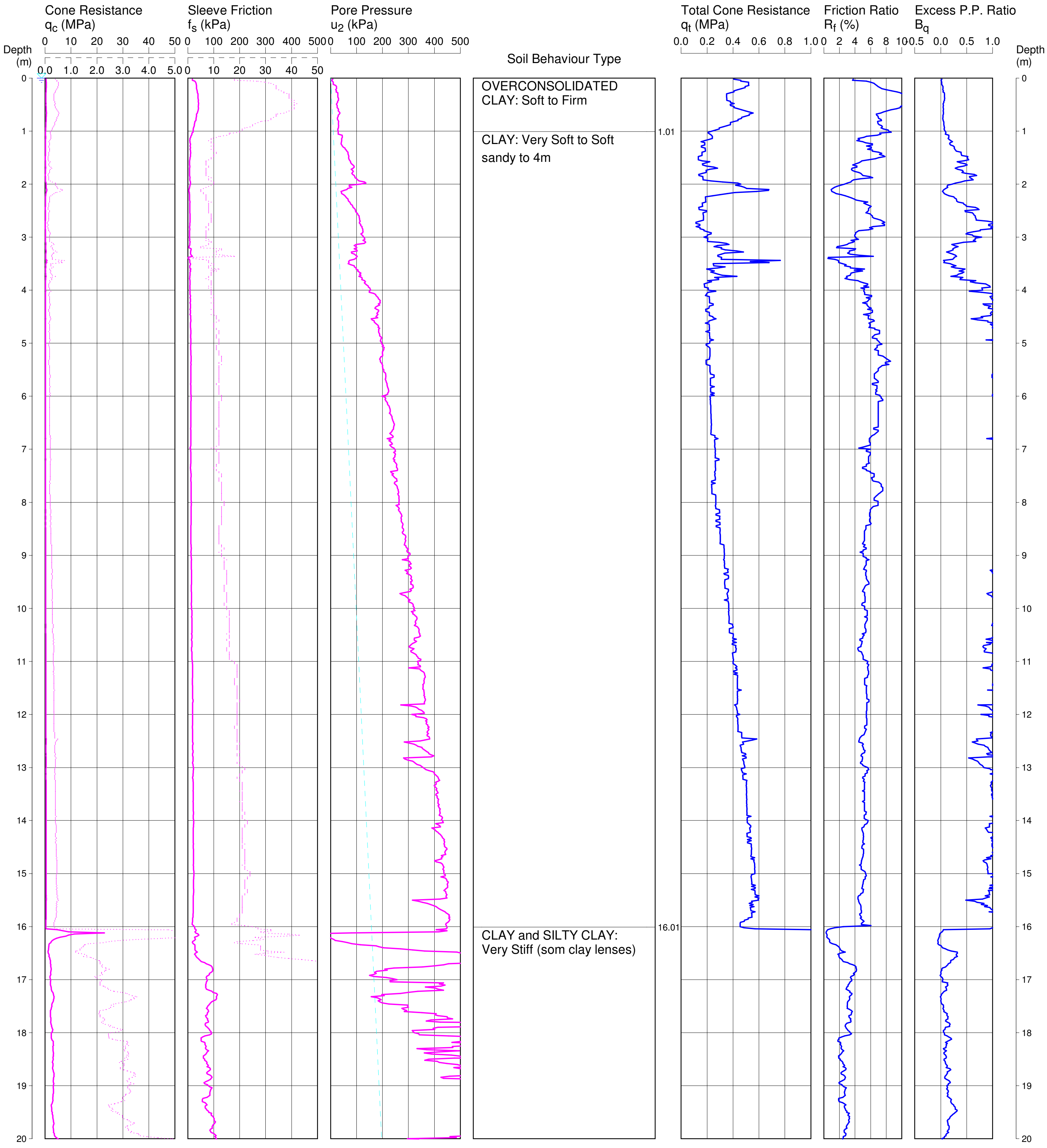

REMARKS: DEPTH TO WATER AT SURFACE
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Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT04.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.8.1
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LOCATION: WOODLANDS CLOSE, HEXHAM

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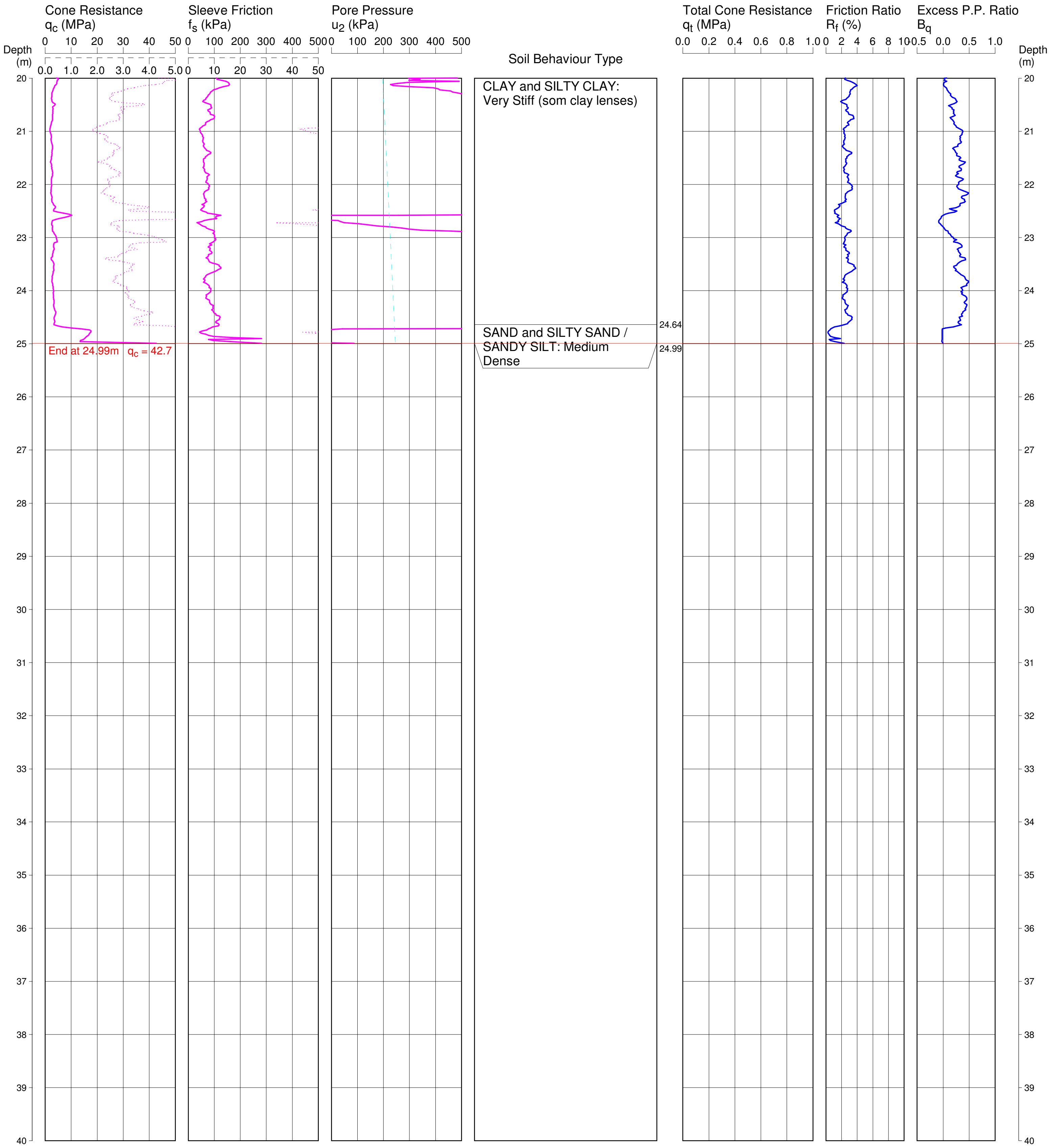

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Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT04.CP5
Cone ID: IGS **Type:** 5 Piezocone

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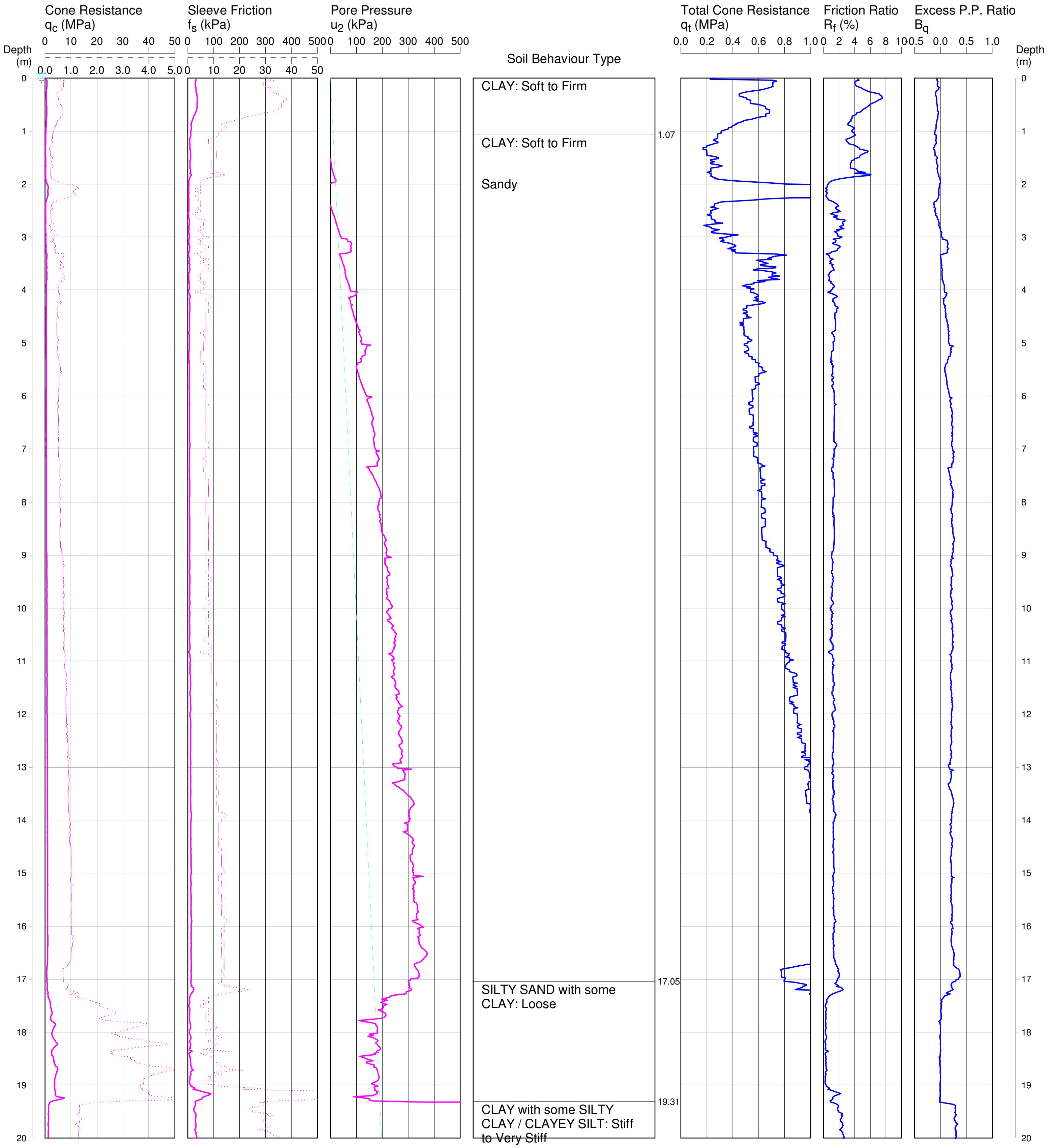

REMARKS: DEPTH TO WATER AT SURFACE
E: 363764 N:1366303

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT05.CP5
Cone ID: ISG **Type:** 5 Piezocone

ConePlot Version 5.8.1

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PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

PROJECT No: 39798

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DATE 16/08/2007

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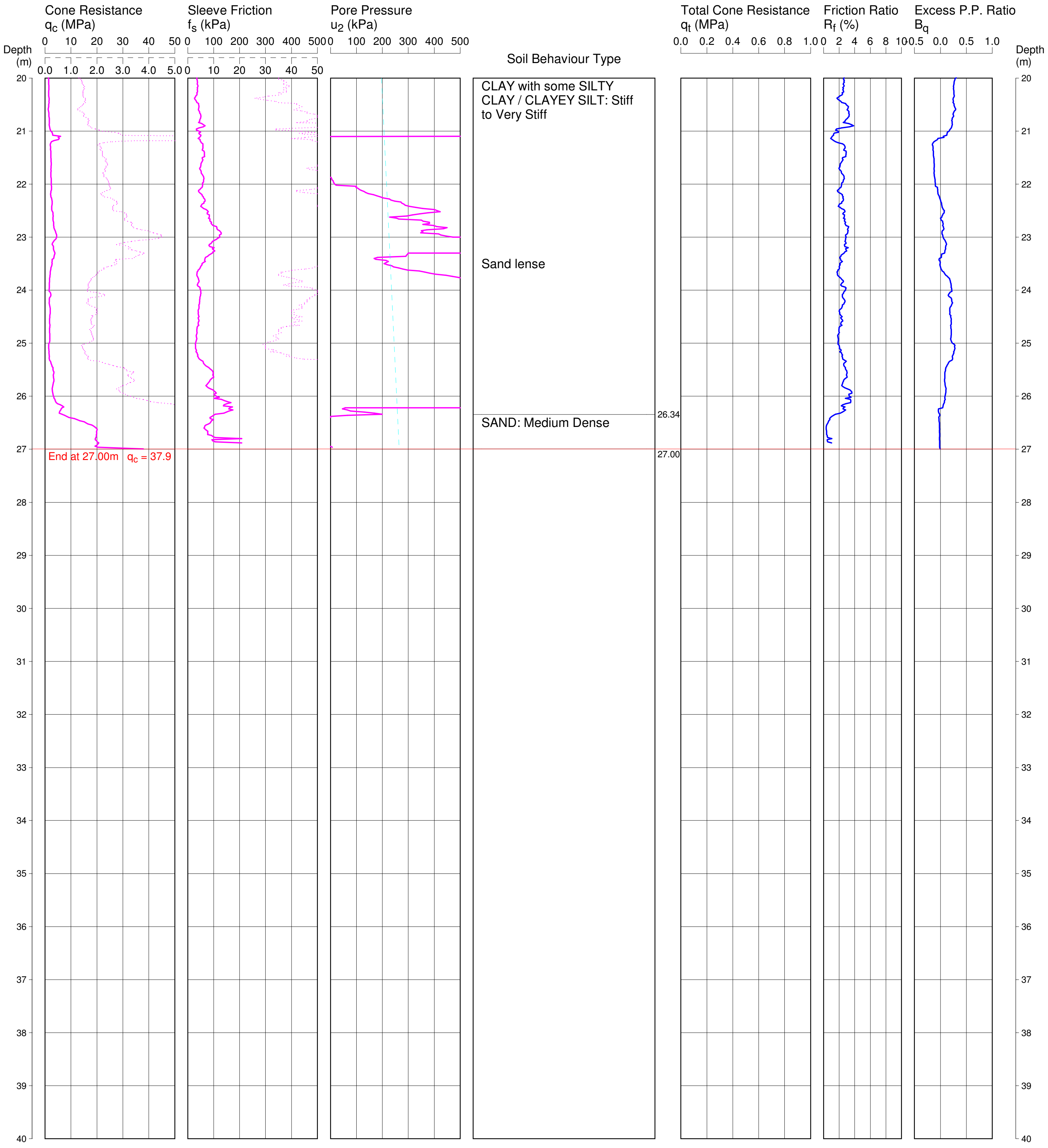

REMARKS: DEPTH TO WATER AT SURFACE
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Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT05.CP5
Cone ID: ISG **Type:** 5 Piezocone

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CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

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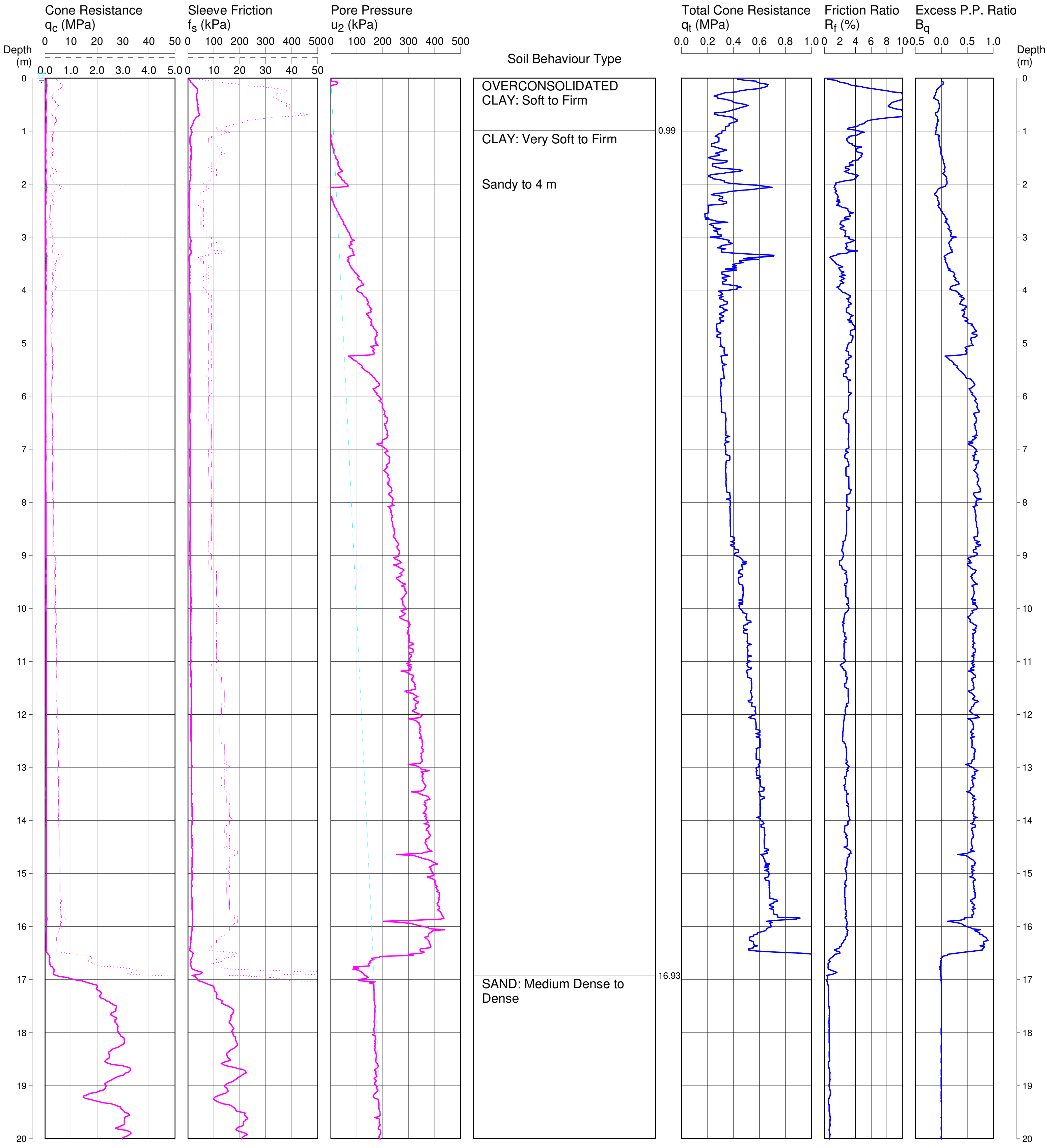
DATE 17/08/2007

