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Bridge 1763 - Bussell Highway Over Sabina River

Geotechnical Factual, Interpretive and Design Report

Bridge 1763 - Bussell Highway Over Sabina River

Geotechnical Factual, Interpretive and Design Report

Client: Main Roads Western Australia

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Executive Summary

AECOM Australia Pty Ltd (AECOM) was commissioned by Main Roads Western Australia (MRWA) to undertake a geotechnical investigation with factual and interpretive reporting for the proposed Bridge 1763 as part of the duplication of the Bussell Highway between Capel and Busselton in Western Australia.

Bridge 1763 will duplicate the existing Bridge 1369 structure. The new highway will lie approximately 25 m east, south or south east of the existing carriageway. A concept design report for bridge 1763 was prepared in April 2016. That report proposed three options for the new bridge. At the time of the investigation, the preferred option had not been confirmed. Following further evaluation of the options, a 15% Design Report (Doc No. 60344161-RPST-0173, dated 15 July 2016) was prepared and includes a description of the preferred bridge configuration.

A geotechnical and limited acid sulfate soil (ASS) site investigation that comprised drilling two boreholes and performing eight cone penetrometer tests (CPTu) was undertaken between the period 31 March and 04 April 2016.

Subsurface conditions: The following generalised subsurface units were encountered in the boreholes and CPTu probings:

Recent Alluvium: This unit is constrained to the valley floor close to the present river stream and represents the recent alluvial deposits of the Ludlow River. It generally consists of an upper horizon dominated by sand and silt overlying a lower horizon dominated by clay with minor organics (including traces of fibrous peat).

Guilford Formation: This unit is similar in variability and materials to the Recent Alluvium but generally of higher density/shear strength. It may be absent from the western abutment. On the eastern abutment it is generally a multi-coloured (dark grey, dark red-brown, dark yellow brown and brown) silty sand, sand and sandy clay ranging from non-plastic to high plasticity depending on the clay content. It includes a zone inferred to be weathered, or very weakly cemented coffee rock between 6.7 m and 7.3 m depth.

Leederville Formation: This unit was found to be dominated by unconsolidated sand to silty sand with minor beds of clay/silt. The sand was typically described as greyish in colour, clayey or silty and generally in a medium dense to very dense condition. The clay beds were assessed as medium plasticity, dark grey and containing rare or occasional coal fragments of coarse sand to fine gravel size. The Leederville formation represents the deepest unit encountered at the site.

Groundwater: A standpipe piezometer was installed in BH1763-02. The piezometer was dipped on 02 May 2016 and the groundwater level was found to be 3.05 m below ground level (bgl) (3.67 m AHD).

Aggressivity: Based on the pH, chloride and sulfate values measured on the tested soil and groundwater samples, the exposure classification for steel and concrete varies between ‘non-aggressive’ and ‘mild’.

Sub-soil Class and Liquefaction: The sub-soil class for the site has been assessed as “Class De – Deep or soft soil site”. A preliminary liquefaction analysis was undertaken based on results from CPT testing.

Pile Foundations: Pile foundations are considered as the preferred option for bridge abutments and pier foundations. Layers of Leederville Formation are considered to be competent enough as the founding strata for pile foundations. Driven steel cased piles are the preferred foundation option. For concept design stage, diameters of 450 mm and 610 mm have been considered. It is understood that 610 mm pile diameter is the structurally preferred option in order to reduce the number of piles per pier/abutment.

Settlements at Approach Embankment: This issue will be considered in a revised version of the report when road alignment design is progressed.

ASS Assessment: A degree of acid sulfate soil risk has been identified in selected soil samples from the field investigation. As such, it is recommended that an ASS management plan be prepared for this site.

1.0 Introduction

1.1 General

AECOM Australia Pty Ltd (AECOM) was commissioned by Main Roads Western Australia (MRWA) to undertake a geotechnical investigation with factual and interpretive reporting for the proposed Bridge 1763 as part of the duplication of the Bussell Highway between Capel and Busselton in Western Australia.

Bridge 1763 will duplicate the existing Bridge 1369 structure. The new highway will lie approximately 25 m east, south or southeast of the existing carriageway.

A concept design report for bridge 1763 was prepared in April 2016. That report proposed three structural options for the new bridge with minor variations in horizontal alignment. At the time of the geotechnical site investigation, the preferred option had not been confirmed. Following further evaluation of the options, a 15% Design Report (Doc No. 60344161-RPST-0173, dated 15 July 2016) was prepared and includes a description of the preferred bridge configuration.

The proposed bridge will be approximately 18 m long between abutment centrelines (single span) and 11.5 m wide between kerbs. The bridge would have a skew angle of 10 degrees to line up with the direction of water flow to minimise water turbulence. A structural option with precast prestressed planks with in-situ reinforced concrete deck slab has been recommended.

This report is prepared by AECOM to an approved scope of work and is to be read subject to the terms and conditions contained within MRWA contract 226/13. It has been prepared in general accordance with MRWA Materials Engineering Report No. 2009-8M Guidelines for Geotechnical Investigation of Bridge Structures (Chowdhury and Rehman 2009). Foundation recommendations are preliminary and will be updated after road and structural designs are progressed further. At time of writing this report the 15% structural design has been prepared by AECOM and it is understood that WML Pty Ltd is progressing a 15% road alignment design.

1.2 Scope of Work

The scope of the work undertaken in this geotechnical investigation can be summarised as:

- coordination and engagement of subcontractors to carry out the fieldworks;
- preparation for the fieldworks and approval applications;
- preparation of the Occupational Health, Safety and Environmental Management Plan (OHSEMP) for the geotechnical investigation and implementation of the management plan during the field works;
- full time coordination of the drilling of two boreholes by geoprobe, wash-boring and diamond coring methods; logging and photographing the samples;
- full time coordination of eight Electric Friction Cone Penetrometer Test (EFCPTu) probings with pore water pressure measurement;
- one standpipe piezometer, installed in BH1763-02;
- scheduling of laboratory testing on the soil and rock samples recovered during the investigation; and
- preparation of this geotechnical investigation factual report.

2.0 Previous Geotechnical Reports and Other Investigations

This report follows on from the Geotechnical Desktop Study (60240577-RPGT-0020_0) dated 05 March 2015 and prepared by AECOM.