SURFACE RL: 0.72



REMARKS: DEPTH TO WATER AT SURFACE
E:363701 N: 1366426

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT06.CP5
Cone ID: IGS **Type:** 5 Piezocone

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LOCATION: WOODLANDS CLOSE, HEXHAM

PROJECT No: 39798

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DATE 17/08/2007

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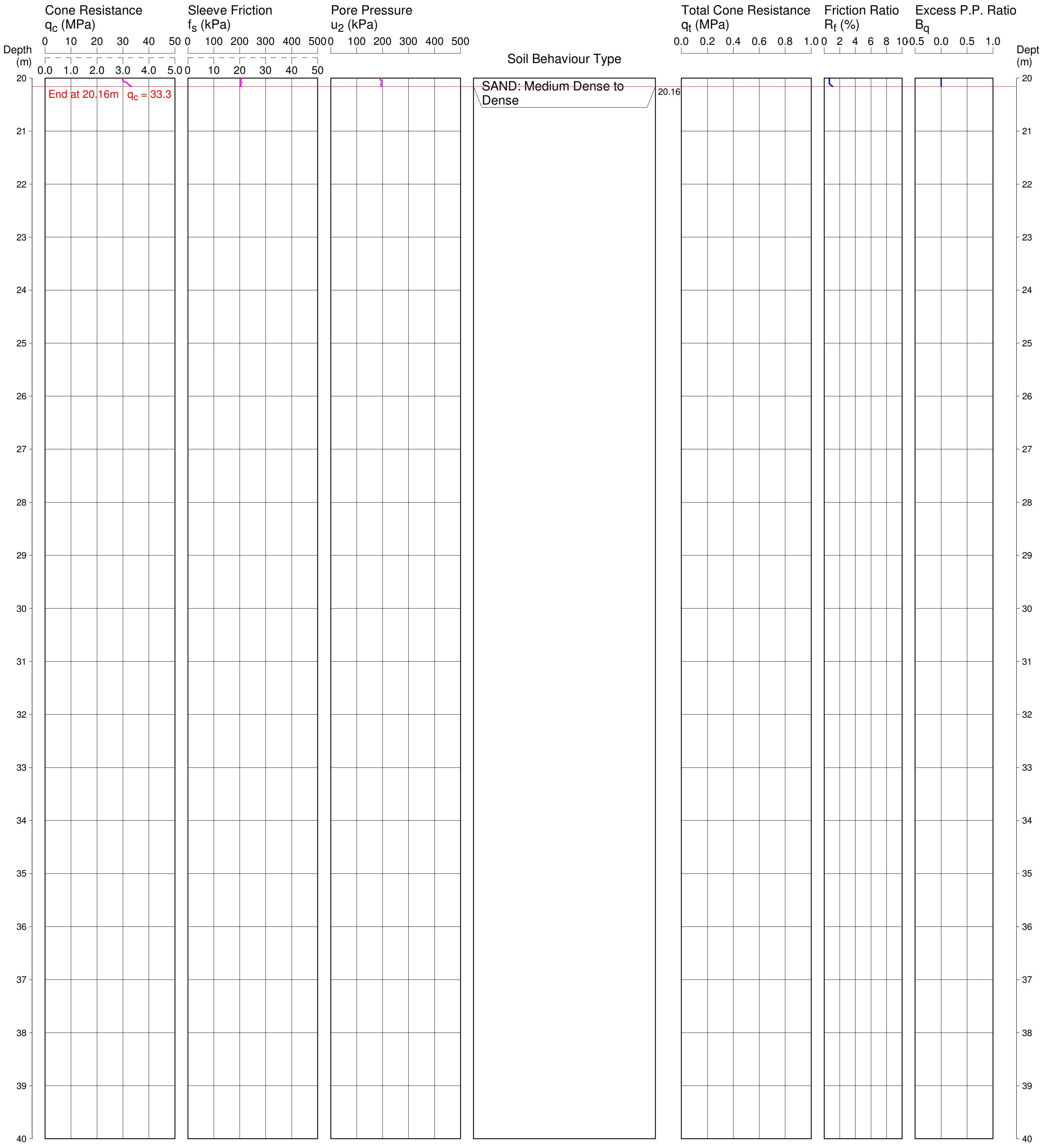

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Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT06.CP5
Cone ID: IGS **Type:** 5 Piezocone

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LOCATION: WOODLANDS CLOSE, HEXHAM

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DATE 17/08/2007

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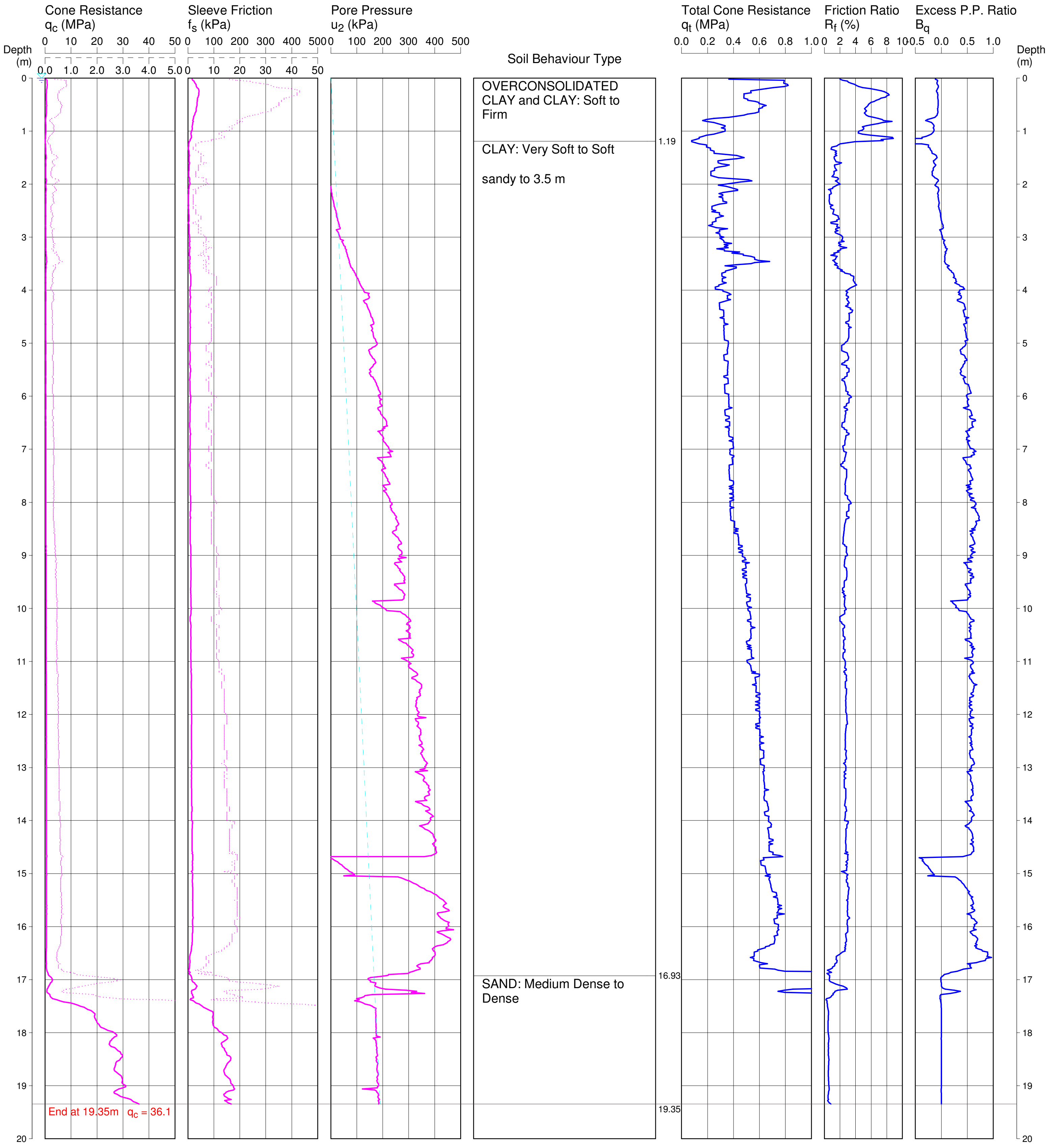

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Date
Plotted
Checked

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Cone ID: IGS **Type:** 5 Piezocone

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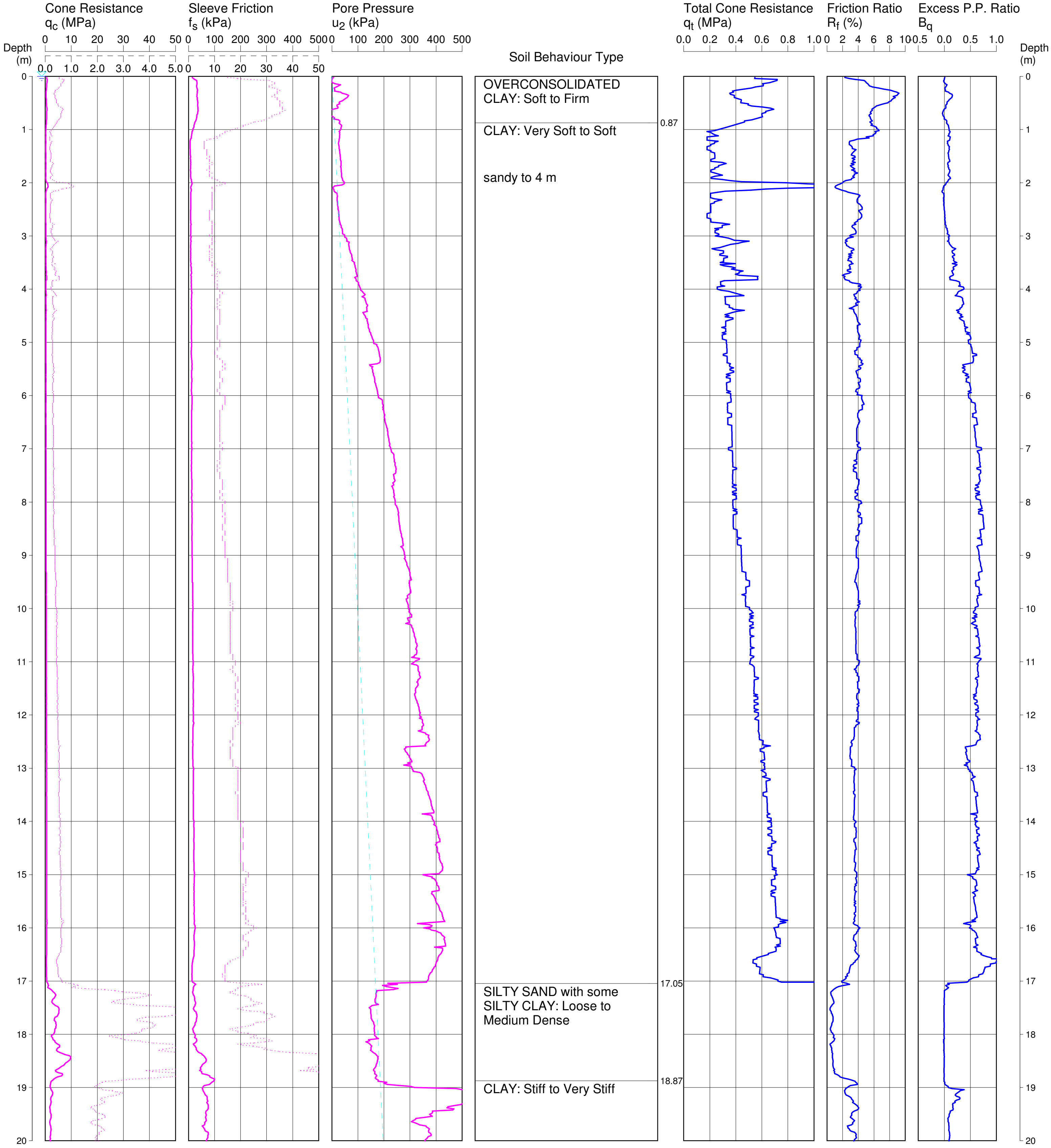
SURFACE RL: 0.67 AHD



REMARKS: DEPTH TO WATER AT SURFACE
E:363727 N:1366340

Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\CPT08.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.8.1

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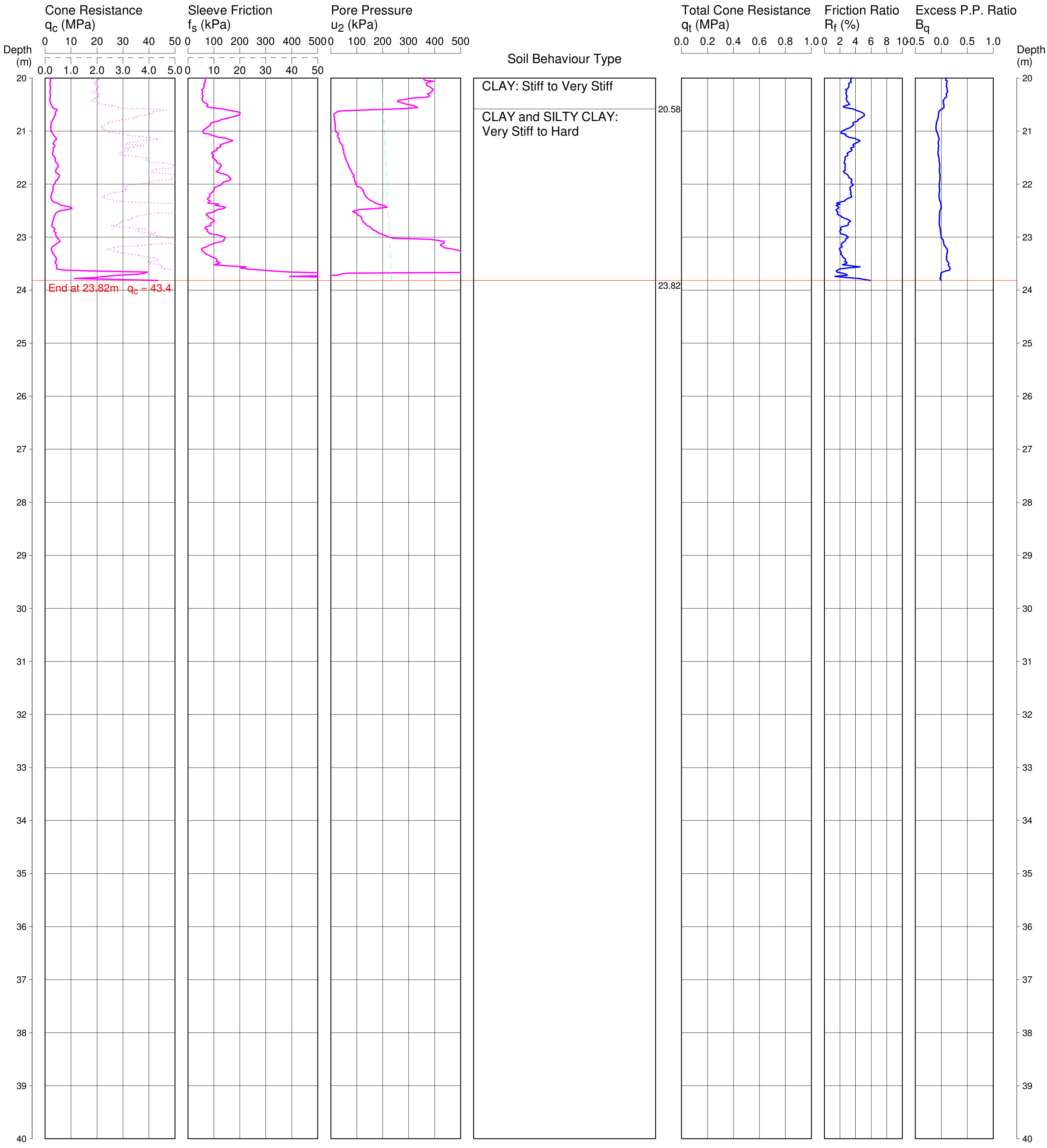
DATE 20/08/2007

SURFACE RL: 0.67 AHD



REMARKS: DEPTH TO WATER AT SURFACE
E:363727 N:1366340

Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\CPT08.CP5
Cone ID: IGS **Type:** 5 Piezocone

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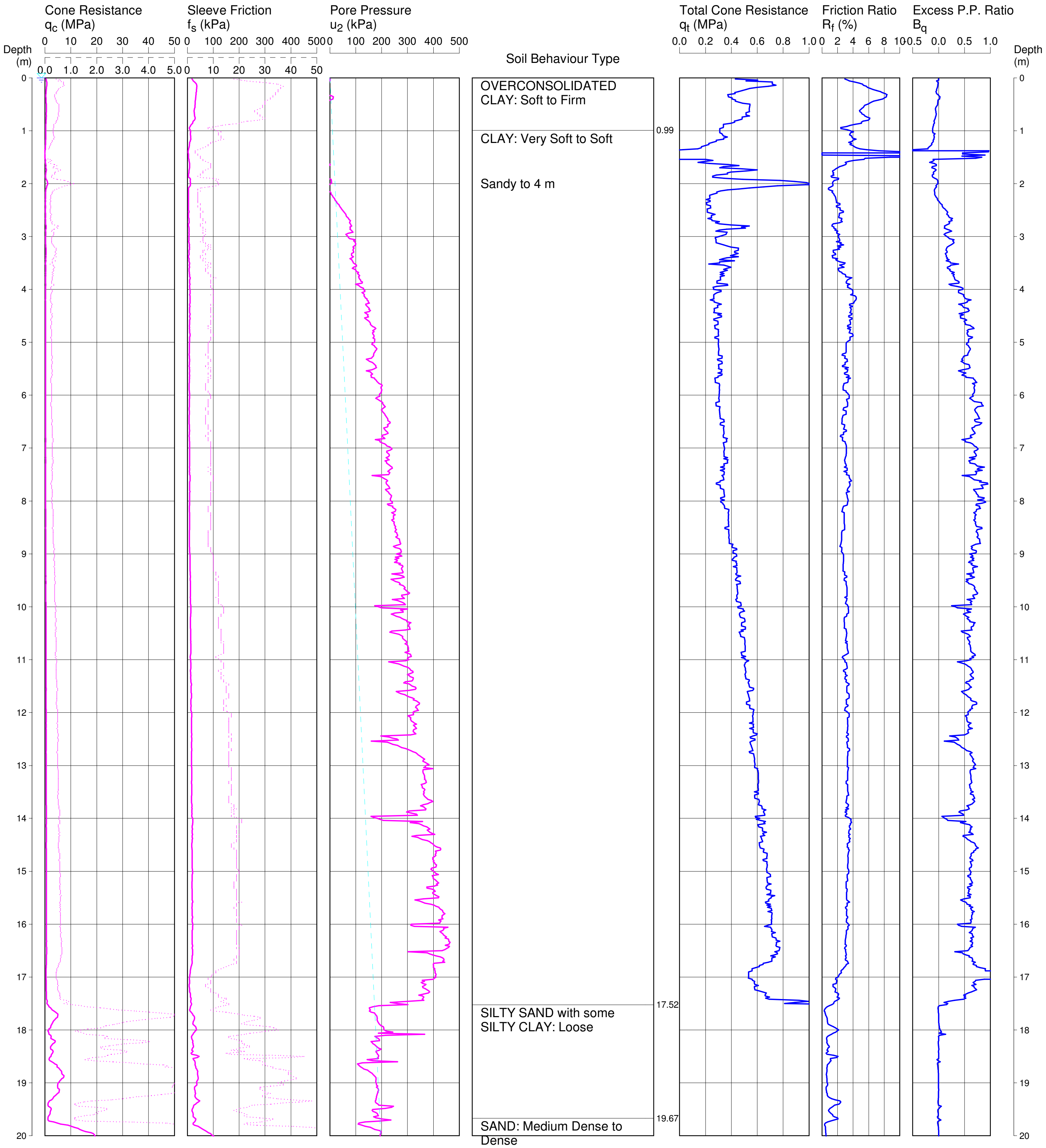