The Geotechnical Desktop Study presents the publically available geotechnical information for the site and discusses the available construction and geotechnical records. The anticipated ground conditions section of the report is reproduced below:

> Bridge 1369/1763 lies on the edge of Alluvium described as clayey sand silt (Msc1) (as Section 4.1.6.2) and sand derived from Tamala limestone (Qts) described as Sand (S7) pale and olive yellow, fine to coarse grained, subangular sand of quartz, moderately sorted, of elluvial origin modified by marine inundation.
>
> Below the alluvium at this bridge, the sequence of soils is likely to comprise Sand (S7) derived from Tamala limestone overlying Tamala Limestone (Qtl) described as light yellowish brown subangular to well-rounded quartz, shell and coral of marine (reefal and backreefal) origin).
>
> This bridge lies approximately 470 m east of borehole GSWA BH BS18. This borehole is reported to have surficial limestone of approximately 2-3 m thickness overlying interbedded sand and clays with interbeds typically some 7-10 m thick. This sequence continues for over 60 m.

The following data was supplied by MRWA:

- AS-built drawings for existing Bridge 1369:
  - Drawing No. 9202-1080-2, Sabina River Stream Retraining (Jan 1993)
  - Drawing No. 9390-10109-2, Bore Information (Feb 1993)
  - Drawing No. 9390-10110-3, Earthworks (Feb 1993)
- LiDAR survey.

3.0 Fieldwork

3.1 General

The fieldwork was carried out by AECOM's Principal Engineering Geologist assisted by a Geotechnical Engineer between 31 March and 04 April 2016.

Figure 2 of **Appendix A** presents the investigation locations in relation to the concept design. Efforts were made to undertake investigation holes as close as possible to the likely bridge and approach foundations, taking into account all three concept designs. The actual locations were constrained by:

- Limited available working space;
- Access by field personnel and equipment;
- Presence of buried obstructions;
- Presence of a large hanging, dead branch on a tree on the east abutment that posed a hazard to workers in the fall-zone of the branch;
- Presence of the steep river bank and marshy ground of the river channel; and
- Presence of trees/tree canopy.

The coordinates and elevations of the geotechnical investigation locations are presented in Table 1.

Table 1 Coordinates, Elevations and Depths of the Field Investigation Locations

Hole Number	Easting+	Northing+	Ground Surface Level+ (m AHD)*	Termination Depth (m)
1763-CPT01	48478.37	174472.62	6.97	17.90
1763-CPT02	48459.72	174469.08	6.54	9.20
1763-CPT03	48440.03	174457.96	6.07	8.02
1763-CPT04	48429.94	174461.39	5.91	14.78
1763-CPT05	48410.95	174456.11	6.04	6.32
1763-CPT05A	Not Surveyed			0.80
1763-CPT05B	48407.23	174464.77	6.10	12.18
1763-CPT06	48392.12	174444.59	6.25	8.26
1763-CPT07	48399.08	174446.71	6.07	15.38
BH1763-01	48411.47	174455.06	6.03	24.95
BH1763-02	48462.43	174471.76	6.72	24.95

+Busselton Coastal Grid (BCG94) coordinate system *m AHD = Metres Australian Height Datum

3.2 Underground Service Location

Prior to the commencement of the fieldwork, a Dial-Before-You-Dig (DBYD) search was carried out and the plans received were reviewed to assess the risk of encountering underground services at the nominated test locations.

Underground services within the proposed development area were then identified on site by an accredited service locator, Cable Locates Pty Ltd, with the help of a Ground Penetrating Radar and Electromagnetic Inducer. The survey was carried out on 24 March 2016 prior to the commencement of field works. Underground services were marked and care was taken to avoid them during the any ground-breaking field works.

3.3 Borehole Drilling

3.3.1 Drilling Works

Boreholes were drilled by National Geotech Pty Ltd using a tracked Geoprobe 7822DT Drilling Rig. The boreholes were advanced using HQ size push sampling techniques using geoprobe methods from the surface until a depth of hole-collapse or refusal. Thereafter, the hole was advanced using a HQ size tungsten-faced drag bit or HQ3 diamond coring through soil and cemented materials.

Boreholes were located as close as possible to the likely abutment locations, however there was a significant dead branch hanging from a tree close to the east abutment that posed a risk to workers in the fall-zone. Boreholes and CPTs were therefore relocated to protect workers. Additionally, the dense stand of trees and overhanging branches limited the choice of sites for investigation locations.

3.4 Geotechnical Logging

Geotechnical logging was undertaken onsite by an experienced engineering geologist and geotechnical engineer from AECOM.

The geotechnical logging of the boreholes was undertaken in general accordance with Australian Standard AS1726–1993 (Geotechnical Site Investigations) with reference to the AECOM soil and rock explanatory sheets (**Appendix B**).

Borehole log descriptions were based on tactile and visual assessments of the samples recovered during drilling and these have been compared with the laboratory test results for the geotechnical analysis. It is a requirement of Chowdhury and Rehman (2009) that laboratory results are not presented on investigation hole logs, accordingly, the descriptions presented on the logs have not been modified in light of the geotechnical laboratory tests results.

Engineering logs of the boreholes, core photographs and explanation sheets defining the classification system adopted, and the terms and symbols used are presented in **Appendix B**.

It should also be noted that core tray image distortion may occur (e.g. photo angle, camera lens distortion, printer templates) and that the scale bar shown in the core tray figure should only be used as a rough measurement scale.

3.5 Handling of Samples and Cores

Following recovery of the core barrel at the end of each drill run, the inner split tube containing the core sample was extracted by the application of a continuous hydraulic pressure to one end of the barrel while the barrel was in a horizontal position. The top section of the split tube inner barrel was then removed and the core carefully cleaned. The core was then transferred into close fitting PVC splits and place in nominally 1 m long galvanised steel core trays to maintain the natural moisture content and physical properties of the core as close as practically possible to its original condition. The core in the trays was logged, photographed and covered and wrapped to prevent drying out occurring while drilling continued.

The core (in the core tray) and PVC split was then completely enclosed in plastic sleeves and sealed at both ends. The wrapped core was then placed back into the core trays and the metal lids fastened.

The core trays were stacked onto pallets and secured for transportation. The pallets were then transferred to the nominated laboratory for appropriate testing and storage.

3.6 Standard Penetration Testing

Standard Penetration Tests (SPTs) were carried out in all boreholes at typically 1.5 m depth intervals, or as instructed by AECOM's Engineer. The test was performed in accordance with AS1289.6.3.1-2004 using a split barrel sampler.