REMARKS: DEPTH TO WATER AT SURFACE
E: 363682 N:1366378

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT09.CP5
Cone ID: IGS **Type:** 5 Piezocone

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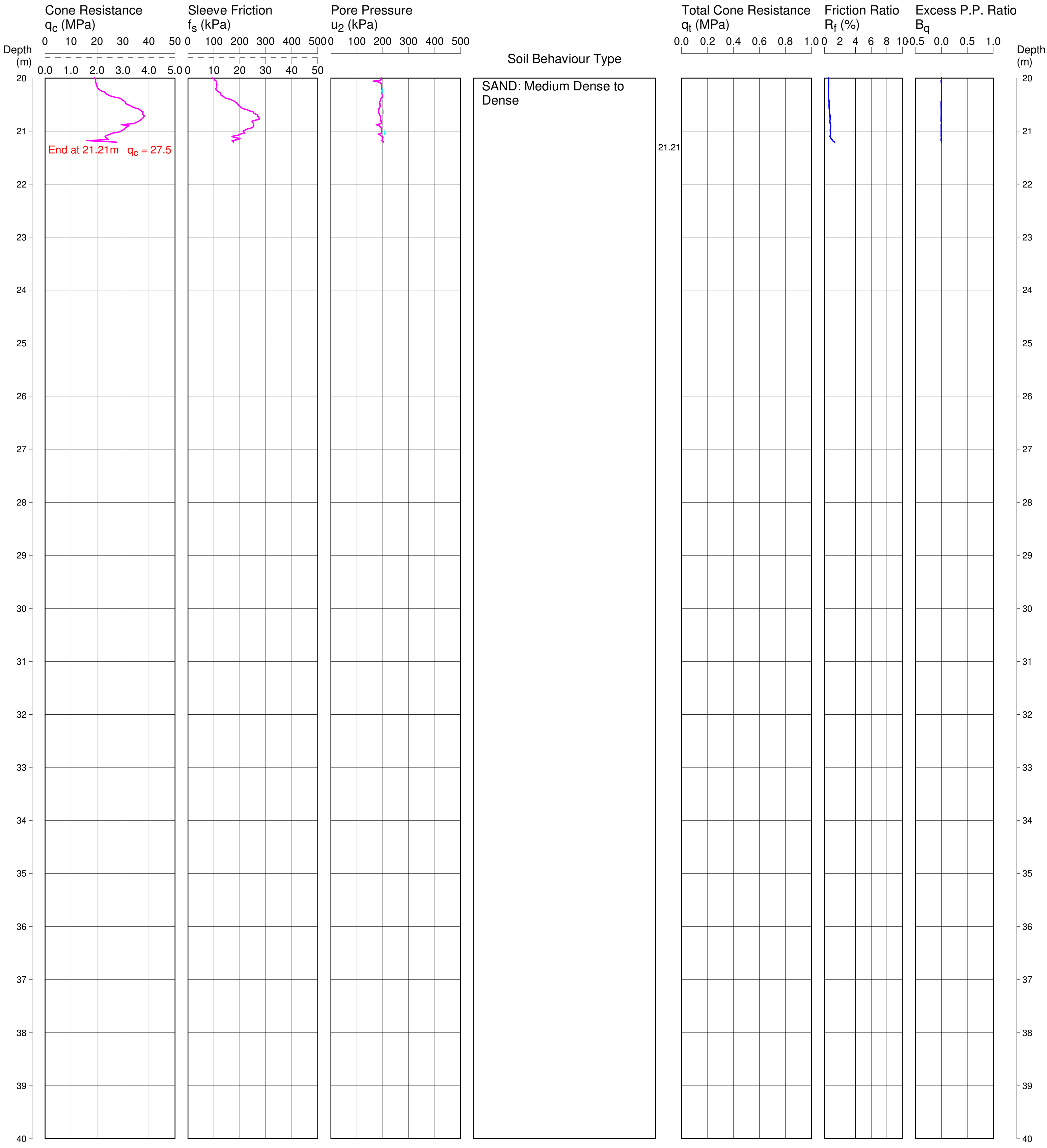
DATE 17/08/2007

SURFACE RL: 0.56 AHD



REMARKS: DEPTH TO WATER AT SURFACE
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Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT09.CP5
Cone ID: IGS **Type:** 5 Piezocone

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DATE 16/08/2007

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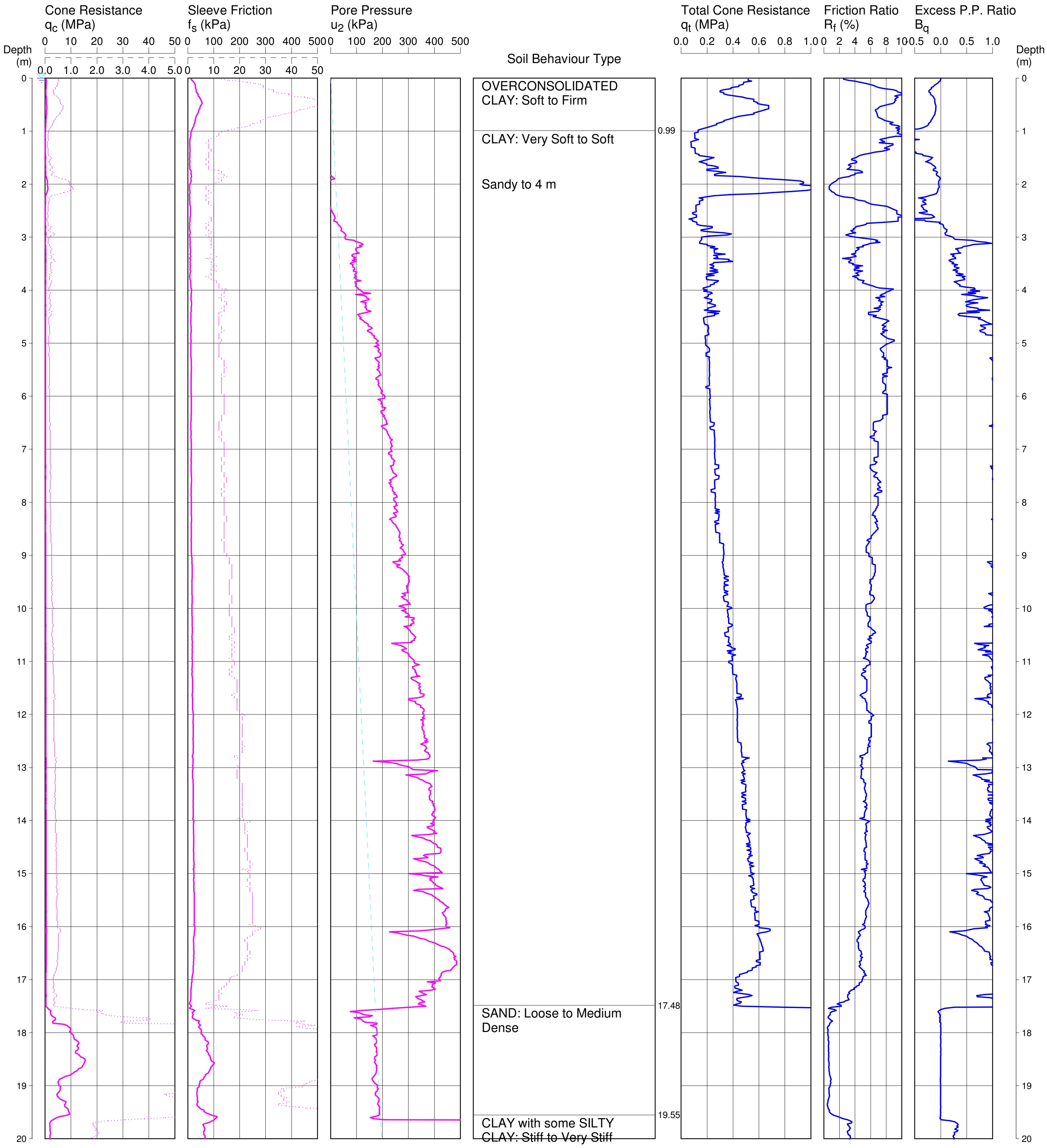

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Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\CPT10.CP5
Cone ID: IGS **Type:** 5 Piezocone

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LOCATION: WOODLANDS CLOSE, HEXHAM

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CPT 10

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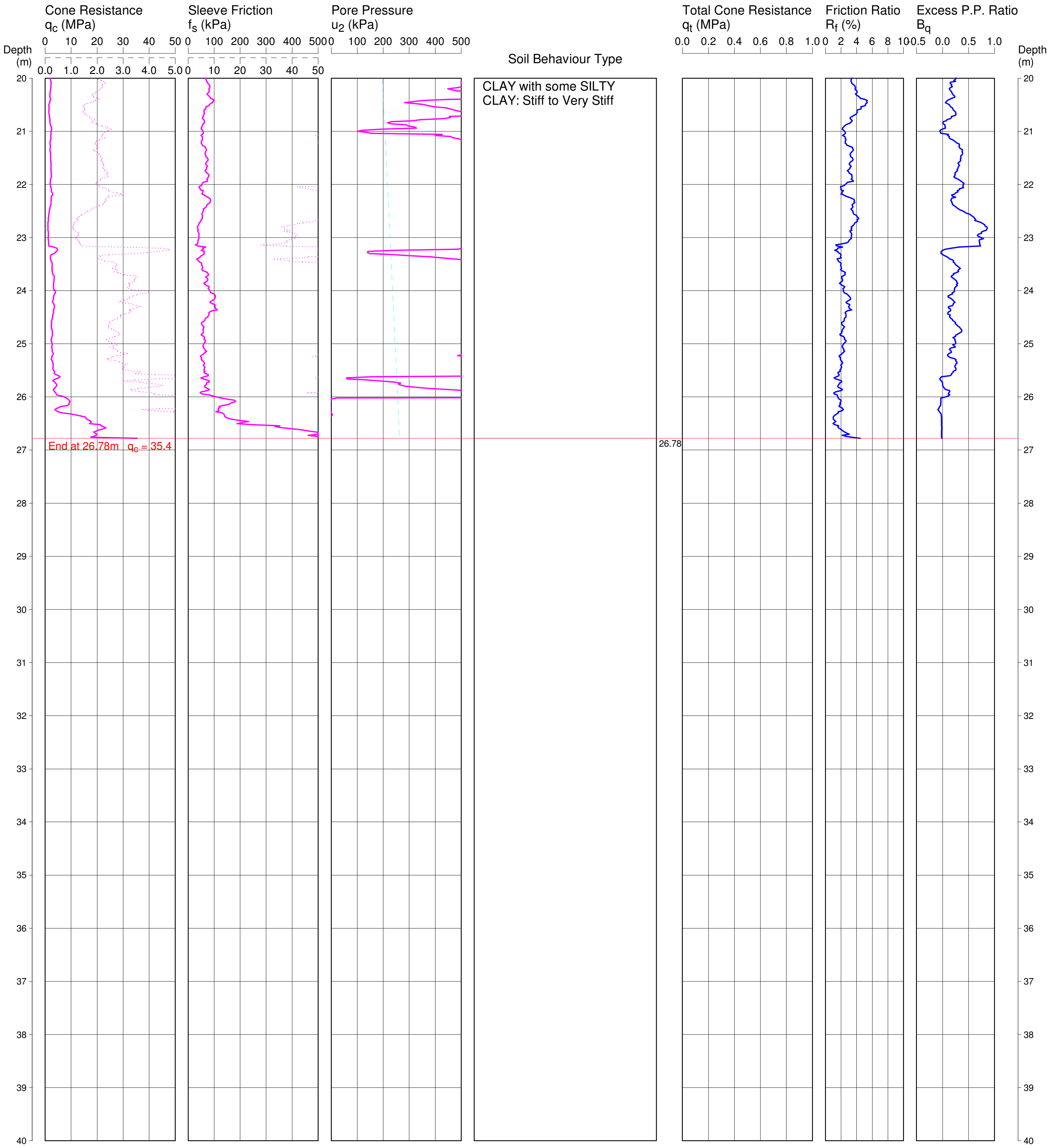
DATE 16/08/2007

SURFACE RL: 0.67 AHD



REMARKS: DEPTH TO WATER AT SURFACE
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Date	
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Checked	

File: P:\39798\Field\CP5 files\CPT10.CP5
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ConePlot Version 5.8.1

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CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

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LOCATION: WOODLANDS CLOSE, HEXHAM

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CPT 11

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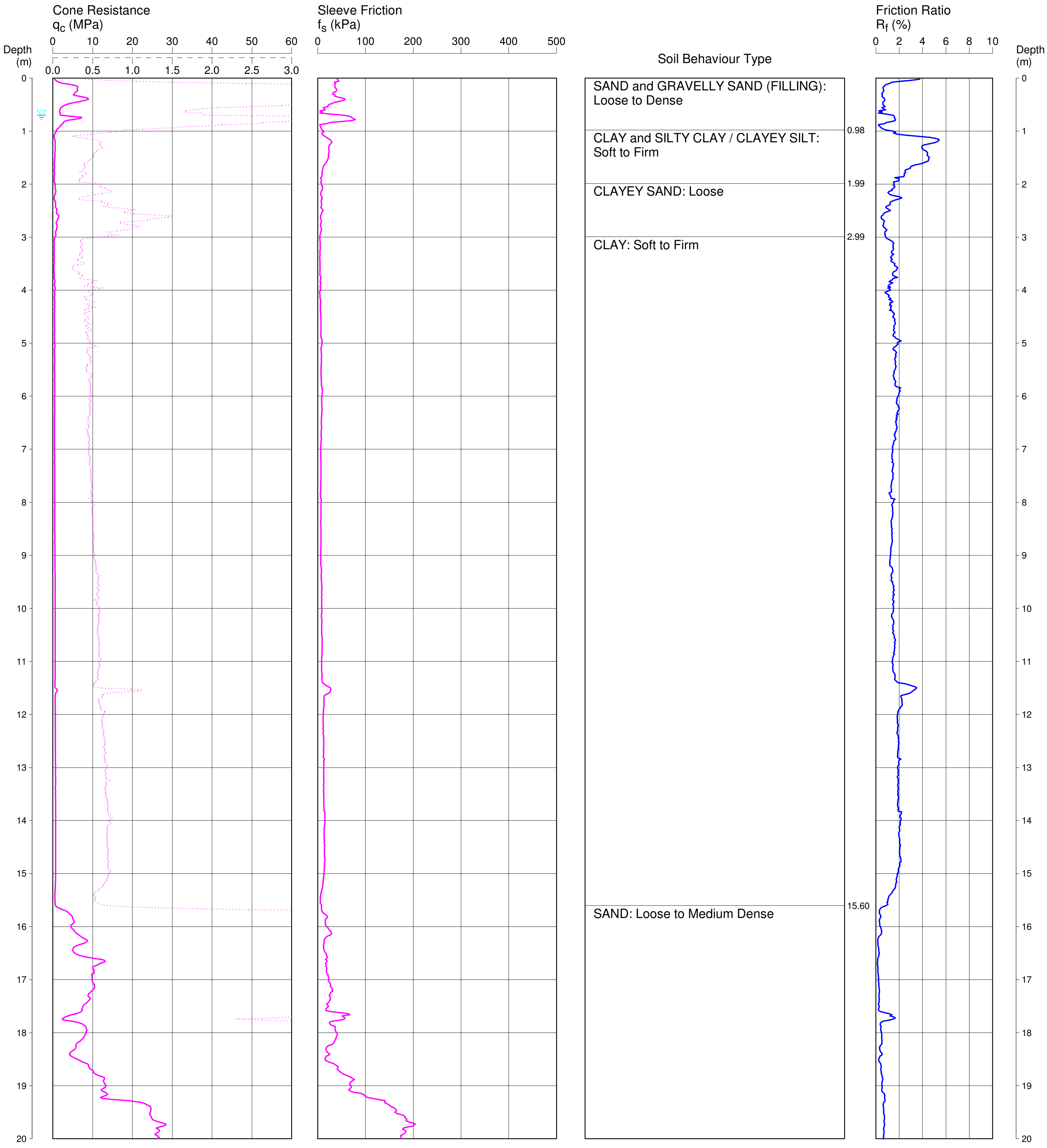
DATE 30/07/2007

SURFACE RL: 1.53 AHD



REMARKS: DEPTH TO WATER NOT MEASURED - WATER LEVEL ASSUMED
E:363726 N:1366266 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT11.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

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CPT 11

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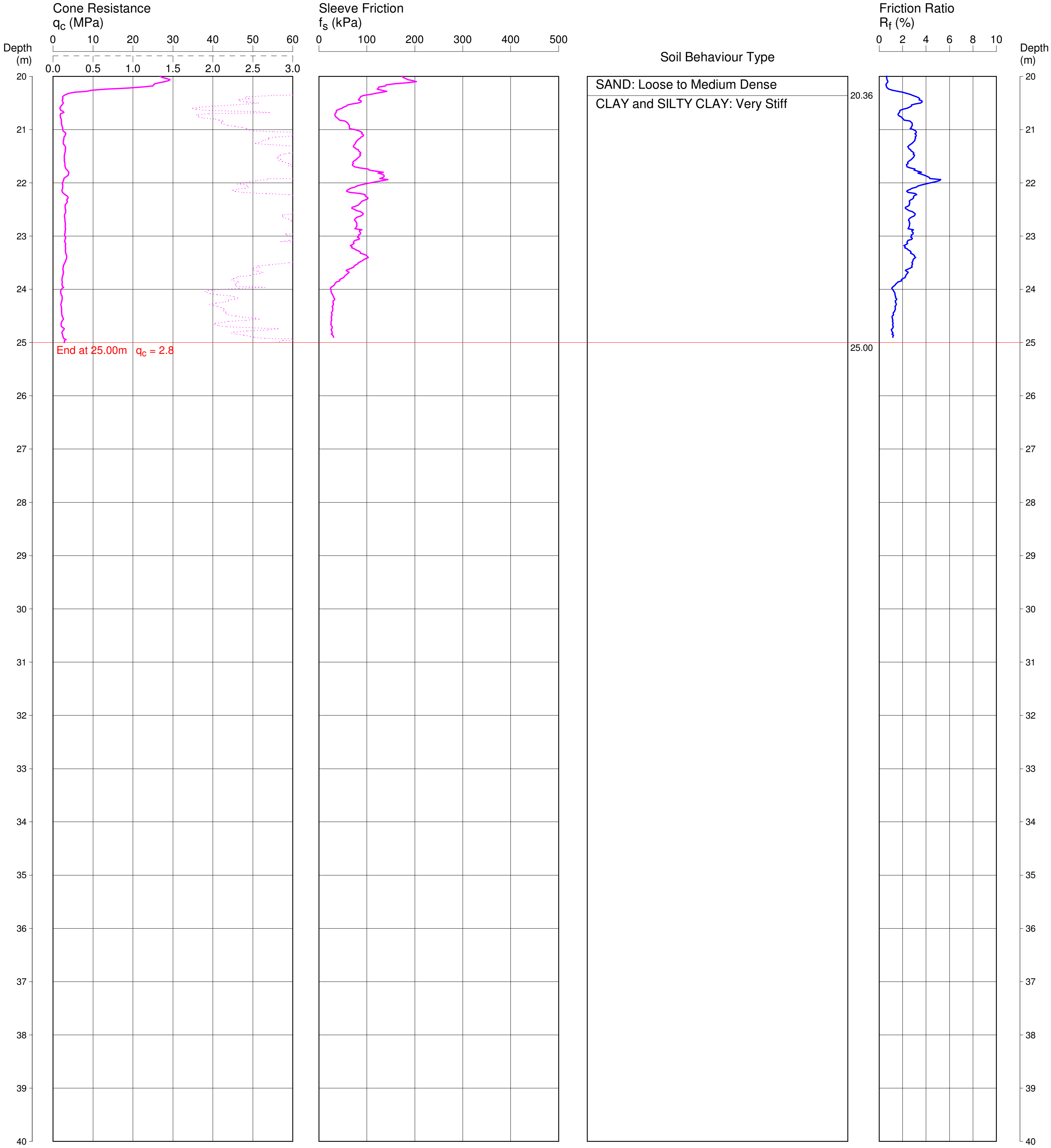
DATE 30/07/2007