The number of blows required to advance the sampler 300 mm in undisturbed soil is known as the Standard Penetration Resistance (N) and can be used as a guide to estimate the relative density of the in situ granular soils. The uncorrected blow counts are given on the borehole logs. Disturbed samples of soil and weathered rock were recovered using the Standard Penetration Test (SPT) split spoon sampler.

3.7 Acid Sulfate Soil Sampling

Sampling activities, including field documentation, were generally based on industry accepted standard practice.

During fieldwork, the following quality control procedures were undertaken:

- Samples were transferred directly into laboratory supplied plastic zip locked bags and placed into an ice filled esky or frozen prior to being transported to the laboratory for analysis.
- Sampling records and chain of custody documentation were prepared for all samples.

Samples were prepared for transportation and delivered to NATA accredited laboratories in good condition. All sampling, handling and transportation of contaminated site samples for analytical testing was carried out in accordance to DER (2015).

3.8 Electric Friction Cone Penetrometer Test Probing

Electric Friction Cone Penetration Test (EFCPTu) probings with pore pressure measurements were undertaken by Probedrill Pty Ltd on the 29 March 2016.

The CPTu probes were advanced using a tracked “Morooka” 12 tonne probe rig. Dissipation tests were undertaken as part of the CPTu investigation at selected depths to estimate consolidation parameters. A 50 MPa cone probe (ID EC26) was used. Wear condition was acceptable and valid calibration certificates were sighted on site. Water was used for saturation of piezocones.

EFCPTu probing was undertaken in general accordance with AS 1289.6.5.1 and IRTP 2001 in the presence of an AECOM engineer. Cone tip resistance (q_c), Friction Ratio (FR) and pore pressure (u) were recorded as continuous traces with probed depth.

Several probes encountered shallow refusal. The termination depth and reason for termination are presented in Table 2.

Table 2 CPT Termination Depth

Probe Number	Termination Depth (m)	Termination Comment
1763-CPT01	17.90	Excessive rod friction coupled with high tip resistance (q_c = 10 MPa)
1763-CPT02	9.20	Tip resistance exceeded maximum permissible load (q_c = 60 MPa)
1763-CPT03	8.02	Tip resistance exceeded maximum permissible load (q_c = 65 MPa)
1763-CPT04	14.78	Excessive rod friction coupled with high tip resistance (q_c = 20 MPa)
1763-CPT05	6.32	Tip resistance exceeded maximum permissible load (q_c = 65 MPa)
1763-CPT05A	0.80	Excessive Inclination
1763-CPT05B	12.18	Tip resistance exceeded maximum permissible load (q_c = 45 MPa)
1763-CPT06	8.26	Tip resistance exceeded maximum permissible load (q_c = 55 MPa)
1763-CPT07	15.38	Excessive rod friction coupled with high tip resistance (q_c = 12 MPa)

Each probing location was dipped to record the water level upon withdrawal of the probe, however the probed holes were occasionally found to have collapsed upon withdrawal. Water level details presented at the foot of the logs stating “Dry to X m” indicates that the hole collapsed to “X” m depth and was found to be dry to the collapse depth.

Water levels were recorded in the CPT holes at depths of between 2.5 m and 3.1 m. Such water levels should be regarded as indicative only as they are unlikely to have reached equilibrium during the short test duration. Generally such water levels indicate that the standing groundwater level will be no deeper than the dipped depth.

One dissipation test was conducted in 1763-CPT05 at a depth of 4.62m. The dissipation test measures the change in pore pressure against time while the cone penetrometer is held stationary. The test continues until the pore pressure stabilises. This point was left to the discretion of the supervising engineer. The soil profile data obtained from the CPT (including dissipation test data) was analysed using the computer software package CPeT-IT, published by Geologismiki (version 1. 7.3.30). This program was used to estimate the horizontal coefficient of permeability and consolidation parameters at the dissipation test locations.

Consolidation parameters obtained from dissipation tests were assessed to be inaccurate based on knowledge from previous projects in those geological units. AECOM inferred compressibility parameters based on soils' plasticity properties and adopted permeability values for consolidation analyses.

The detailed EFCPTu results are presented in **Appendix C**.

3.9 Survey of Investigation Locations

Surveying of the investigation locations was undertaken by an accredited survey specialist, Harley Dykstra Pty Ltd on 04 April 2016. The survey accuracy was better than ± 50 mm horizontal and ± 50 mm vertical. All investigation locations were reported using Bunbury Coastal Grid coordinate system (BCG94). The surveyed locations have been presented in Table 1.

3.10 Piezometers

A 50 mm standpipe piezometer was installed in BH1763-02. The piezometer construction details are provided in Table 3.

Table 3 Standpipe Piezometer Details

From depth (m)	To depth (m)	Material
0.0	1.0	Concrete backfill and lockable steel cover, recessed into the ground. Plain (unslotted) pipe.
1.0	2.0	Bentonite seal and plain (unslotted) pipe
2.0	3.5	Gravel pack and plain (unslotted) pipe
3.5	6.5	Gravel pack and filter sock and slotted pipe. Spaces between the slots were nominally 1 mm wide.

3.11 Groundwater Monitoring

The standpipe in BH1763-02 was dipped on 02 May 2016 and the groundwater level was found to be 3.05 m bgl (3.67 m AHD). Groundwater samples were taken on the same day for laboratory analyses.

Seasonal variation in groundwater level is reported to be approximately 1 metre in the vicinity of the site (Schafer et al. 2008). The region is known to have been subjected to widespread dewatering associated with mineral sand mining. Such dewatering may influence groundwater levels both during mining operations and for a significant time after operations have been completed. Current groundwater level may still be under the influence of active dewatering, or be recovering following historic dewatering activities.

4.0 Laboratory Testing

4.1 General

The laboratory testing program was designed to characterise and classify the soils and assess their typical strength, stiffness, aggressivity and acid sulfate soil (ASS) potential properties.

Laboratory testing on collected soil samples was undertaken by NATA accredited laboratories. The testing standard applicable to each test is recorded on the laboratory testing certificates/reports.