SURFACE RL: 1.53 AHD



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Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\CPT11.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

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CLIENT: QUEENSLAND RAIL

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LOCATION: WOODLANDS CLOSE, HEXHAM

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CPT 12

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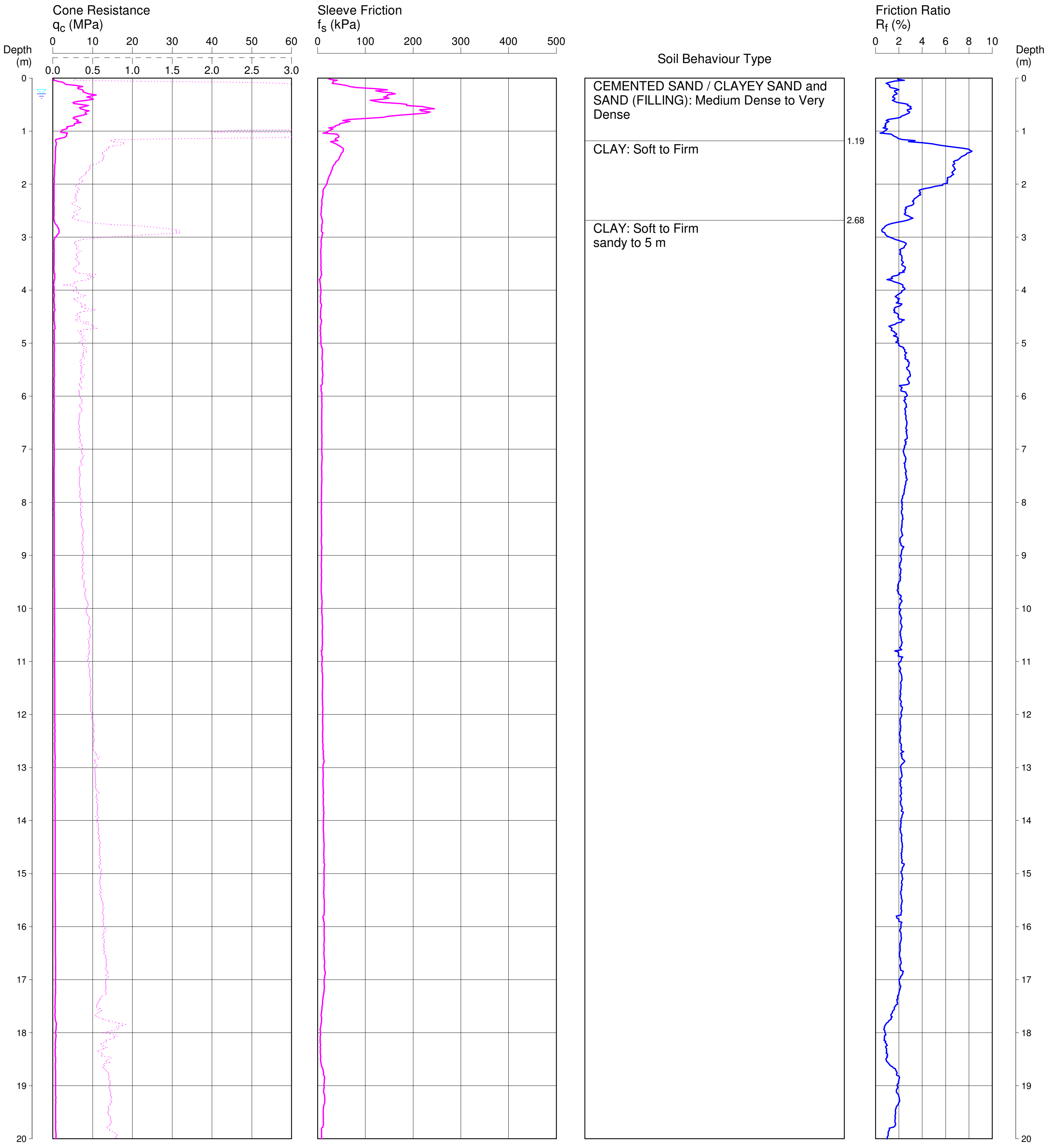
DATE 30/07/2007

SURFACE RL: 1.3 AHD



CEMENTED SAND / CLAYEY SAND and SAND (FILLING): Medium Dense to Very Dense

CLAY: Soft to Firm

CLAY: Soft to Firm
sandy to 5 m

REMARKS: DEPTH TO WATER AT COMPLETION OF TEST :0.3 m
E:363819 N:1366055 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT12.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1
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LOCATION: WOODLANDS CLOSE, HEXHAM

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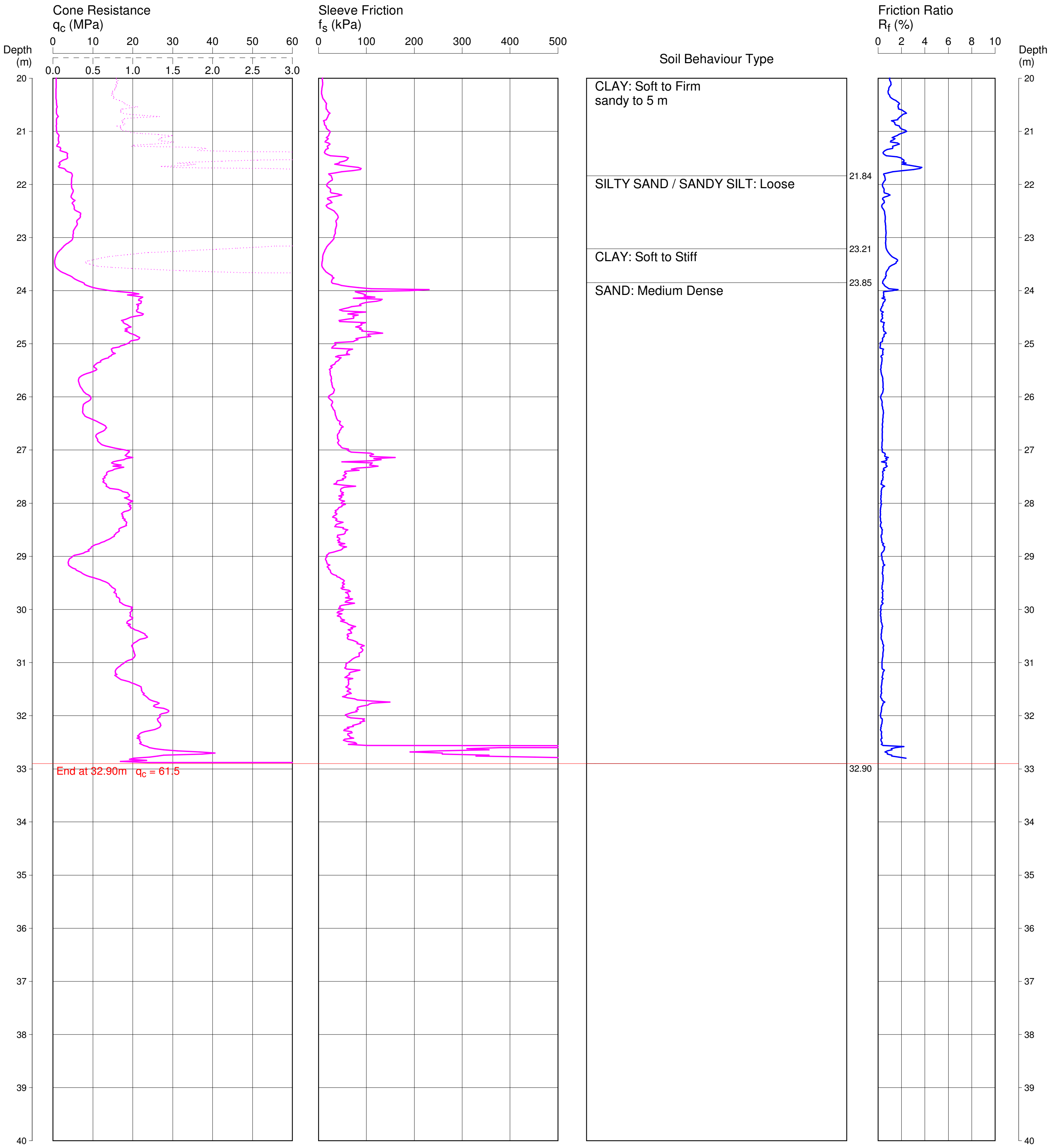
DATE 30/07/2007

SURFACE RL: 1.3 AHD



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST :0.3 m
E:363819 N:1366055 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\CPT12.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

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CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PRELIMINARY GEOTECHNICAL INVESTIGATION

LOCATION: WOODLANDS CLOSE, HEXHAM

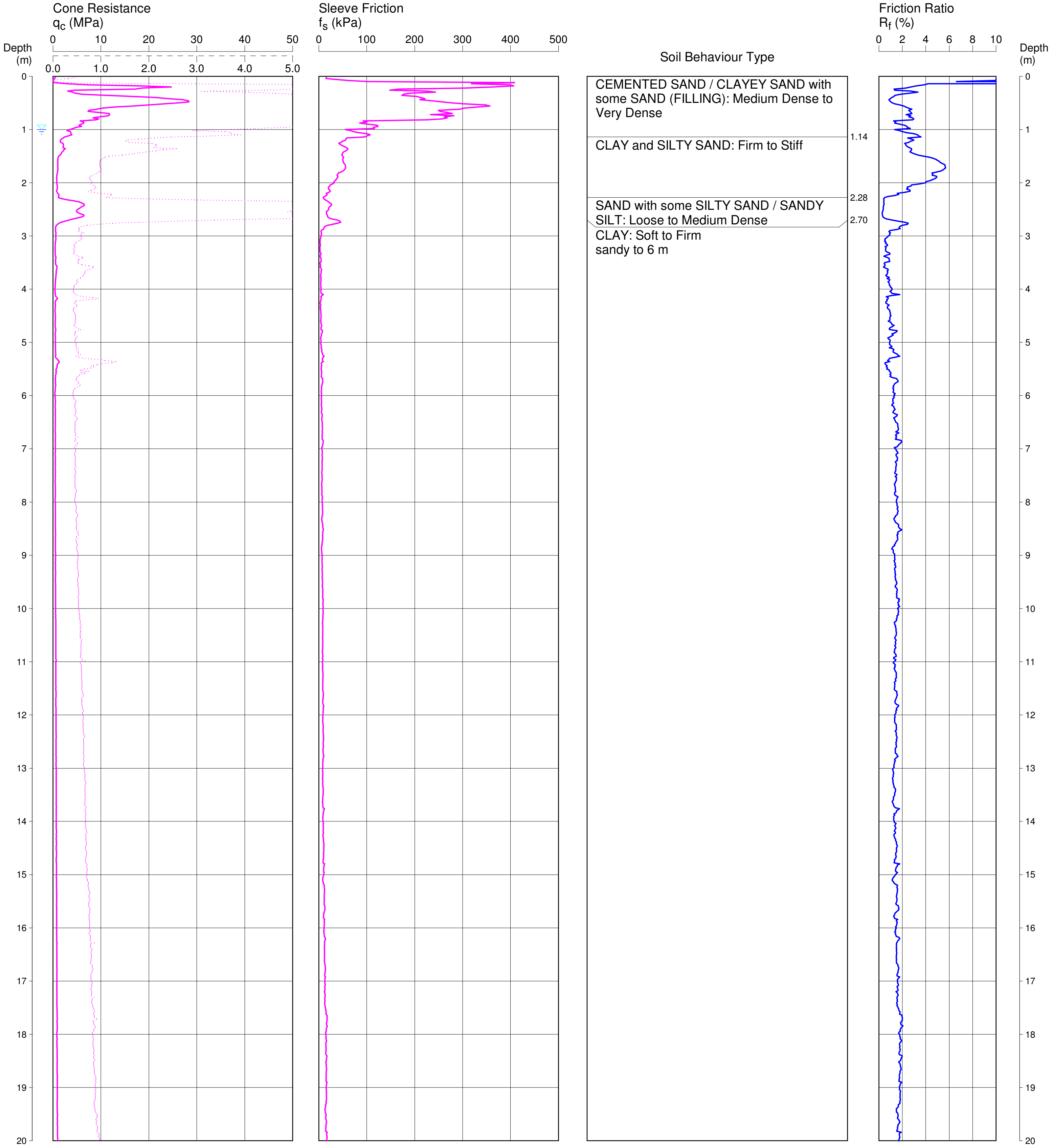
PROJECT No: 39798

CPT TP13

Page 1 of 2

DATE 30/07/2007

SURFACE RL: 1.89 AHD



CEMENTED SAND / CLAYEY SAND with some SAND (FILLING): Medium Dense to Very Dense

CLAY and SILTY SAND: Firm to Stiff

SAND with some SILTY SAND / SANDY SILT: Loose to Medium Dense

CLAY: Soft to Firm
sandy to 6 m

REMARKS: HOLE COLLAPSE AT SURFACE (WATER LEVEL ASSUMED)
DUMMY CONED USED FROM SURFACE TO 0.6mE:364405 N:1364670 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\TP13.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PRELIMINARY GEOTECHNICAL INVESTIGATION

LOCATION: WOODLANDS CLOSE, HEXHAM

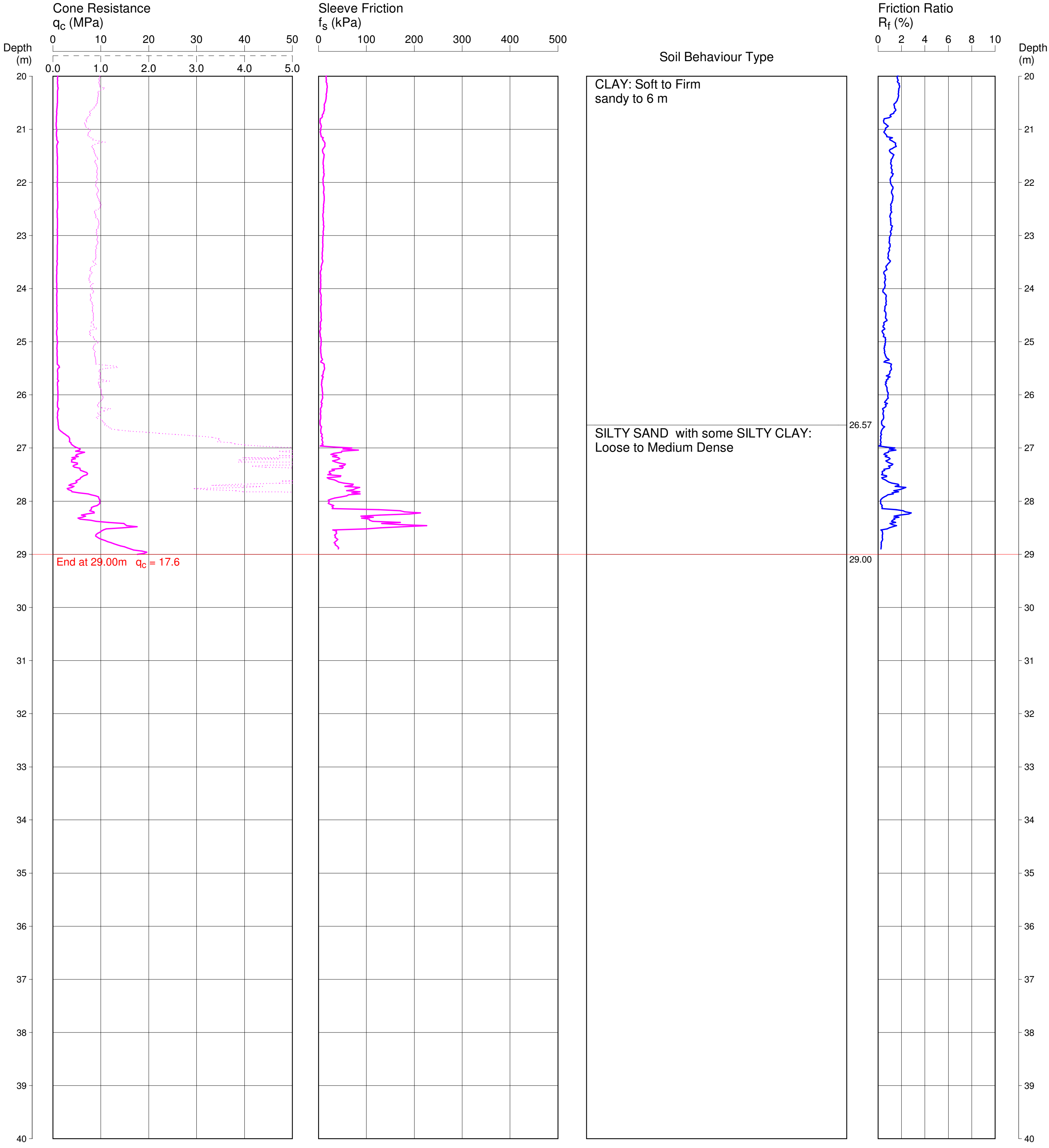
PROJECT No: 39798

CPT TP13

Page 2 of 2

DATE 30/07/2007

SURFACE RL: 1.89 AHD



CLAY: Soft to Firm
sandy to 6 m

SILTY SAND with some SILTY CLAY:
Loose to Medium Dense

REMARKS: HOLE COLLAPSE AT SURFACE (WATER LEVEL ASSUMED)
DUMMY CONED USED FROM SURFACE TO 0.6mE:364405 N:1364670 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\TP13.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

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CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