Table 4 Laboratory Testing Methods and Quantity

Test Type	Test Method	No. of Tests
Field moisture content	WA110.1	10
Atterberg limits including linear shrinkage	WA120.2 212.1 122.1 123.1	6
Particle size distribution (PSD) (sieve)	WA115.1	7
Soil particle density	AS1289 3.5.1	6
Aggressivity suite (pH, SO_4 Cl, total soluble salts (TSS))	AS1289.4.3.1,4.2.1, WA 910.1, ALS in-house method EA002/EA014/ EA055/ED045G/ED040T	6
ASS field screening suite pH_F /pH_{FOX}	ALS in-house method EA037	18
ASS Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) testing	ALS in-house method EA029	3
ASS groundwater suite	ALS in-house method ASSGW-1	1

4.2 Laboratory Test Results

Copies of the laboratory test certificates are provided in **Appendix D** along with summary tables of the results.

Note that the investigation for this bridge was undertaken concurrently with adjacent bridges 1761 and 1762. Soil and groundwater chemistry lab testing has been reported for multiple bridges on the same test certificates, therefore some results presented in **Appendix D** relate to the other bridges.

4.3 Commentary on Laboratory Test Results

4.3.1 Deviations from Test Methods

It is noted that not all of the laboratory testing has been carried out in strict compliance with the prescribed testing standards. Deviations from the testing standard may occur where there is insufficient volume of sample or sample dimensions do not satisfy the standard (e.g., sample volume requirements for PSD testing). Where deviations from the testing standard occurred, this has typically been noted on the testing certificates. It is particularly important that the deviations noted on the test certificates be reviewed and the implications of these deviations understood in terms of the reliability and validity of the results reported. Caution should therefore be exercised when using the result summary tables as deviations from the specified test method were not noted.

4.3.2 Sample Descriptions on Laboratory Test Certificates

It is important to note that some of the sample descriptions provided on the test certificates are different to the descriptions shown on the engineering logs and in the laboratory test results summary tables. The reason for this difference is that the laboratories have simply stated the field sample descriptions provided by AECOM at the time of laboratory scheduling. Also, in some cases the

laboratories have used their own sample descriptions on the laboratory certificates. In all cases the descriptions presented on the certificate should not be considered to be engineering descriptions.

4.4 Acid Sulfate Soils Testing

4.4.1 Introduction

The site lies within the area of detailed ASS risk mapping provided by the WA Department of Environment Regulation (DER). The bridge lies within or adjacent to an area assessed as having a high to moderate ASS risk.

A preliminary ASS investigation was undertaken to facilitate the assessment of the risk of encountering acidic or potentially acidic soils during construction. The investigation undertaken was preliminary in nature but was in general accordance to the requirements of the DER for ASS investigations.

4.4.2 Field Testing

ASS field screen testing was undertaken on eighteen soil samples at ALS Pty Ltd, a NATA accredited laboratory, due to the OHS risk associated with the test reagents.

Field test results were reviewed in order to identify samples for Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS)/Chromium Reducible Sulfur (CRS) testing.

The following criteria was used to provide an indication of the potential existence of either actual ASS (AASS) or potential ASS (PASS):

- A pH_f of 4 or less suggests the presence of actual AASS.

Three indicators are used together to indicate the likelihood of PASS presence:

- A pH_{fox} of less than 3;
- A strong, or extreme reaction to the introduction of hydrogen peroxide; and
- A difference between pH_f and pH_{fox} of greater than 3.

Where none or one of these indicators were observed in field test results, the tested sample was inferred to have a low PASS potential. Where two indicators were observed, the sample was inferred to have a medium PASS potential and where three indicators were observed, the sample was inferred to have a high PASS potential.

ASS test results are presented in **Appendix D**. Test results that meet the above criteria are highlighted in red text on the ASS summary table included in Appendix D.

Representative samples for PASS or AASS were selected for SPOCAS testing.

The field screen ASS test results are discussed in Section 9.0.

4.4.3 Suspension Peroxide Oxidation Combined Acidity & Sulfur (SPOCAS) Method

The SPOCAS method is a self-contained acid base accounting test. The complete method provides 12 individual analytes (plus five calculated parameters), which leads to a better prediction of a soil's likely acid–generating potential. The method involves the measurement of pH, titratable acidity, sulfur and cations of two soil sub samples. One soil sample is oxidised with hydrogen peroxide and the other is not. The differences between the two values of the analytes from the two sub samples are then calculated.

SPOCAS is the preferred method for soils that may contain organic material. In accordance with accepted practices, 10% of the number of the samples designated for SPOCAS testing were tested using the CRS test method.

Due to space restrictions, CRS results are not presented in the summary table however test certificates are included in **Appendix D**.

ASS test results are discussed in Section 9.0

5.0 Site Conditions

5.1 Location and Surroundings

The study area is located in the Main Roads South West Region (SWR) of Western Australia (WA). Bridge 1763 lies within the Shire of Busselton and is centred on approximate Busselton Coastal Grid (BCG94) Coordinates 48426 E,174458 N. Bridge 1763 is located approximately 25 m south of the existing Bussell Highway bridge structure (Bridge 1369) and crosses the Sabina River.

The natural ground level at the crest of the river bank is approximately 6.3 m AHD. The site is located within an area of relatively flat grassland within a dense stand of eucalypt trees and bushes along the river edge. A slight depression in the terrain is evident within approximately 40 m to 50 m either side of the river, this depression represents the zone of the historic meandering of the river channel.

At the time of the investigation the river channel was dry. The base of the channel was estimated to lie at approximately 4.0 m AHD based on available LiDAR data.

It is noted that the river channel was re-trained during the construction works for Bridge 1369. A plan showing the original and current river in relation to the proposed indicates that the west abutment of the bridge is likely to lie on or close to the former river channel (Drawing No. 9202-1080-2).

Plate 1 – West abutment looking south

Plate 2 – East abutment looking east showing hanging branch

A site location plan is presented in Figure 1 of **Appendix A**, showing the proposed bridge, road alignment and site environs.

5.2 Regional Geology

The regional geology is dominated by a Cretaceous to Recent sedimentary sequence that was deposited within a major graben structure in the southern Perth Basin. This depositional sequence has formed the Swan Coastal Plain.

The long and stable development of the Perth Basin has resulted in vast thicknesses of materials with a similar mode of deposition. Of importance to the bridge structure, the Leederville formation, Guildford formation, Bassendean sand and Recent Alluvium are principally deposited as alluvial and nearshore deposits with each later deposit being comprised of reworked material from the former along with new material derived from the rocks and soils of the hinterland.

Alluvial materials are characterised by their variability, with multiple lenses, beds and laminae of sand to clay size particles and mixtures thereof. Often the boundary between these formations can only be ascertained where they are marked by an erosional break that is captured in the borehole core, or the presence of a material typical of a geological feature such as beach ridge, coffee rock, or pedocrete.