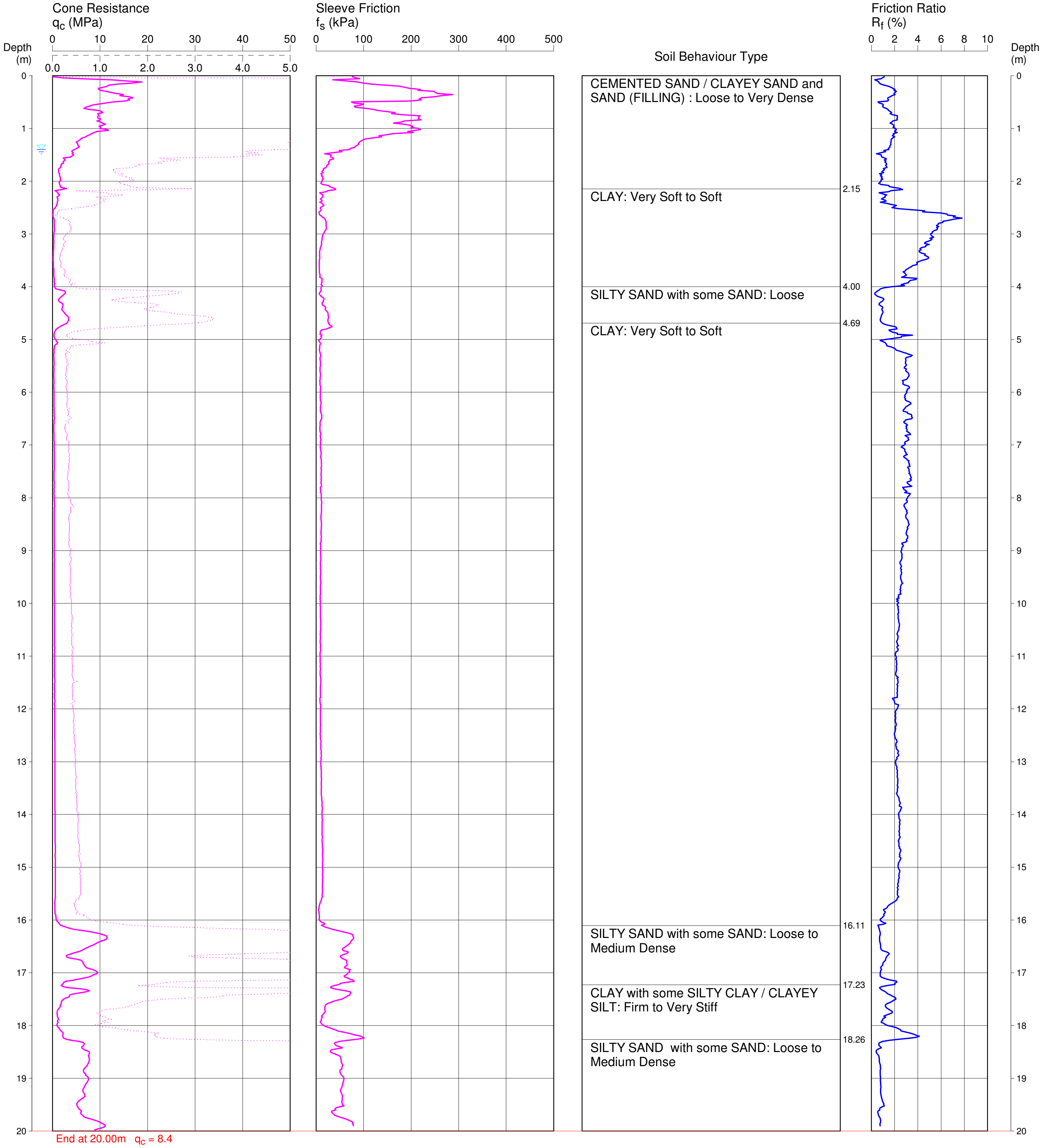
PROJECT No: 39798

CPT TP15

Page 1 of 1

DATE 30/07/2007

SURFACE RL: 2.64 AHD



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 1.4 m
E: 364228 N:1365028

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\TP15.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1
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CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

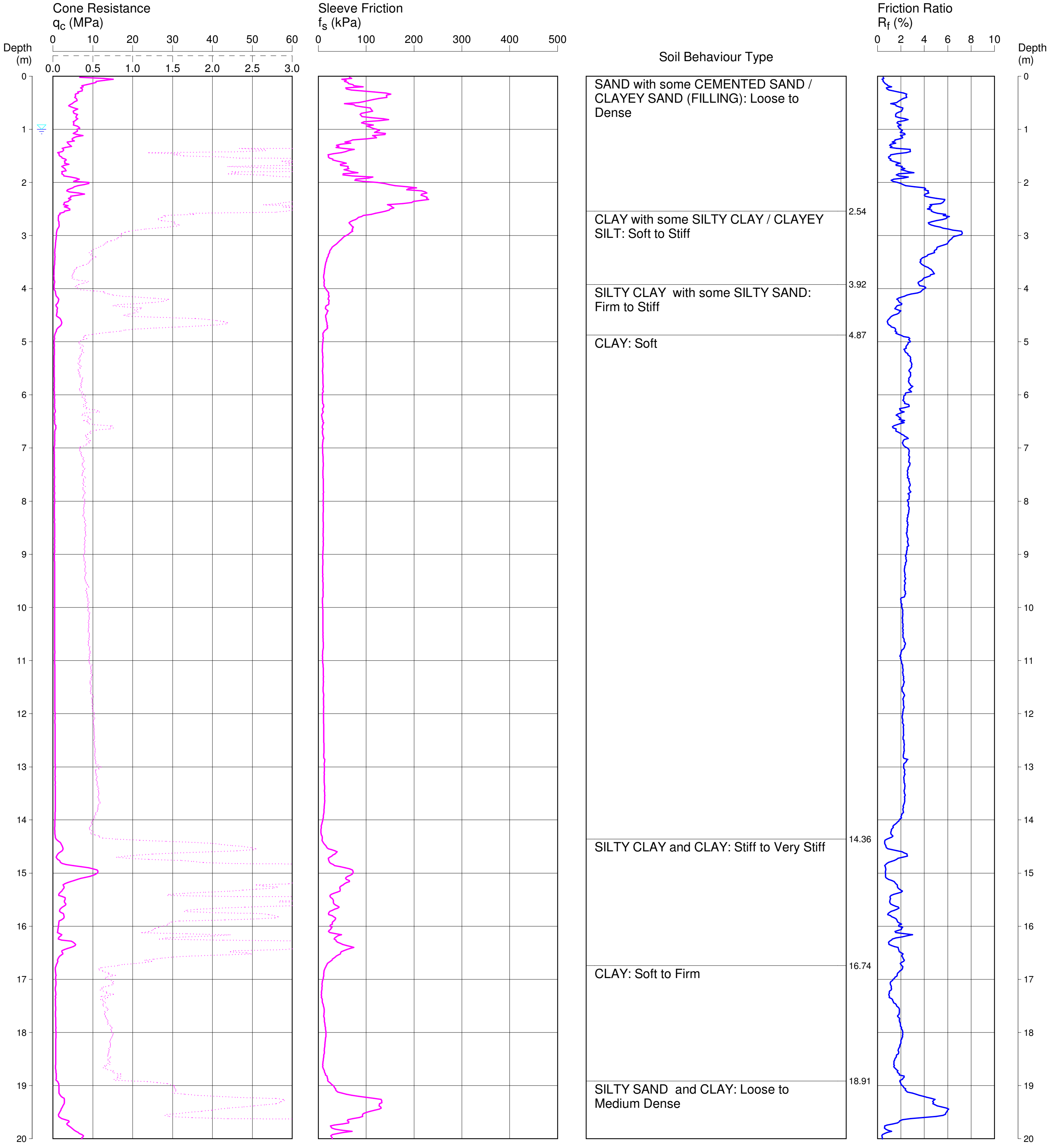
PROJECT No: 39798

CPT TP17

Page 1 of 2

DATE 30/07/2007

SURFACE RL: 2.59 AHD



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 1.0 m
E:3647094 N:1365405

Date	
Plotted	
Checked	

File: P:\39798\Field\CP5 files\TP17.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

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CONE PENETRATION TEST

CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY

LOCATION: WOODLANDS CLOSE, HEXHAM

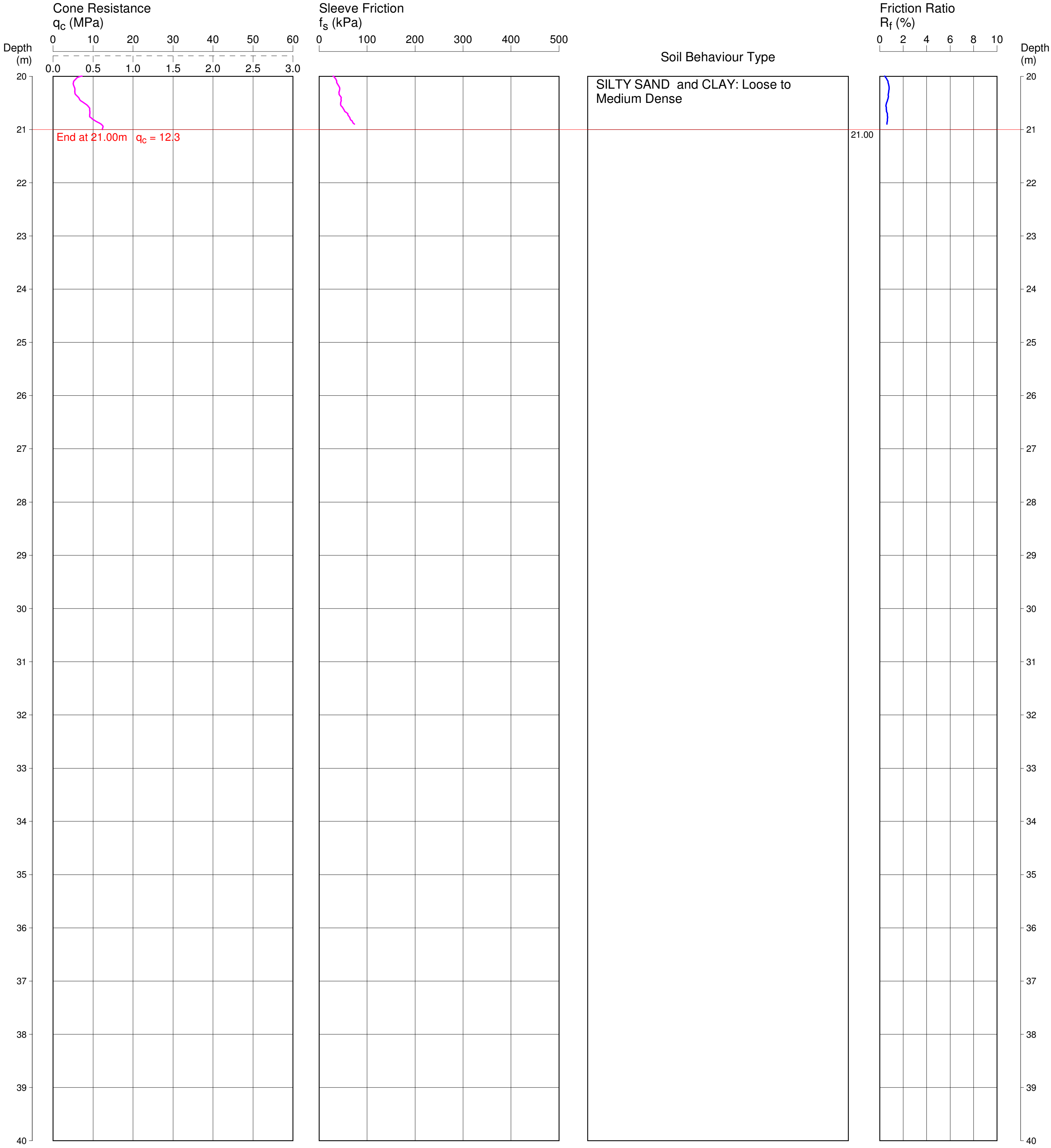
PROJECT No: 39798

CPT TP17

Page 2 of 2

DATE 30/07/2007

SURFACE RL: 2.59 AHD



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 1.0 m
E:3647094 N:1365405

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\TP17.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1
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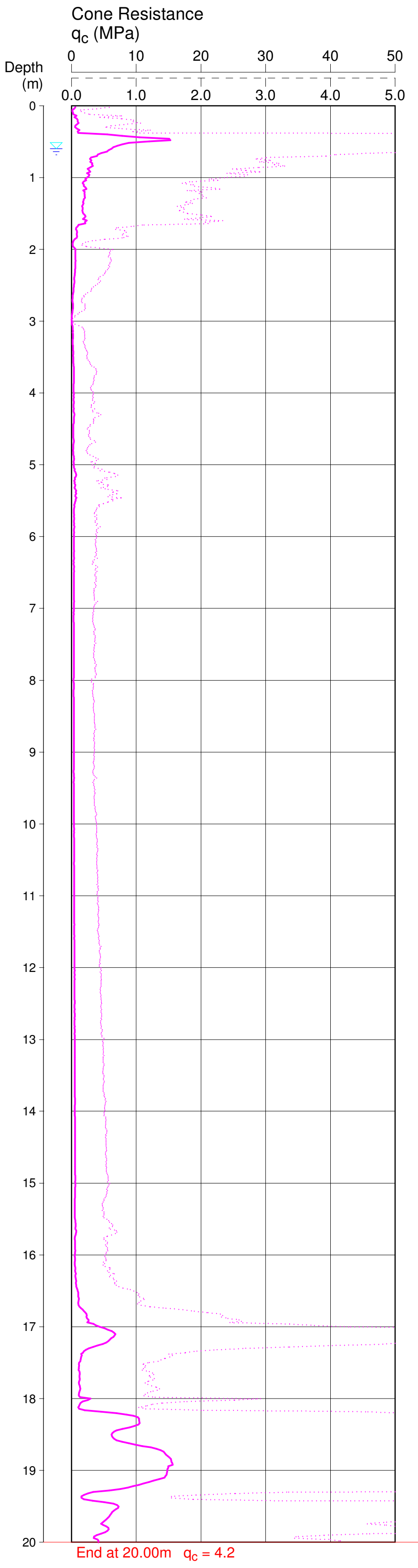
CONE PENETRATION TEST

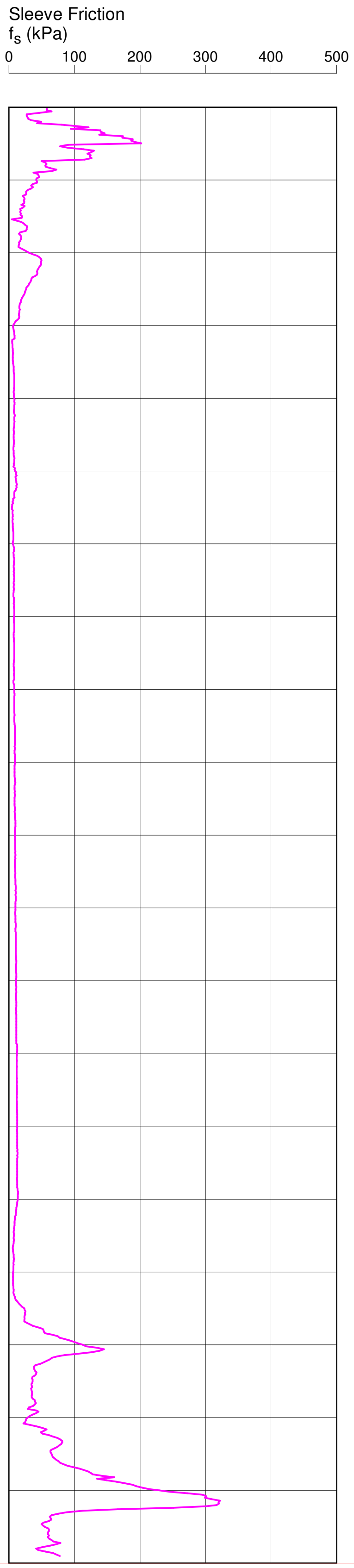
CLIENT: QUEENSLAND RAIL

PROJECT: PROPOSED MAINTENANCE FACILITY
LOCATION: WOODLANDS CLOSE, HEXHAM
PROJECT No: 39798

CPT TP19

Page 1 of 1
DATE 30/07/2007
SURFACE RL: 1.5





Soil Behaviour Type

OVERCONSOLIDATED CLAY and CEMENTED SAND / CLAYEY SAND: Very Soft to Stiff

0.77

SAND and SILTY SAND: Loose to Medium Dense

1.88

CLAY: Very Soft to Firm

3.21

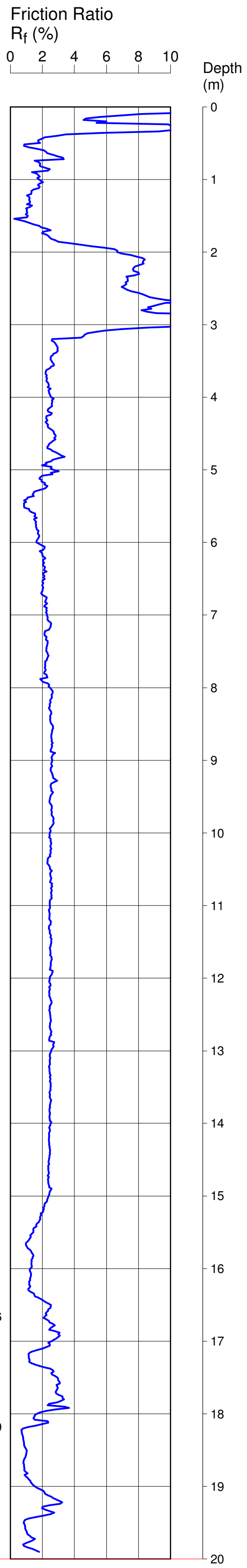
CLAY: Very Soft to Soft

16.66

CLAY and SILTY SAND / SANDY SILT: Stiff to Hard

18.19

SILTY SAND with some SAND: Loose to Medium Dense



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 0.6 m
SURFACE LEVEL ASSUMED 364027 N:1365782 (approx)

Date
Plotted
Checked

File: P:\39798\Field\CP5 files\TP19.CP5
Cone ID: 400 **Type:** 2 Standard

ConePlot Version 5.8.1

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BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

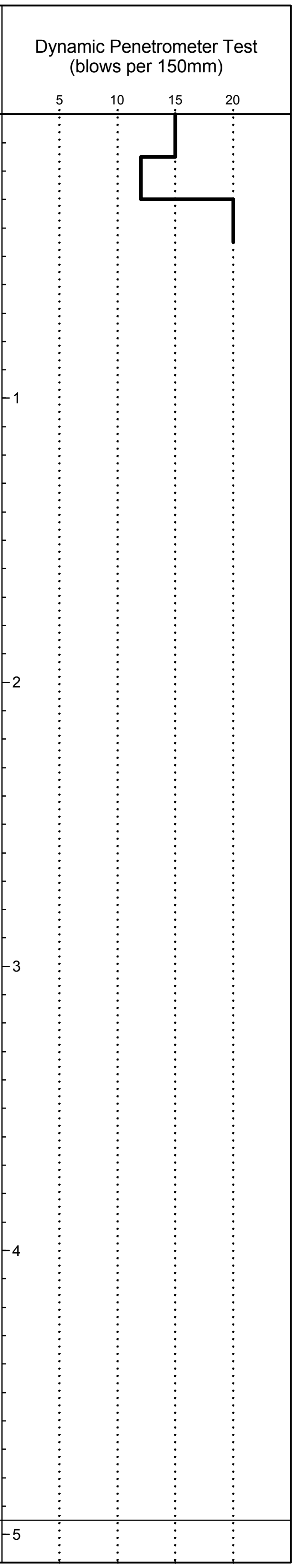
SURFACE LEVEL: 1.53 AHD
EASTING: 364313
NORTHING: 1364847
DIP/AZIMUTH: 90°/--

BORE No: TP14
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata
0.0	FILLING: Dark grey/black gravelly sand (coal reject) some silt, damp
0.4	FILLING: Orange, fine to medium grained gravelly fine to coarse grained sand (roadbase), humid
0.6	FILLING: Dark grey/brown, fine gravelly clay, M>Wp
1.3	SILTY CLAY: Soft to firm, grey silty clay, M>Wp From 1.7m depth, sandy clay
2.0	SILTY SAND: Very soft, grey silty fine grained sand, saturated From 2.9m depth, sandy silt, some shells
4.95	Bore discontinued at 4.95m, limit of investigation

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A,PID	0.1		< 1 ppm
B,PID	0.0–0.5		< 1 ppm
A, PID	0.8		< 1 ppm
A	1.3		
S	1.5–1.95		1,1,3 N = 4
pp	1.95		120-150kPa
A	2.4		
A	2.9		
S	3.0–3.45		0,0,1 N = 1 under hammer 300mm
S	4.0–4.45		0,0,1 N = 1 under hammer 300mm