Near river valleys, the Guilford Formation deposits tend to grade into the river sediments and, unless marked by an erosional break, are impossible to differentiate.

For this reason the differentiation of the units presented on the Figure 3 should be regarded as conceptual only.

5.3 Geotechnical Subsurface Model

The geotechnical subsurface model presented here is based on AECOM's interpretation of the available data. For engineering purposes, the materials that exhibit particular or characteristic properties are grouped together into units. Characteristics that differentiate material units include:

- Soil type and mode of deposition;
- Stiffness and density of the material;
- Particle size distribution of particles that make up the material ; and
- Lateral and vertical continuity of the material between boreholes.

The units and their interpreted extents are presented on the simplified geological section on Figure 3 of **Appendix A**

5.3.1 Mining Backfill

Mineral sands are mined in the region from a deposit of the Capel paleo-shoreline (Baxter 1977) which is marked by an arcuate ridge parallel to and about 7 km inland from the present coast. The bridge site is located immediately adjacent to this deposit, however the Sabina river is interpreted to have down cut through this ridge.

The sands of this paleo-shoreline contain economic quantities of the heavy minerals ilmenite, secondary ilmenite, leucoxene (titanium ores) and zircon. Typically, the maximum depth of the mine pits was approximately 10 m bgl.

Mining has been undertaken close to the bridge and abutment locations, however, there is no evidence to suggest that the bridge or approach embankment sites are located on infilled pits.

Extensive dewatering of the area is associated with the mineral sand extraction.

5.3.2 Recent Alluvium

This unit is constrained to the valley floor close to the present river stream and represents the recent alluvial deposits of the Sabina River. It generally consists of an upper horizon dominated by sand and silty sand overlying a lower horizon dominated by clay with minor organics (including traces of fibrous peat). At this site only an upper sandy horizon was observed in the boreholes. The upper sand layers were generally classified as SP or SM and described as fine to medium grained and dark brown to brown.

The source material of this unit includes reworked Bassendean sand and it may be intercalated with the Bassendean sand therefore some of the sand units may have similar properties to Bassendean sand and have aggressivity/ASS properties typical of that unit.

This unit is likely to be generally normally consolidated, although silt/clay horizons may still be undergoing virgin consolidation (under-consolidated).

5.3.3 Guildford Formation

Beneath the Alluvium and potentially present near-surface in away from the river channel lies a unit assigned to be of the Guildford formation.

This unit is similar in variability and materials to the alluvium but generally of higher density/ shear strength. It generally described as a multi-coloured (grey, orange-brown to red brown) interbedded silty or clayey sand with multiple zones of dark or black coffee rock (ferrungized sandstone).

5.3.4 Leederville Formation

The Leederville formation represents the deepest unit encountered at the site. This formation is commonly described as being several hundred meters in thickness.

The Leederville Formation is of Lower Cretaceous age and consists predominantly of discontinuous, interbedded sandstones, siltstones and shales/clay (Allen, 1979). The sand is fine to coarse grained,

angular to subangular, and mainly poorly sorted. Pyrite and carbonaceous material are common in the non-marine facies of the formation and glauconite is common in the marine facies, particularly south of Perth.

At this site it was found to be dominated by clay, silty clay or sandy clay with occasional beds of silty sand. The clay units were assessed as medium plasticity, dark brown or dark grey and containing occasional coal fragments of coarse sand to fine gravel size. They were often faintly laminated with mica-rich silt and sand laminae and were very stiff to hard in consistency.

The sand layers were described as silty, grey brown, angular to subrounded and fine to coarse grained sand that was medium dense to very dense. Some coal fragments were also observed.

6.0 Piled Foundations

6.1 Proposed Foundations Type

It is inferred that ground conditions are relatively uniform but differentiation of main geological units is not clear. Surface alluvium layers vary from mixed fines and sand to clay and silt dominated. Loose to medium dense sand layers are observed in alluvium unit dominated by mixed fines and sand, while thick and soft layers are observed in clay and silt dominated alluvium unit. Varying thickness and composition of the alluvium unit might result in excessive long term differential settlements between adjacent sub-structure elements.

Pile foundations are considered as the preferred option for bridge abutments and pier foundations. Layers of Leederville Formation are considered to be competent enough as the founding strata for pile foundations. The Leederville formation represents the deepest unit encountered at the three sites. This formation thickness is commonly described as being several hundred metres in thickness.

Driven steel cased piles are the preferred foundation option following the evaluation of substructure alternatives during concept design stage. Pile diameters of 450 mm and 610 mm were considered initially but from a structural engineering perspective a reduced number of elements in a single row is preferred and then the 610 mm diameter reinforced concrete pile with drive steel casing is preferred and is discussed in detail in this report.

6.2 Driven Pile Hazards and Issues

The advantage of driven piles is the speed of installation and the ability to test the capacity of the piles during installation. For Bridge 1763, the steel casing will be driven first and then the material inside the casing will be excavated. Some project specific geotechnical risks and issues that should be considered further:

- The load carrying capacity of steel driven piles in alluvial settings may be highly variable over very short distances. Pile capacity verification by means of dynamic testing should be an integral part of the installation process.
- Irregular pile penetration depths.
- The inferred variable nature of soil strength vertically and laterally may result in variable achieved driven depths. Estimated pile toe levels may not be achieved but it may be demonstrated that adequate capacities have been achieved by pile dynamic testing.
- Relatively difficult driving conditions: zones of very dense sand are inferred at all borehole locations (Leederville Formation). These materials may result in difficult driving conditions. Pile stresses should be checked during installation of piles under difficult driving conditions to ensure piles are not overstressed and the risk of hammer damage is minimised.
- Pile setup: the rate at which setup occurs (if any) is not known and this represents a risk if pile driving is to stop for any substantial amount of time. The pause in driving could result in substantial increases in the driving resistance upon the commencement of re-driving.
- End of drive and re-strike testing on at least two test piles is recommended to be undertaken to assess the magnitude of setup. This will assist in assessing the target mobilised pile resistance during initial driving and the risk of unexpected increases in driving resistances following pauses in pile driving at a pile location.

6.3 Pile Design Criteria

Geotechnical foundation design for the bridge is based on AS2159-2009: Piling-Design and Installation. The criterion covering the design is:

$$R_{d,g} = \phi_g R_{d,ug} \geq E_d \qquad (6.1)$$

Where,

$R_{d,g}$ = the design geotechnical strength of pile,

ϕ_g = the geotechnical strength reduction factor,

$R_{d,ug}$ = the design ultimate geotechnical strength,

E_d = the design action effect.

Ultimate geotechnical strength of a pile loaded in compression is determined from the equation:

$$R_{d,ug} = f_{m,s} A_s + f_b A_b \quad (6.2)$$

Where,

$f_{m,s}$ = the average skin friction for condition of full mobilisation,

A_s = the surface the area of the pile in intimate contact with soil,

f_b = the ultimate base pressure in intimate contact with the ground,

A_b = the plan area of the pile base.

6.4 Pile Design Methodology

Two methods were adopted to assess pile capacities. Soil parameters for pile design, i.e. ultimate skin friction and end bearing, are based on correlations with standard penetration test (SPT) results, CPT tip resistance and skin friction measured and laboratory test results as appropriate. SPT tests were carried out in all boreholes during the ground investigation generally at 1.5 m depth intervals.

The correlation of pile design parameters with SPT results proposed by Decourt (1995) was adopted as first method. Additionally, the correlation of pile design parameters with CPT results suggested by Bustamante and Gianeselli (1995), also known as the LCPC method, has also been adopted.

6.4.1 Decourt (1995) method

The correlation of pile design parameter with SPT value based on Decourt's (1995) recommendation is presented below.

- **Ultimate skin friction:**

$$f_s = AN_{av}+B \text{ kPa}$$

where N_{av} = average SPT along shaft

A = 1.8

B = 5 kPa

- **Ultimate end bearing:**

$$f_b = KN_p+B \text{ kPa}$$

where N_p = average SPT in vicinity of pile base

K = 165 (sand), 115 (sandy silt), 100 (clayey silt) and 80 (clay)

For calculation end bearing capacity, the following have been adopted:

K = 80 for firm sandy clay

K = 100 for stiff to very stiff sandy clay

K = 120 for very loose to loose cohesion less materials

K = 140 for medium dense cohesion less materials

K = 160 for dense to very dense cohesion less materials

- **Limiting resistance:**

A limiting skin friction of 90 kPa and end bearing of 8 MPa for all soil types has been adopted in the pile design. These values follow recommendations of limiting resistance in API RP 2A-WSD (2010).

6.4.2 LCPC method

The LCPC method is presented below.

Skin friction:

$f_{m,s}$ taken as ultimate skin friction (f_s) as follows:

$$f_s = q_c/\alpha_{LCPC} \quad \leq \quad f_{p,max} \tag{6.3}$$

Where,

q_c = measured cone penetration tip resistance

α_{LCPC} = friction coefficient (depending on pile and material type)

$f_{p,max}$ = limiting value of shaft friction are based on pile and soil type

Ultimate end bearing:

$$f_b \quad = \quad k_c \cdot q_{ca} \tag{6.4}$$

Where,

k_c = end bearing coefficient, k_c (function of pile and soil type)

q_{ca} = equivalent average cone resistance

The equivalent average cone resistance, q_{ca}, at the base of the pile used to compute the unit end bearing, f_b, is the mean q_c value measured along two fixed distances, a (a = 1.5D, where D is the pile diameter) above (-a) and below (+a) the pile tip.

6.5 Design Actions

A detail analysis of design actions for the pile foundations was not available during preparation of this version of the report.

The following preliminary Ultimate Limit State (ULS) pier and abutment pile group actions were considered. These values are taken about the local axis of the pile cap (i.e. bending moment have not been transformed for the 10 degree skew). As the proposed bridges are integral, only axial loads and moments about the bridge centreline are provided. All other design actions are dependent on the pile arrangement and will be assessed by the bridge engineer when design is progressed to 85%.

Table 5 Considered Ultimate Limit State (ULS) Design Actions for Bridge Abutments

Loading Case	Abutments	
	Fz (kN)	Mx (kNm)
Max Fz and Co-Acting Mx	7,005	2,650
Max Mx and Co-Acting Fz	5,930	9,110

These loads correspond to a generic case used for concept design of Bridges 1761, 1762 and 1763. As a consequence this section will be revised once specific design actions are available for Bridge 1763.

6.6 Pile Design

6.6.1 Vertical Bearing Capacity

Vertical bearing capacity of the piles was calculated based on the methodology discussed above (Section 6.4) and the ground model at respective bridge pier/abutment location. According to the criteria in Section 6.3, the design geotechnical strength, $R_{d,g}$, is required to be greater than the design action effect, E_d.

In the evaluation of pile capacity, a geotechnical reduction factor (ϕ_g) of 0.75 was adopted, which is based on the requirement that at least 15% of piles will be subject to dynamic load testing supported

by full wave signal matching (CAPWAP analysis). Acceptance of this amount of testing needs to be confirmed before proceeding with final design of piled foundations. The weight of pile is relatively negligible when considering the design action effects and therefore has not been considered in the estimates of mobilised resistance.

While no tension loads have been provided at this stage, estimates were prepared for piles acting in tension, for which the critical capacity case is assumed to be a shear failure at the pile to soil interface. The tension capacity is estimated to be 0.8 times the external shaft friction in compression in consideration of potential shear reversal effects.

Vertical bearing capacity was calculated for driven piles with 610 mm diameter with steel pipes. Calculation tables and plots of bearing capacities of piles are presented in **Appendix E**. Summary of vertical capacities for 610 mm diameter steel piles are presented in Table 6.

Table 6 Estimated Toe Levels for 610 mm Diameter Driven Piles

Pile Location	Max Axial Design Action Effect, E_d (kN)	Est. Pile Toe Levels, RL (m AHD)	Est. Pile Embedment (m)	Pile Size (mm)	Number of Piles
Abutment 1	1,750 (C)	- 7.0	13.5	610	6
Abutment 2	1,750 (C)	- 7.0	13.5	610	6

Notes: (C) = compression load, Est. = Estimated values of maximum ULS axial design actions provided by the Bridge Engineer. These are assumed to be conservative and will be refined following detailed structural analyses.

Number of piles may change if less testing is specified or if loads change during detail structural analysis.

6.6.2 Lateral Capacity

All piles will need to be driven/drilled to a suitable depth and set to achieve the required compression and lateral capacities. In addition to the minimum lateral capacity, the piles should penetrate sufficiently to be able to achieve lateral fixity and keep the lateral deflections below tolerable limits.