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.1m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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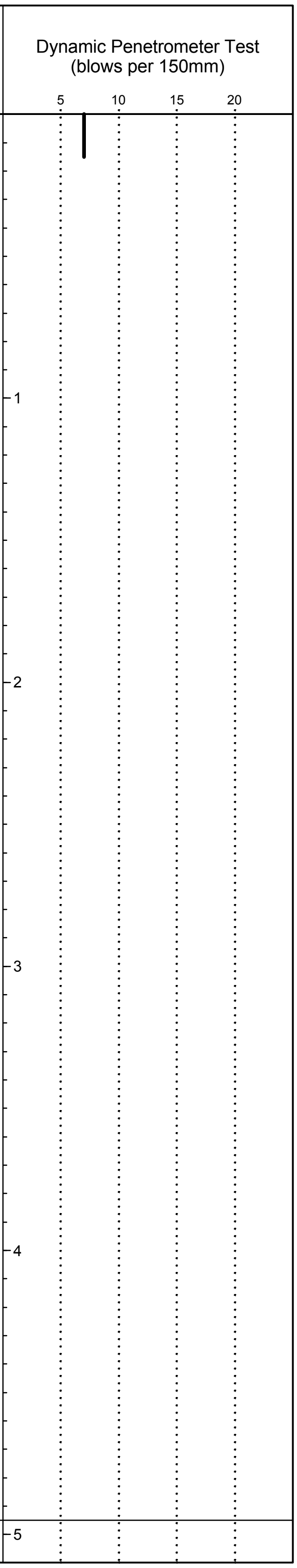
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 2.34 AHD
EASTING: 364160
NORTHING: 1365216
DIP/AZIMUTH: 90°/--

BORE No: TP16
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	FILLING: Dark grey/black gravelly sand (coal reject), with some silt, moist	A, PID	0.4 0.5		<1 ppm	
	From 0.7m depth, saturated	S	0.95		1,2,1 N = 3	▼
		A, PID	1.4 1.5		<1ppm	
		S	1.95		3,2,2 N = 4	
2.0	SILTY CLAY: Firm, grey/brown silty clay, M>Wp	A,pp	2.3		700-100kPa	
2.7	SANDY SILTY CLAY: Very soft, grey, fine grained sandy silty clay, some clay, saturated	A	2.8 3.0			
		S	3.45		sunk 300mm under hammer then 1 blow, N=1	
	From 3.7m depth, with some shells					
4.95	Bore discontinued at 4.95m, limit of investigation					



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 0.7m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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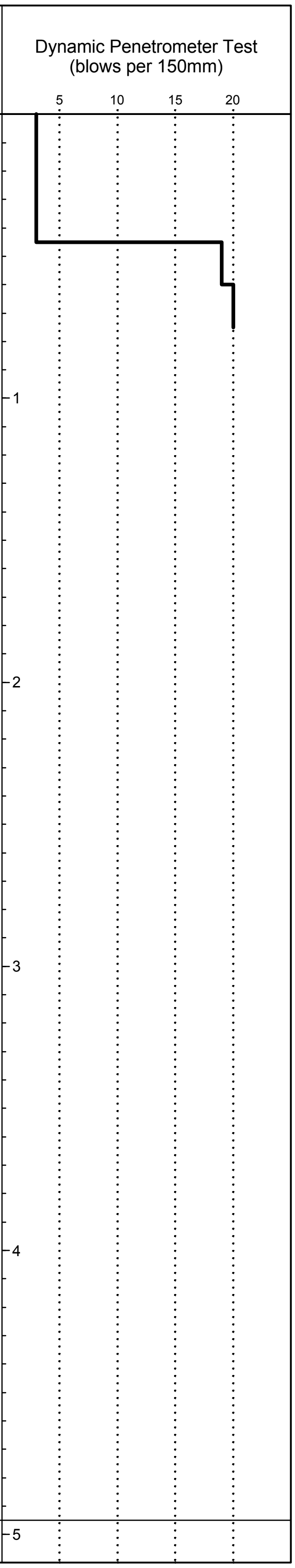
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 2.21 AHD
EASTING: 364027
NORTHING: 1365593
DIP/AZIMUTH: 90°/--

BORE No: TP18
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING: Dark grey/black, fine to medium gravelly fine to coarse grained (coal reject), some silt, humid			0.0			
2								
				B A,PID	0.5		<1ppm	
	1			A,PID	1.0		<1ppm	
1								
				S	1.5 1.95		3,4,3 N = 7	
	2							
0								▼
				A.PID	2.5		<1 ppm	
		Some cobbles from 2.6m depth						
	2.8	SILTY CLAY: Stiff, grey silty clay, M>Wp						
	3			pp	3.0		130-150kPa	
-1							2,2,2 N = 4	
		From 3.3m depth, sandy clay, firm						
				pp	3.45		70-90kPa	
	4							
	4.1	SANDY SILT: Very soft to soft, fine grained sandy silt, saturated						
-2								
				S	4.5 4.95		0,0,1 N = 1	
	4.95 5	Bore discontinued at 4.95m, limit of investigation						



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 2.2m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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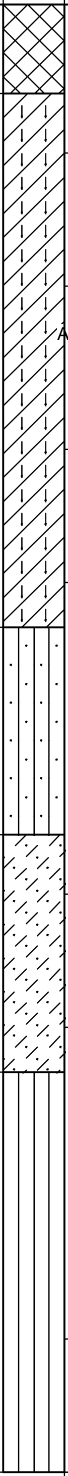
BOREHOLE LOG

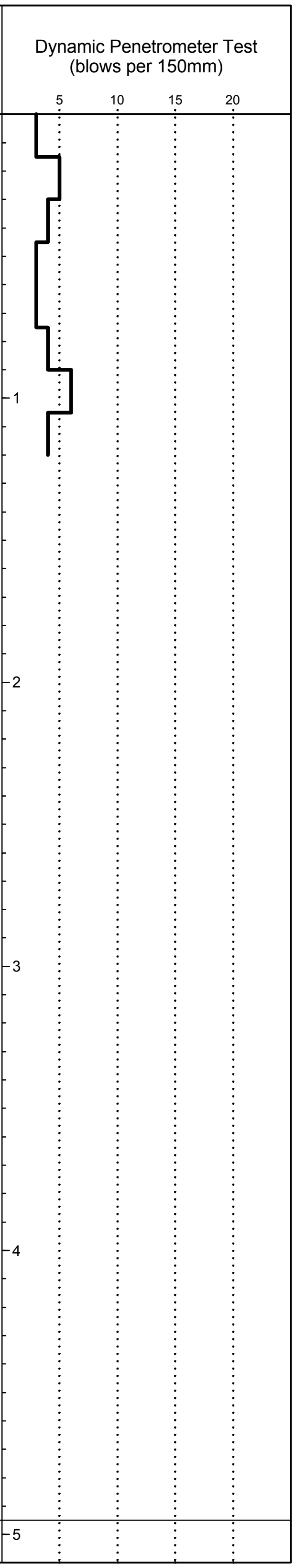
CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.51 AHD
EASTING: 363827
NORTHING: 1366158
DIP/AZIMUTH: 90°/--

BORE No: TP21
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0	FILLING: Dark grey/brown, fine to medium gravelly fine to coarse grained sand, some silt, moist to wet					
	0.3	SILTY CLAY: Firm, grey/brown silty clay, M>Wp					
1			S	0.5		1,2,4 N = 6	▼
	1		pp, PID	0.95		90-120kPa , <1ppm	
			A,pp,PID	1.1		100-120kPa,1ppm	
		From 1.2m depth, mottled orange					
0		From 1.5m depth, very soft to soft, with some sand	S	1.5		1,1,1 N = 2	
	2		pp	1.95		60-100kPa	
	2.1	SANDY SILT: (Very soft), grey fine grained sandy silt with some clay, saturated	A	2.4			
-1							
	2.8	CLAYEY SAND: Very soft, grey, fine grained clayey sand with some silt and shell, saturated					
	3		S	3.0		1,0,0 N = 0	
				3.45			
-2	3.6	SILT: Very soft, grey silt, some fine grained sand, clay and shells, saturated					
	4						
-3				4.5			
	4.95			4.95			
	5	Bore discontinued at 4.95m, limit of investigation					




Dynamic Penetrometer Test (blows per 150mm)

RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 0.5m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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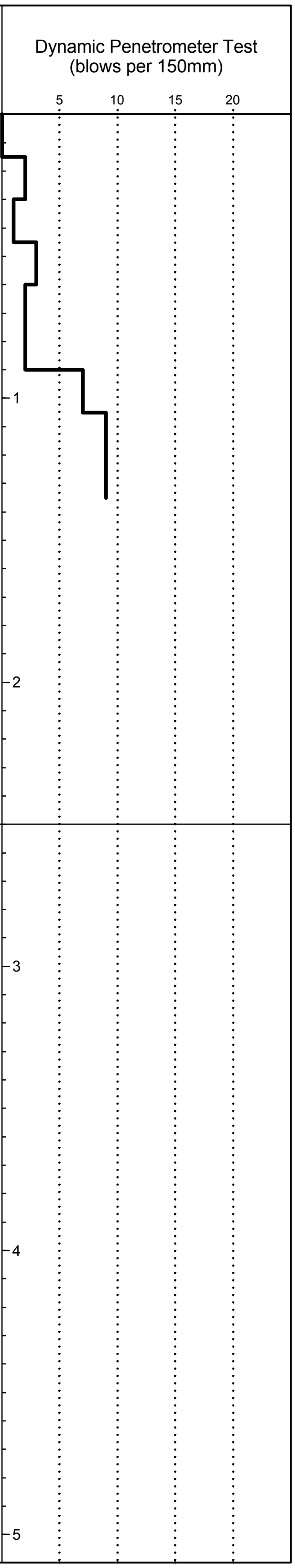
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 0.72 AHD
EASTING: 363700
NORTHING: 1366538
DIP/AZIMUTH: 90°/--

BORE No: TP22
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
0.0	CLAYEY SILT - Grey-brown clayey silt, some organics, M>Wp					▼
0.2	SILTY CLAY - Firm, grey silty clay, M>Wp	A,pp	0.4		50-80 kPa	
			0.9			
1.2	CLAYEY SILTY SAND - Grey mottled orange silty sand, saturated		1.4			
			1.7			
			2.4			
2.5	Bore discontinued at 2.5m, collapse					



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Water at surface 50mm
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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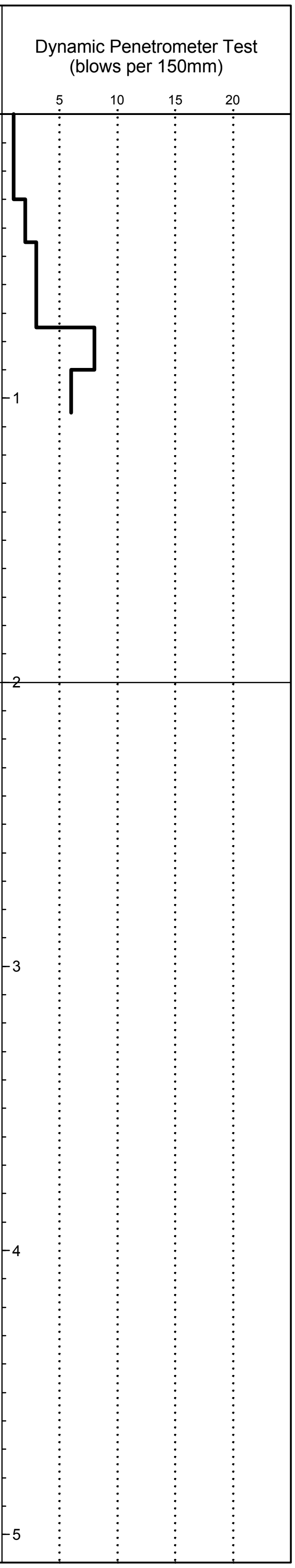
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.07 AHD
EASTING: 363644
NORTHING: 1366730
DIP/AZIMUTH: 90°/--

BORE No: TP23
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments
1		FILLING - Generally comprising fine to coarse sandy fine to medium gravel with some dark grey-black coal reject, saturated				
	0.1	SILTY CLAY - Grey silty (firm) clay, some organics, M>>Wp				
			pp	0.5		50-90 kPa
			A	0.7		
		from 0.8m, grey mottled orange with some fine grained sand	A	0.9		
0	1.1	CLAYEY SILTY SAND - Grey clayey silty sand with some clay, saturated, trace organics	A	1.2		
-1	2.0	Bore discontinued at 2.0m, collapse				



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Free groundwater at surface ~150mm
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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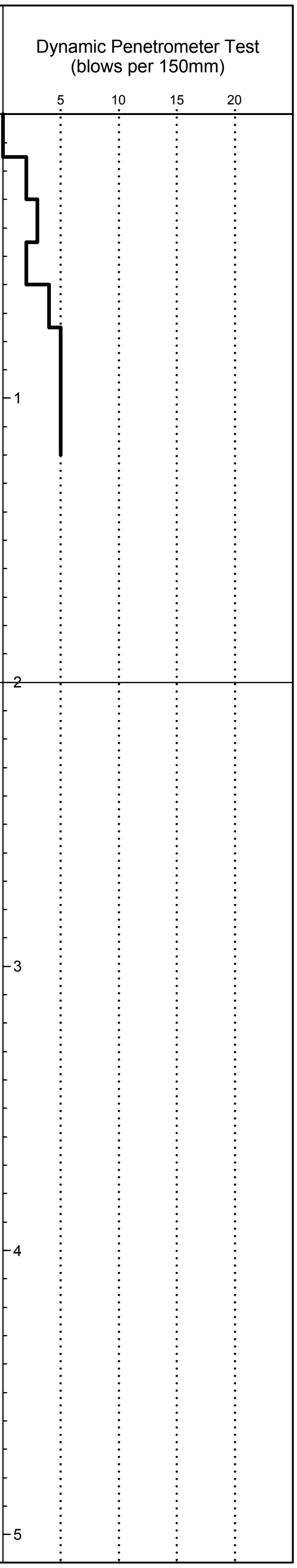
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 3.48 AHD
EASTING: 363582
NORTHING: 1366920
DIP/AZIMUTH: 90°/--

BORE No: TP24
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
3		SILTY CLAY - Firm, grey-brown silty clay, some organics, M>>Wp		A	0.4			▼
	0.6	SILTY SAND - Grey (firm), mottled orange silty sand with some clay, saturated		A	0.7			
				A	0.9			
2				A	1.6			
	2.0	Bore discontinued at 2.0m, collapse						



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Free groundwater at surface
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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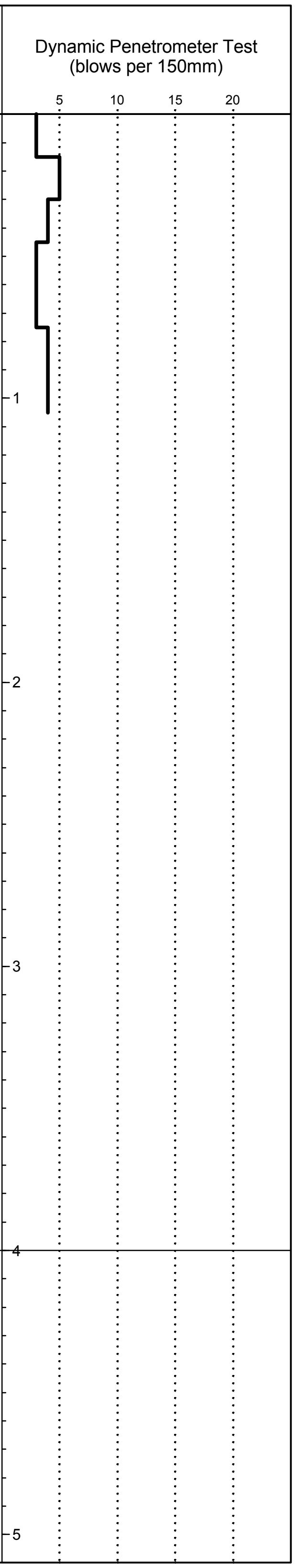
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.33 AHD
EASTING: 363505
NORTHING: 1367105
DIP/AZIMUTH: 90°/--

BORE No: TP25
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		SILTY SAND: Brown, fine grained silty sand, moist			0.0			
1	0.1	SANDY CLAY: Firm, brown, fine grained sandy clay, M>Wp		B	0.5			
				S			1,3,2 N = 5	▼
	0.8	SILTY SAND: Loose, brown, fine grained silty sand some clay, saturated			0.95 1.0			
0	1			A	1.14			
					1.5			
				S			2,3,5 N = 8	
	2				1.95			
-1		From 2.3m depth, very loose with shell fragments between 2.4m to 2.5m		A	2.4			
	3				3.0			
-2				S			under hammer	
					3.45			
				A	3.9			
	4 4.0	Bore discontinued at 4.0m, limit of investigation						
-3								
	5							



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 0.8m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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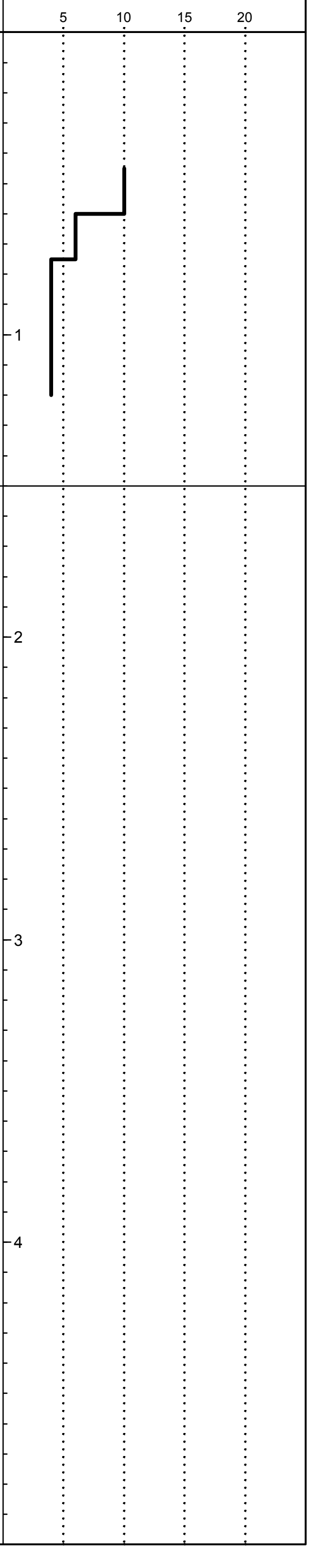
BOREHOLE LOG

CLIENT:	Queensland Rail	**SURFACE LEVEL:**	1.42 AHD	**BORE No:**	TP26
PROJECT:	Proposed Maintenance Facility	**EASTING:**	363424	**PROJECT No:**	39798
LOCATION:	Woodland Close	**NORTHING:**	1367277	**DATE:**	19 Sep 07
		DIP/AZIMUTH:	90°/--	**SHEET**	1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Grey clayey gravelly sand filling, dry to moist (gravel containing slog)	▨					
1	0.4	FILLING - Brown clayey gravelly sand (ash), moist	▨					
	0.7	FILLING - Stiff grey mottled orange brown clay filling, some silt, M>Wp from 1.0 m moisture content increasing with strength	▨					
	1.3	FILLING - Stiff orange brown gravelly clay filling	▨					
0	1.5	Bore discontinued at 1.5m, due to potential service						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Hand Tools **DRILLER:** McFarlane **LOGGED:** McFarlane **CASING:** Uncased

TYPE OF BORING: 90 mm diameter hand auger

WATER OBSERVATIONS: No Free Ground Water Observed

REMARKS: Adjacent to access load, 10m south of peg

☐ Sand Penetrometer AS1289.6.3.3

☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED

Initials:

Date:

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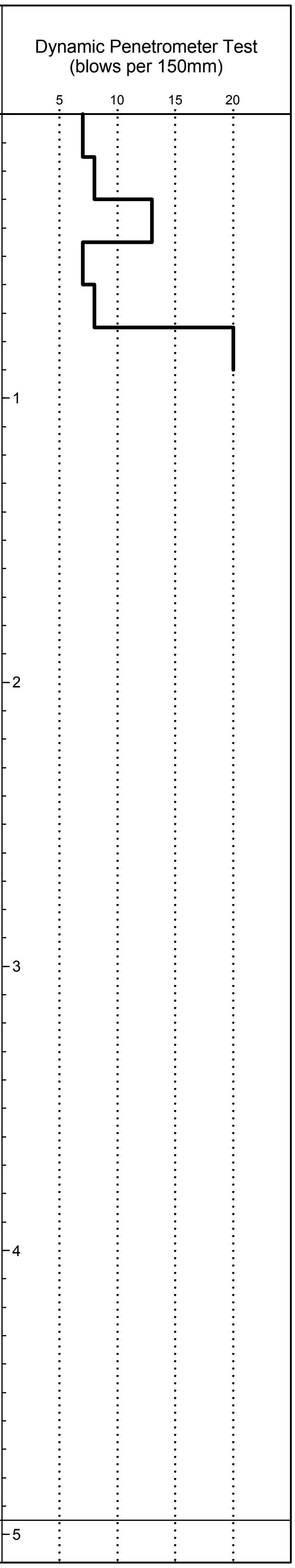
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.77 AHD
EASTING: 364225
NORTHING: 1364963
DIP/AZIMUTH: 90°/--

BORE No: TP27
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
		FILLING: Dark grey/black, fine gravelly fine to coarse sand (coal reject) some silt, humid	A,PID	0.4		<1ppm	
			S	0.5		6,bounce,ref refusal	
1							
	1			1.0			
			B A,PID	1.3		<1 ppm	▼
	1.5	SILTY CLAY: Soft to firm, grey silt clay, M>Wp		1.5			
0			S			1,1,2 N = 3	
	2		pp	1.95		100-150kPa	
	2.1	CLAYEY SILTY SAND: Very soft, grey, fine grained clayey silty sand, saturated					
			A	2.4			
		decreasing clay from 2.5m depth					
-1							
			A	2.9			
	3			3.0			
			S			0,0,1 N = 1 hammer under pressure	
				3.45			
-2							
	4						
				4.5			
			S			0,0,1 N = 1	
-3							
	4.95			4.95			
	5	Bore discontinued at 4.95m, limit of investigation					



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.3m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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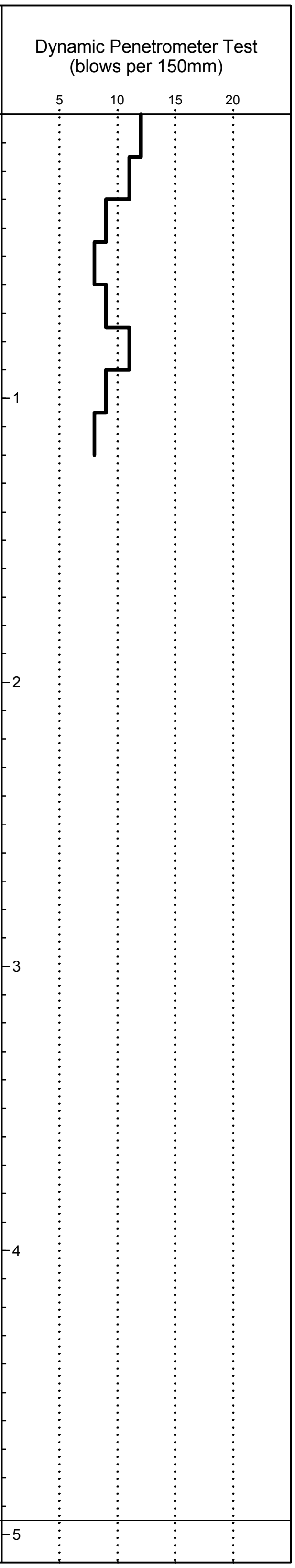
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 3.05 AHD
EASTING: 364053
NORTHING: 1365366
DIP/AZIMUTH: 90°/--

BORE No: TP28
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
3		FILLING: Dark grey/black, fine to medium gravelly fine to coarse grained sand (coal reject), humid	A,PID	0.1		<1ppm	
	0.3	FILLING: Orange, fine gravelly, fine to coarse sand (roadbase)					
	0.5	FILLING: Dark grey, fine to medium grained sand, some site, moist					
2	1		A,PID	1.0		<1ppm	
	1.3	FILLING: Grey/brown, fine to medium gravelly clay, M>Wp					
			A,PID	1.5		<1ppm	▼
			S	1.95		7,7,9 N = 16	
1	2						
			A,PID	2.5		<1ppm	
	2.7	SILTY CLAY: Firm to stiff, grey silty clay, M>Wp					
0	3		S	3.0 3.25		3,7/100,ref refusal bouncing on backfill	
			pp	3.3		120-140kPa	
	3.8	SANDY SILT: Very soft to soft grey, fine grained sandy silt, saturated					
-1	4						
			S	4.5 4.95			
-2	4.95 5	Bore discontinued at 4.95m, limit of investigation					



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.5m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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BOREHOLE LOG

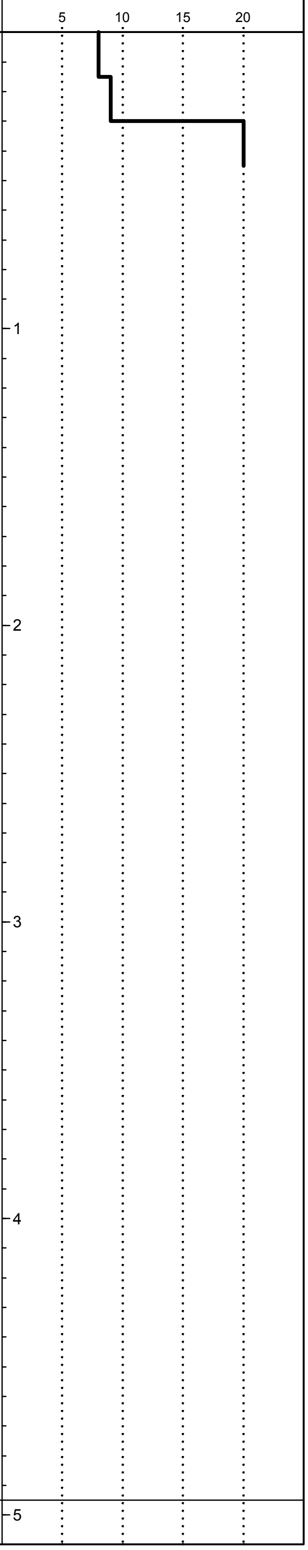
CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 3.76 AHD
EASTING: 363920
NORTHING: 1365716
DIP/AZIMUTH: 90°/--

BORE No: TP29
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING: Brown silty fine to coarse sand with some low to medium dark grey/black gravelly sand (coal reject), humid					
			A,PID	0.4		<1ppm	
3	0.8	FILLING: Dark grey/black, fine to medium gravelly fine to coarse sand (coal reject), moist	A,PID	0.9		<1ppm	
			A,PID	1.4		<1ppm	
2			S	1.5 1.95		2,2,3 N = 5	
							▼
			A,PID	2.4		<1ppm	
1			A,PID	2.9		<1ppm	
			S	3.0 3.45		1,1,2 N = 3	
0							
	4.2	SILTY CLAY: Firm, grey silty clay, M>Wp					
		From 4.5m depth, firm/stiff	pp	4.5		110-140kPa	
-1			S			1,2,3 N = 5	
	4.95	From 4.9m depth, firm	pp	4.9 4.95		70-90kPa	
		Bore discontinued at 4.95m, limit of investigation					

Dynamic Penetrometer Test (blows per 150mm)



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 2.3m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.76 AHD
EASTING: 363764
NORTHING: 1366115
DIP/AZIMUTH: 90°/--

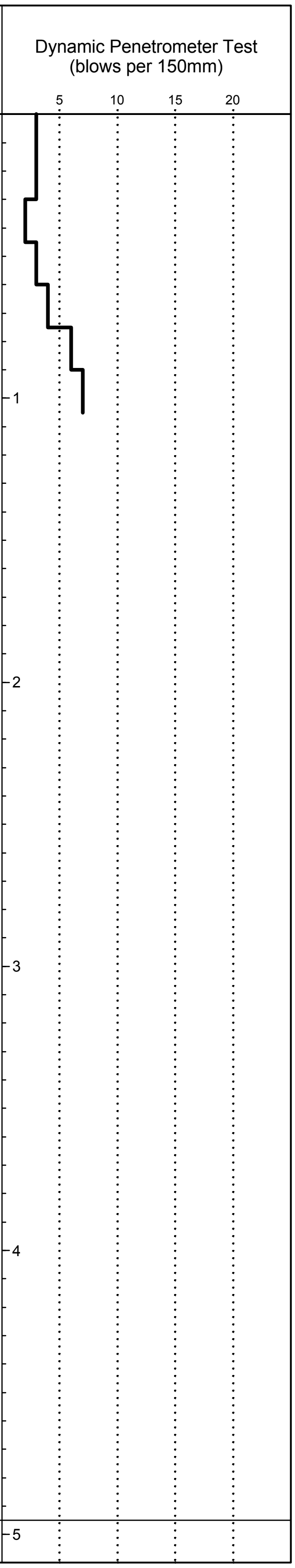
BORE No: TP30
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata
0.1	SILTY SAND: Brown, fine to medium grained silty sand, damp to moist
1.1	SANDY CLAY: Firm, brown fine grained sandy clay some silt, M>Wp
1.6	CLAY: Very soft to soft, grey clay, M>Wp
2.3	SILTY SAND: Very loose, grey mottled orange silty fine grained sand, saturated
4.95	CLAYEY SILT: Very soft grey clayey silt, some fine grained sand and abundant shells, saturated
	Bore discontinued at 4.95m, limit of investigation

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A	0.4 0.5		
S	0.5 0.95		2,2,3 N = 5
A,pp	1.4 1.5		<50-70kPa
S	1.5 1.95		weight of hammer
A	2.4		
S	3.0 3.45		weight of hammer
S	4.5 4.95		weight of hammer

Water: ▼ at approx. 1.7 m



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.7m
REMARKS: 10m west of pegged location

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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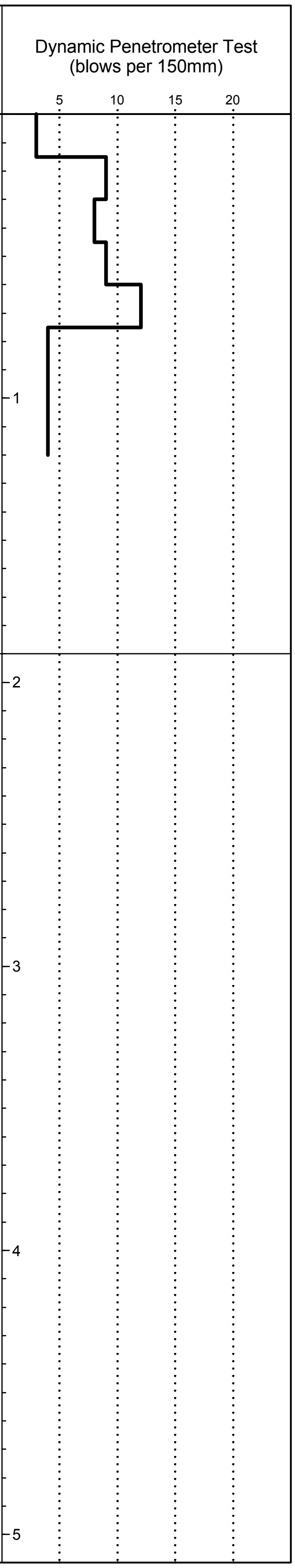
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.30 AHD
EASTING: 363743
NORTHING: 1366178
DIP/AZIMUTH: 90°/--

BORE No: TP31
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
1		FILLING - Generally comprising dark grey-black fine to coarse sandy fine to medium gravel (coal reject), wet to saturated	☒					▼
0	1.0	SILTY CLAY - (Firm to stiff), grey mottled orange silty clay, M>>Wp	▨	A	1.3			
		from 1.5m, stiff		A,pp	1.5		100-160 kPa	
-1				A	1.8			
	1.9	Bore discontinued at 1.9m, limit of investigation						



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Free groundwater at 0.4m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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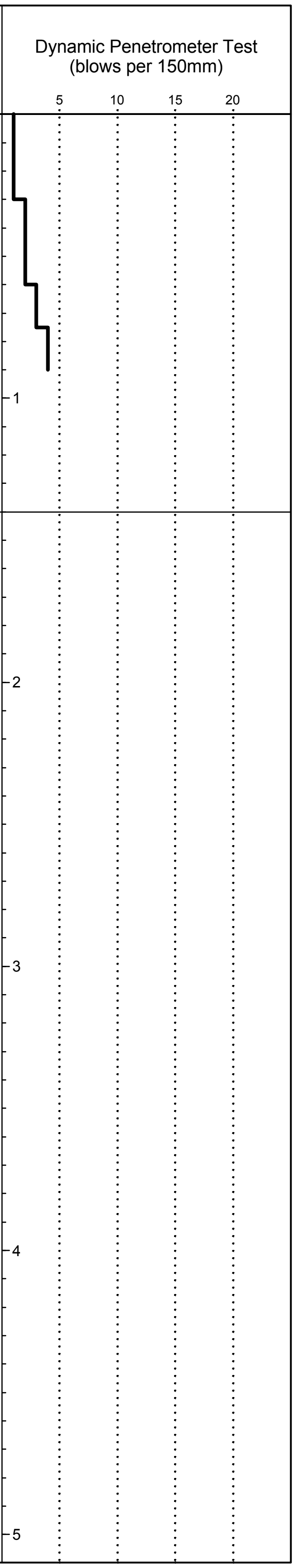
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 0.66 AHD
EASTING: 363604
NORTHING: 1366467
DIP/AZIMUTH: 90°/--

BORE No: TP32
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		CLAYEY SILT - Grey-brown clayey silt, some organics, M>Wp, saturated						▼
	0.4	SILTY CLAY - Firm to stiff, grey silty clay, M>Wp		A,pp	0.5		110-140 kPa	
	1.3	SILTY SAND - Grey mottled orange silty sand, saturated						
	1.4	Bore discontinued at 1.4m, due to hole collapse						



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Free groundwater at surface ~150mm
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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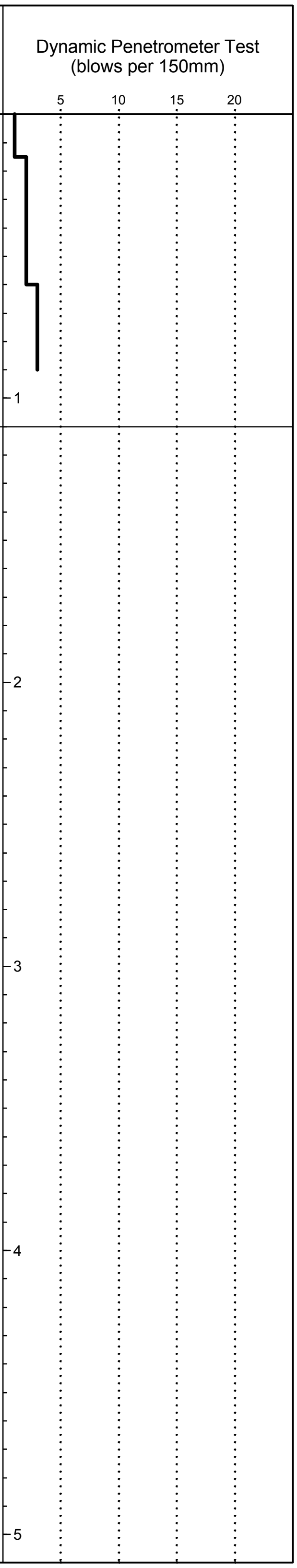
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 0.54 AHD
EASTING: 363666
NORTHING: 1366490
DIP/AZIMUTH: 90°/--

BORE No: TP33
PROJECT No: 39798
DATE: 22 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments
	CLAYEY SILT - Grey-brown clayey silt, some organics, M>Wp, saturated				
0.3	SILTY CLAY - Firm to stiff, grey silty clay, M>Wp	A,pp	0.5		90-130 kPa
1.0	SILTY SAND - Grey mottled orange silty sand, saturated				
1.1	Bore discontinued at 1.1m, due to hole collapse				



RIG: Hand Tools **DRILLER:** Musgrove **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: 90mm hand auger
WATER OBSERVATIONS: Free groundwater at surface ~200mm
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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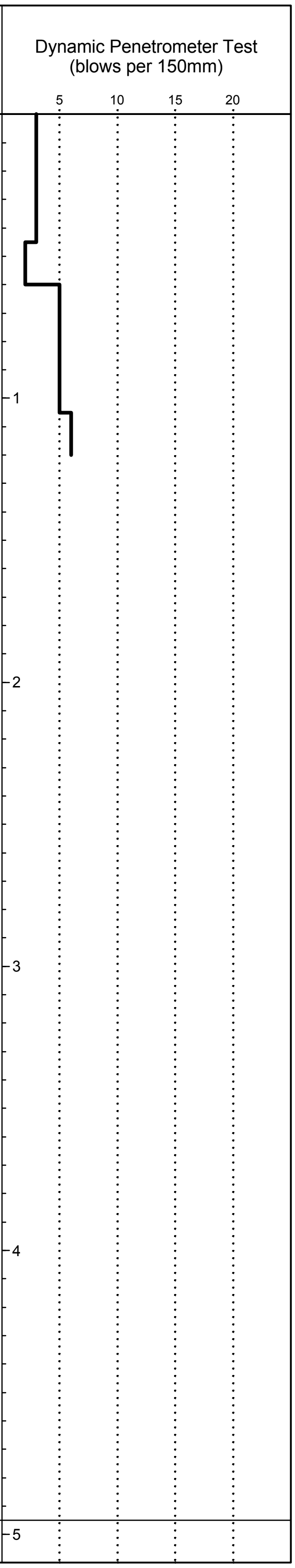
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: --
EASTING: 363632
NORTHING: 1366677
DIP/AZIMUTH: 90°/--

BORE No: TP34
PROJECT No: 39798
DATE: 06 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water
				Type	Depth	Sample	Results & Comments	
		FILLING: Grey/orange, fine to coarse gravelly fine to coarse grained sand (roadbase, humid						▼
	0.7	CLAY: Fimr to soft, grey clay, M>Wp		B	0.7			
	1			pp	1.0		100-150kPa	
	1.1	SILTY CLAY: Very soft, grey silty clay, saturated		A,pp	1.3		<50-70kPa	
				S	1.5 1.95		weight of hammer	
	2			A	2.4			
	3			S	3.0 3.45		weight of hammer	
	4.0	CLAYEY SILT: Very soft grey clayey silt, abundant shells, saturated						
				S	4.5 4.95		weight of hammer	
	4.95	Bore discontinued at 4.95m, limit of investigation						



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 0.5m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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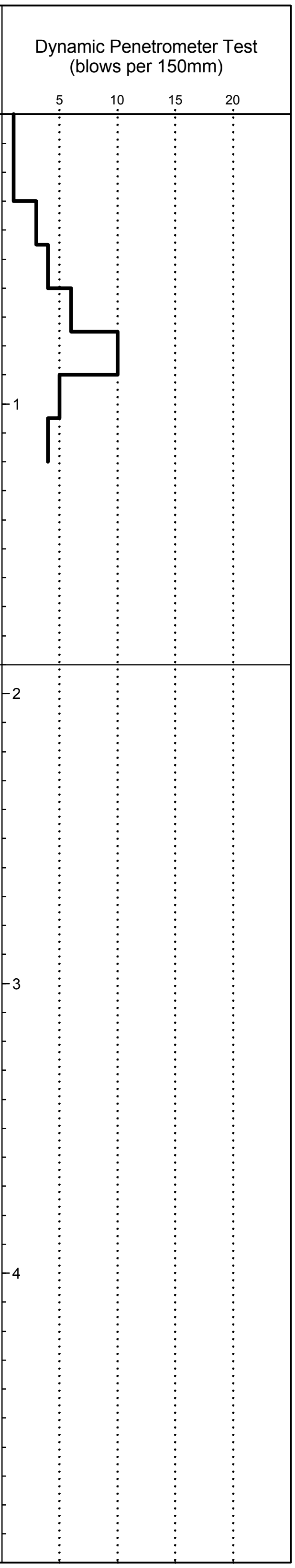
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Woodland Close

SURFACE LEVEL: 1.07 AHD
EASTING: 363538
NORTHING: 1366848
DIP/AZIMUTH: 90°/--

BORE No: TP35
PROJECT No: 39798
DATE: 19 Sep 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
1		TOPSOIL - Dark grey silty clay topsoil, some rootlets, moist					
	0.3	CLAYEY SILT - Firm to stiff brown mottled orange brown clayey sit, some fine sand					
	0.5	CLAYEY SAND - Firm to stiff light grey mottled orange brown clayey sand					▼
0	0.9	SAND - Loose to medium dense light grey mottled orange brown sand, some clay, saturated					
	1.2	SANDY CLAY - Firm light grey mottled orange brown sandy clay, M>Wp					
	1.3	CLAYEY SAND - Light grey mottled orange brown clayey sand, saturated					
-1	1.9	Bore discontinued at 1.9m					
-2	3						
-3	4						



RIG: Hand Tools **DRILLER:** McFarlane **LOGGED:** McFarlane **CASING:** Uncased
TYPE OF BORING: 90 mm diameter hand auger
WATER OBSERVATIONS: Free Ground Water Observed at 0.8 m depth
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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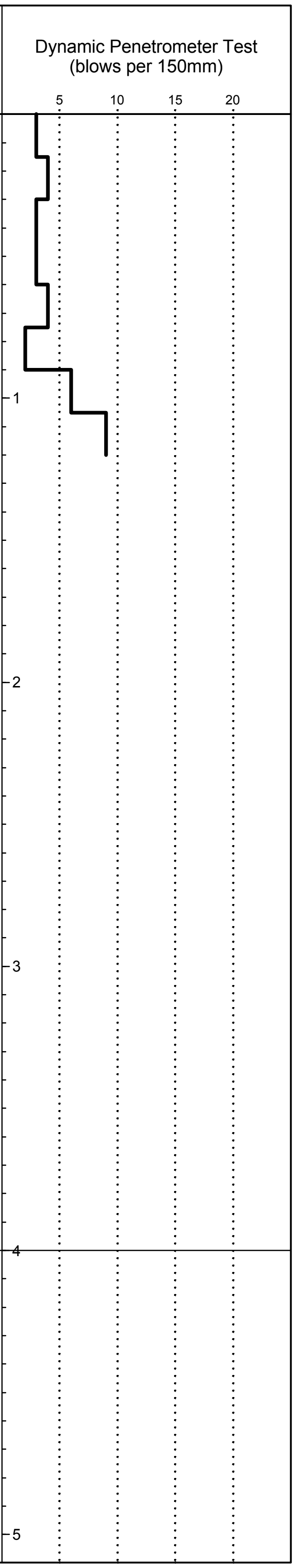
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.22 AHD
EASTING: 363507
NORTHING: 1367026
DIP/AZIMUTH: 90°/--

BORE No: TP36
PROJECT No: 39798
DATE: 07 Aug 07
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	SILTY SAND: Brown, fine grained silty sand, moist					
0.1	SANDY CLAY: Stiff, brown, fine grained sandy clay, M>Wp		0.1 0.3			
		S B			3,4,4 N = 8	
		pp	0.95 1.0		130-150kPa	
1.2	SAND: Very loose to loose, brown sand with abundant shells, some clay, saturated					▼
		A	1.4 1.5			
		S	1.95			
2.2	SILTY SAND: Very loose to loose, grey silty sand, abandant shells, saturated					
		A	2.5			
			3.0			
		S	3.45		under hammer	
	with some clay from 3.5m depth					
4.0	Bore discontinued at 4.0m, limit of investigation	A	4.0			



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.2m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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BOREHOLE LOG

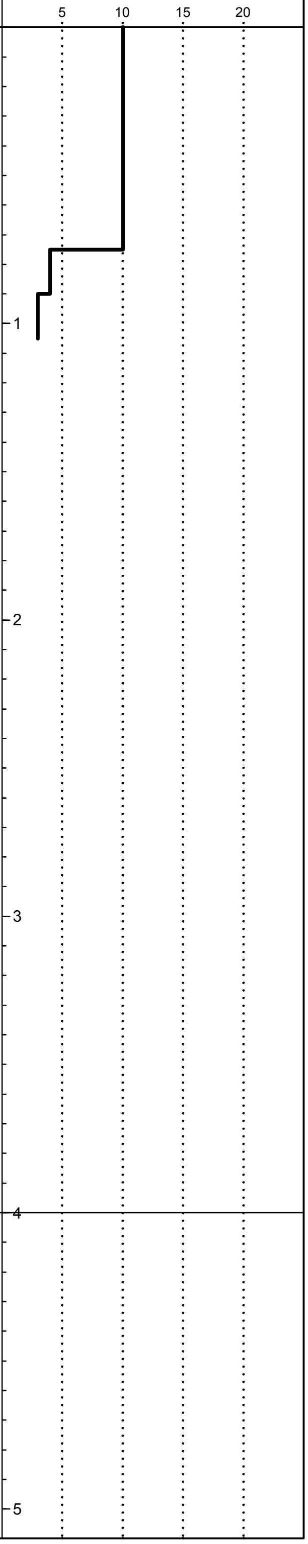
CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Off Woodlands Close, Hexham

SURFACE LEVEL: 1.29 AHD
EASTING: 363449
NORTHING: 1367181
DIP/AZIMUTH: 90°/--

BORE No: TP37
PROJECT No: 39798
DATE: 07 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water
				Type	Depth	Sample	Results & Comments	
		FILLING: Intermixed dark grey black gravelly, fine to coarse sand (coal reject) and brown, fine to medium grained silty sand, humid	☒	A,PID	0.4		<1ppm	
				S	0.5 0.95		3,5,3 N = 8	
	1.1	CLAY: Very soft to firm, grey clay, some silt, M>Wp	▨	A	1.4			▼
	1.5	CLAYEY SILT: Very soft, grey clayey silt, some fine grained sand, abundant shells, saturated	▨	A,pp	1.5		70-90kPa	
				S	1.5 1.95		0,0,1 N = 1	
				A	2.4			
				A	3.0 3.45			
					3.9			
	4.0	Bore discontinued at 4.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 4WD Mounted Drill Rig **DRILLER:** Atkins (Foody) **LOGGED:** Rice **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.1m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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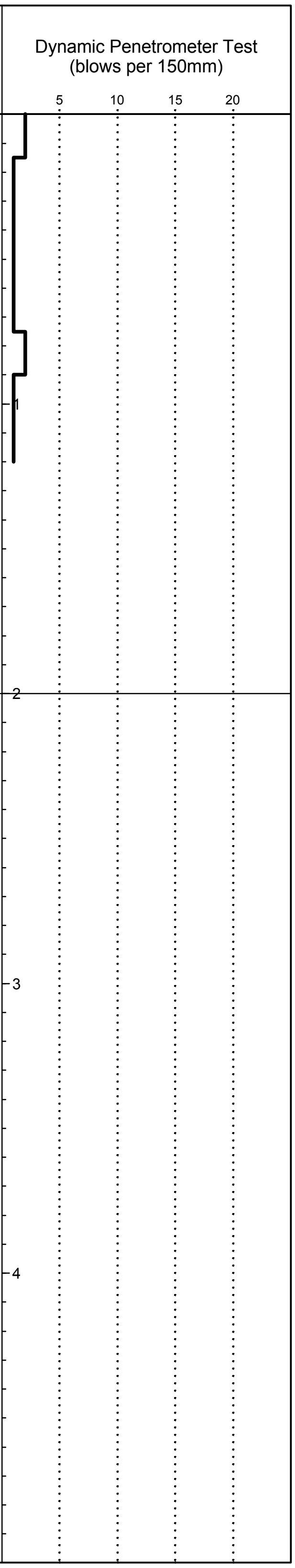
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Woodland Close

SURFACE LEVEL: 0.21 AHD
EASTING: 363347
NORTHING: 1367365
DIP/AZIMUTH: 90°/--

BORE No: TP38
PROJECT No: 39798
DATE: 19 Sep 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		CLAYEY SILT - Firm brown grey clayey silt, some organics, M>Wp						
	0.15	CLAY - Firm to stiff grey mottled orange brown clay		A	0.25			
		from 0.6 m soft to firm grey mottled orange brown						▼
		from 0.7 m soft		A	0.9			
				A	1.3			
	2.0	Bore discontinued at 2.0m						



RIG: Hand Tools **DRILLER:** McFarlane **LOGGED:** McFarlane **CASING:** Uncased
TYPE OF BORING: 90 mm diameter hand auger
WATER OBSERVATIONS: Sepage from 0.6 m
REMARKS: Adjacant to Drain (0.5 m higher than water)

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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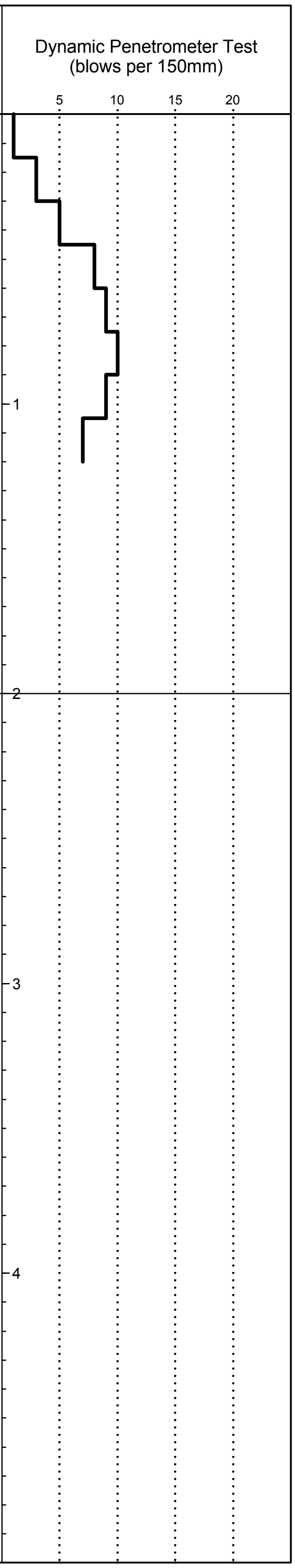
BOREHOLE LOG

CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Woodland Close

SURFACE LEVEL: 0.87 AHD
EASTING: 362895
NORTHING: 1367574
DIP/AZIMUTH: 90°/--

BORE No: TP39
PROJECT No: 39798
DATE: 19 Sep 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.15	TOPSOIL - Dark grey silty clay, topsoil, some rootlets, moist					
	0.5	CLAY - Stiff light grey mottled orange brown clay M>Wp					
0	1.5	CLAYEY SAND - Stiff brown mottled orange brown clayey soil, moist					▼
	1.8	SANDY CLAY - Soft grey mottled orange brown sandy clay, M>>Wp					
-1	2.0	SILTY CLAY - Soft grey silty clay, some sand M>>Wp					
-2 -3 -4		Bore discontinued at 2.0m					



RIG: Hand Tools **DRILLER:** McFarlane **LOGGED:** McFarlane **CASING:** Uncased
TYPE OF BORING: 90 mm diameter hand auger
WATER OBSERVATIONS: Free Ground Water Observed at 0.8 m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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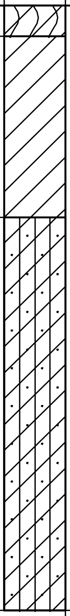
BOREHOLE LOG

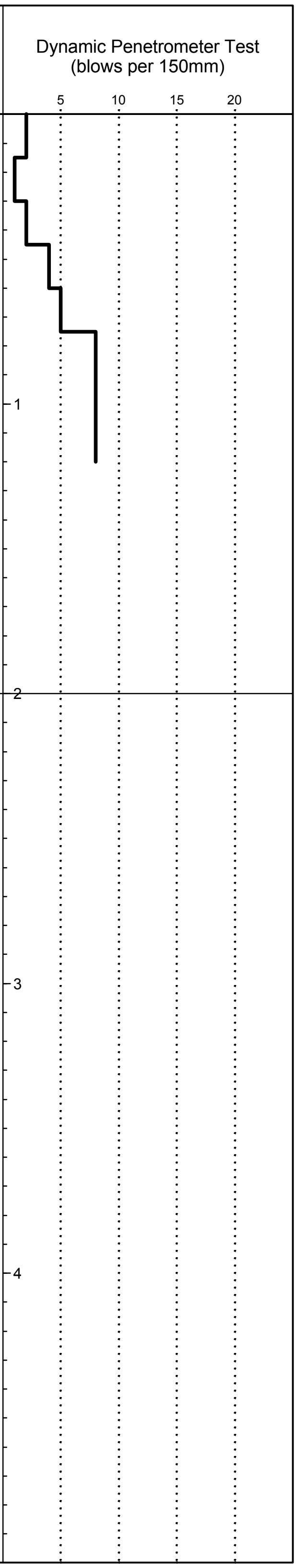
CLIENT: Queensland Rail
PROJECT: Proposed Maintenance Facility
LOCATION: Woodland Close

SURFACE LEVEL: 0.76 AHD
EASTING: 362517
NORTHING: 1367641
DIP/AZIMUTH: 90°/--

BORE No: TP40
PROJECT No: 39798
DATE: 19 Sep 07
SHEET 1 OF 1



RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - Dark grey clay with sone silt and rootlets, moist					
	0.7	CLAY - Stiff dark grey clay, some silt< M>Wp from 1.2 m with some shells / shell fragments from 0.4 m light grey mottled orange brown from 0.6 m sand content increasing, becoming firm					▼
	2.0	SANDY SILTY CLAY - Firm to stiff grey sandy silty clay, M>Wp from 1.5 m abundant shells					
		Bore discontinued at 2.0m					



RIG: Hand Tools **DRILLER:** McFarlane **LOGGED:** McFarlane **CASING:** Uncased
TYPE OF BORING: 90 mm diameter hand auger
WATER OBSERVATIONS: Free Ground Water Observed at 0.5 m
REMARKS:

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date:

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RESULTS OF DYNAMIC PENETROMETER TESTS

CLIENT	Queensland Rail	DATE	6.8.07– 19.09.07
PROJECT	Proposed Maintenance Facility	PROJECT NO	39798
LOCATION	Off Woodlands Close, Hexham	PAGE NO	Page 1 of 3

TEST LOCATIONS	TP14	TP16	TP18	TP21	TP22	TP23	TP24	TP25	TP26	TP27
RL OF TEST	1.53	2.34	2.21	1.51	0.72	1.07	3.48	1.33	1.42	1.77
DEPTH m	PENETRATION RESISTANCE BLOWS/150mm									
0.00 - 0.15	15	7	3	3	0	1	0	3	-	7
0.15 - 0.30	12	bouncing	3	5	2	1	2	5	-	8
0.30 - 0.45	20		3	3	1	2	3	4	10	13
0.45 - 0.60	ref		19	3	3	3	2	3	6	7
0.60 - 0.75			20/100	4	2	3	4	3	4	8
0.75 - 0.90			ref	6	2	8	5	4	4	20
0.90 - 1.05				4	7	6	5	4	4	ref
1.05 - 1.20					9		5			
1.20 - 1.35					9					
1.35 - 1.50										
1.50 - 1.65										
1.65 - 1.80										
1.80 - 1.95										
1.95 - 2.10										
2.10 - 2.25										
2.25 - 2.40										
2.40 - 2.55										
2.55 - 2.70										
2.70 - 2.85										
2.85 - 3.00										

TEST METHOD AS 1289.6.3.2, CONE PENETROMETER ☑
AS 1289.6.3.3, FLAT END PENETROMETER ☐

TESTED BY: BRR/SAM
CHECKED BY:

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RESULTS OF DYNAMIC PENETROMETER TESTS

CLIENT	Queensland Rail	DATE	6.8.07 – 19.09.07
PROJECT	Proposed Maintenance Facility	PROJECT NO	39798
LOCATION	Off Woodlands Close, Hexham	PAGE NO	Page 2 of 3

TEST LOCATIONS	TP28	TP29	TP30	TP31	TP32	TP33	TP34	TP35	TP36	TP37
RL OF TEST	3.05	3.76	1.76	1.3	0.66	0.54	-	1.07	1.22	1.29
DEPTH m	**PENETRATION RESISTANCE** BLOWS/150mm									
0.00 - 0.15	12	8	3	3	1	1	3	1	3	10
0.15 - 0.30	11	9	3	9	1	2	3	1	4	10
0.30 - 0.45	9	20	2	8	2	2	3	3	3	10
0.45 - 0.60	8	ref	3	9	2	2	2	4	3	10
0.60 - 0.75	9		4	12	3	3	5	6	4	10
0.75 - 0.90	11		6	4	4	3	5	10	2	8
0.90 - 1.05	9		7	4			5	5	6	4
1.05 - 1.20	8			4			6	4	9	3
1.20 - 1.35										
1.35 - 1.50										
1.50 - 1.65										
1.65 - 1.80										
1.80 - 1.95										
1.95 - 2.10										
2.10 - 2.25										
2.25 - 2.40										
2.40 - 2.55										
2.55 - 2.70										
2.70 - 2.85										
2.85 - 3.00										

TEST METHOD AS 1289.6.3.2, CONE PENETROMETER ☑
AS 1289.6.3.3, FLAT END PENETROMETER ☐

TESTED BY: BRR/SAM
CHECKED BY:

Douglas Partners
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RESULTS OF DYNAMIC PENETROMETER TESTS

CLIENT Queensland Rail
PROJECT Proposed Maintenance Facility
LOCATION Off Woodlands Close, Hexham

DATE 6.8.07 – 19.09.07
PROJECT NO 39798
PAGE NO Page 3 of 3

TEST LOCATIONS	TP38	TP39	TP40							
RL OF TEST	0.21	0.87	0.76							
DEPTH m	PENETRATION RESISTANCE BLOWS/150mm									
0.00 - 0.15	2	1	2							
0.15 - 0.30	1	3	1							
0.30 - 0.45	1	5	2							
0.45 - 0.60	1	8	4							
0.60 - 0.75	2	9	5							
0.75 - 0.90	1	10	8							
0.90 - 1.05	1	9	8							
1.05 - 1.20		7	8							
1.20 - 1.35										
1.35 - 1.50										
1.50 - 1.65										
1.65 - 1.80										
1.80 - 1.95										
1.95 - 2.10										
2.10 - 2.25										
2.25 - 2.40										
2.40 - 2.55										
2.55 - 2.70										
2.70 - 2.85										
2.85 - 3.00										

TEST METHOD AS 1289.6.3.2, CONE PENETROMETER ☑
AS 1289.6.3.3, FLAT END PENETROMETER ☐

TESTED BY: BRR/SAM
CHECKED BY:

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