Loads provided in Section 6.5 correspond to a generic analyses for the three bridges. Analyses and design against lateral capacity will be carried out in a revised version of this report following a detail evaluation of load combinations specific for Bridge 1763. It is noted that embedment depths in Table 5 are in excess of ten pile diameters and should provide adequate lateral and moment fixity to support lateral loading requirements and to limit lateral displacements under serviceability loads.

Detailed assessment of lateral deflection of piles will be considered once the pile configuration is progressed in the bridge structural design but it is not expected to be a critical issue to change the foundation design. Pile group loading would also be modelled once the configuration and design actions of the pile groups are progressed in the bridge structural design.

6.6.3 Axial Pile Displacement under Serviceability Loads

Provided piles are constructed to the design toe levels to resist the design action effects presented in Tables 4 and 5 pile settlements under axial design serviceability loads are expected to be in the order of 5 mm to 15 mm. The minimum separation between piles is recommended to be three times of pile diameter or equivalent diameter and, therefore, interaction effects between piles are expected to be minimal. Differential settlement between abutments could be in the order of 5 mm.

6.7 Design and Construction Issues

The estimated pile toe levels in Table 6 are based on inferred ground conditions at the nearest borehole/CPT locations and also on a generic evaluation of structural actions. Variation in ground conditions can be expected across the site and actual pile toe levels required to resist design actions may vary from those estimated.

Individual analyses of piles will be carried out when the information on load distribution amongst piles within each group becomes available.

6.8 Pile Testing

The estimated pile embedment and toe levels will be assessed during the detailed design and will need to be confirmed and adjusted as necessary, prior to and during construction. As such, for preliminary costing purposes, allowance should be made for proving the capacity of the piles by carrying dynamic pile load tests.

In accordance with the recommendations in AS2159-2009, a pile load testing programme is required if a geotechnical reduction factor of $\phi_g = 0.75$ is adopted. Allowance should be made for assessing the capacity of piles by carrying out dynamic pile load tests on piles during driving.

To enable assessment of the contributing portions of shaft and base resistance from dynamic pile load testing, the testing should be accompanied by a rigorous analysis of a selected blow from the final set, using full wave signal matching of the recorded data obtained from the instrumentation transducers.

The adopted geotechnical reduction factor of $\phi_g = 0.75$ was calculated using a 'testing benefit factor', K, based only on dynamic load testing of 15% of the piles. This corresponds to two (2) piles to be tested for the 610 mm pile diameter option. The recommended locations will be selected depending on the proposed construction sequence but is expected to cover at least one pile at each abutment

6.9 Pile Driveability

6.9.1 Pile Driveability Analyses

A preliminary pile driveability assessment has been undertaken assuming a 610 mm circular pile section driven into ground with subsurface conditions based on upper bound values of SPT data from boreholes 1763-BH01 and 1763-BH02. These driveability assessments are carried out for value engineering to confirm feasibility of preferred piling solution and are based on assumptions about hammer energy and other criteria as summarised below. A generic hammer typically available in WA and used for recent projects in the south-west region have been considered.

The purpose of this exercise is to assess the feasibility of directly driving the piles casing to their target depths without the need of additional piles to achieve the required axial capacities in tension and compression.

The commercial software program GRLWEAP 2010 (Wave Equation Analysis of Pile Driving, by GRL Engineers Inc. and Pile Dynamics Inc., V2010-3, Jan 2012) was used in the analyses discussed below.

6.9.2 Hammer Details

Details of the hammer selected for this preliminary study are presented in Table 7..

Table 7 Summary of Pile Hammer Details

Hammer Id.	Rated Energy (kJ)	Maximum Stroke (m)	Ram Weight (kN)	Efficiency (%)
IHC S-35 (hydraulic)	34.6	1.17	29.50	95

Note: Manufacturer recommended helmet/cushion details have been adopted in the analysis for the appropriate pile size.

6.9.3 Soil Details

The piles are to be driven though materials typically comprising recent alluvial deposits of the Sabina River, Guilford Formation (mainly towards eastern abutment) and sandy materials of the Leederville Formation. Pile toes are expected to penetrate the top of Leederville Formation unit.

For the analysis presented in this report, a soil profile strength based on maximum measured resistance from SPT testing carried out in two boreholes was adopted. Considering variation in results between the two boreholes, separate analyses were carried out. These analyses need to be updated when structural design is progressed and details of available driving equipment is provided.

6.9.4 Other Considerations for Analysis

6.9.4.1 Set up Factors

The setup factors represent the reduction in resistance that occurs as the piles are driven and are used to estimate the resistance at the time of driving (SRD). The set up factors are applied to the shaft friction only and not end bearing. For the preliminary assessment considered in this report with most piles driven through sandy soils it is assumed that there is no reduction in resistance at the time of driving to be conservative.

6.9.4.2 Gain / Loss Factors

The driveability assessment has been undertaken assuming no overall gain / loss factors for each case analysed. A range of factors could be considered in future (when a particular hammer is selected) to assess the range of possible penetration resistance responses that may occur during driving.

6.9.4.3 Quake and Damping

The quake and damping parameters adopted in the analysis are as recommended in the GRLWEAP manual and are summarised below:

- Toe quake = 2.5 mm (open ended pile driving unplugged); 10.15 mm for a plugged response conservative model.
- Shaft quake = 2.54 mm
- Toe damping = 0.49 s/m
- Shaft damping = 0.164 s/m.

6.9.4.4 Distribution of Soil Resistance

For this preliminary assessment the piles are assumed to derive their soil resistance at time of driving from full internal and external shaft resistance plus end bearing of the annular area of a 610 mm circular hollow section (CHS) cross-section. In reality, this is expected to be a conservative approach as internal friction (in internal sides of the circular hollow section) could be significantly less than external friction due to disturbance effects. As part of this value engineering exercise, a pessimistic driving case was modelled for both boreholes assuming plugged response.

6.9.5 Driveability Analysis Results

Typical details of the analyses are presented in Appendix F.

Generally the results indicate that:

- Proposed pile toe levels can be reached when using hammers with a minimum rated energy of 32 kJ. A minimum ram weight of 30 kN is recommended.
- No refusal is expected above the required pile toe levels.
- The refusal levels for 610 mm CHS vertical piles for different structural elements of the bridge are estimated to be mostly below the target depth to achieve compression and tension capacities when using hammers with a minimum ram weight of 30 kN, operating under the assumed conditions presented previously.
- The estimated maximum compressive stresses at the time of driving for hammers with ram weight of 30 kN are estimated to be within the allowable stress limit for 610 mm CHS piles. Preliminary plots are included in Appendix F.
- Hammers with ram weight higher than 50 kN are not considered appropriate as they are likely to induce excessively high stresses during driving that may lead to pile damage. Hammers with ram weights greater than 50 kN could be considered if the stroke can be limited to a reduced energy value.

It is recommended to carry out a specific driveability analysis for the particular equipment and pile type chosen. Acceptance criteria for the driving of piles should be defined based on the specific driving

equipment used. Recommendations on these issues will be provided after structural design of bridge is complete.

Specifications for pile driving should be developed on the basis of specific assessment of driveability results for the final configuration of piles and selected equipment.

7.0 Approach Embankment

7.1 General

Geohazards associated with construction in an alluvial-valley setting are typically related to the presence of soft, compressible and organic soils, complex soils profiles due to the presence of abundant lenses and the presence of a high groundwater level. The main feature of the site that will contribute to total settlements is related to the very loose to loose density of some layers of recent alluvial deposits near the ground surface. However, these are in general well drained materials (medium to high permeability) and settlements are expected to occur in a relatively short amount of time.

Construction of approach embankment is required on the eastern and western ends of the proposed bridge. To estimate the magnitude and rate of ground settlement that is likely to be more onerous under the approach embankment at the eastern side of the bridge due to the higher compressibility of the underlying soils as compared to the western side of the bridge, total settlement calculations were carried out using a proprietary Finite Element Program, 'PLAXIS 2D, V 2012.01' (by Plaxis bv Netherlands).

7.2 Eastern Approach Embankment and Soil Profile

A ground model was developed for the eastern end approach embankment. The soil profile was developed based on the CPTu05, CPTu05B, CPTu07, CPTu08 and BH01 profiles. Assumed dimensions of approach embankment are as follows:

- Height : 1.8 m (i.e., difference of elevations between the eastern river bank and the proposed road surface)
- Crest width : 25 m
- Side slope : 1V: 2H
- Loading on embankment : 10 kPa.
- Fill materials : Compacted granular fill.

The soil profile and soil parameters adopted for PLAXIS analysis are presented in Plate 1 and Table 8, respectively. Mohr-Coulomb and 'Soft Soil Creep' (time dependent behaviour model as described in Plaxis manual) models were used for sandy soils and cohesive soils, respectively.

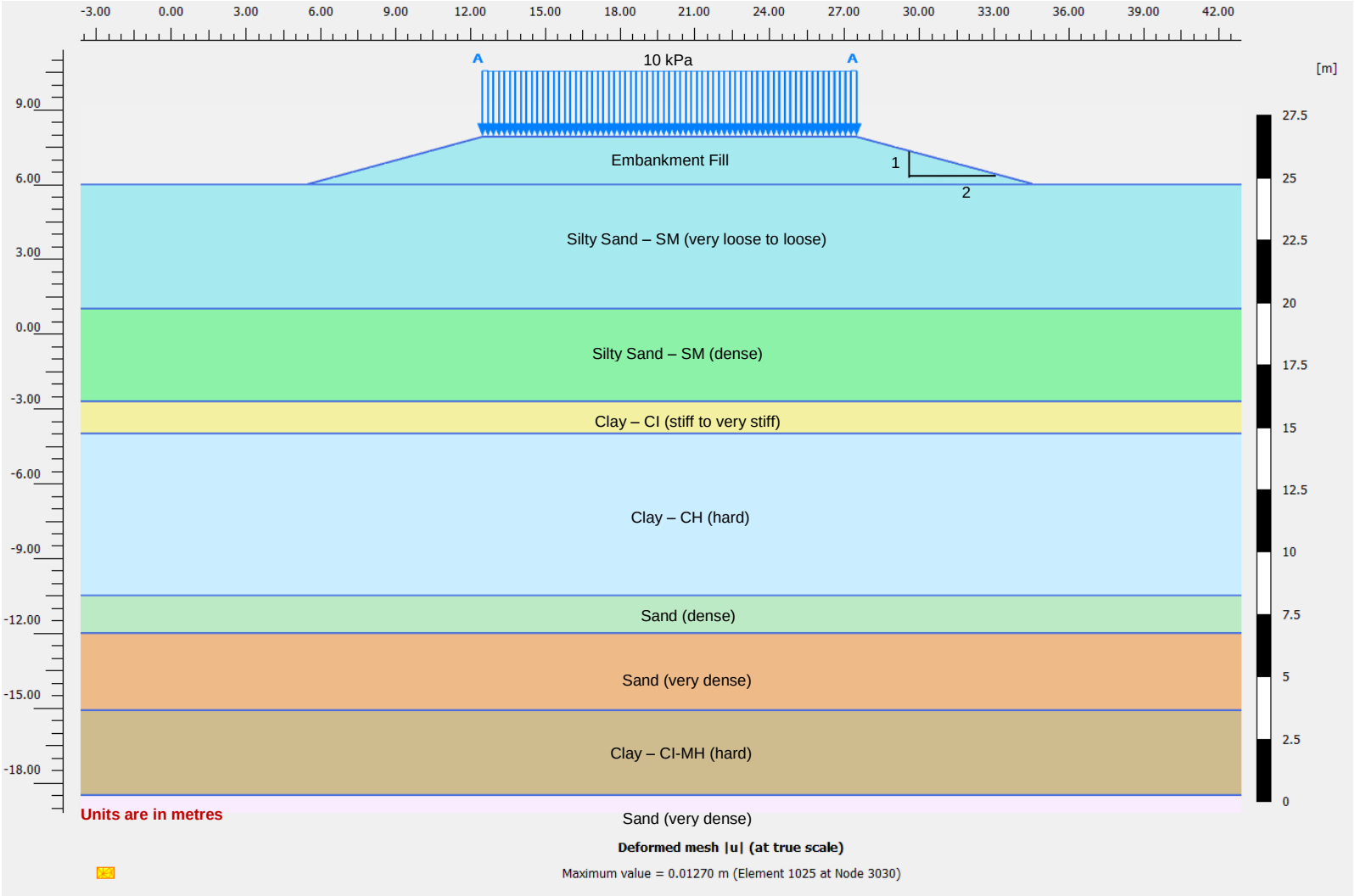

Plate 1 Soil Model for Eastern Approach Embankment of Bridge 1763

Table 8 Soil Parameters Adopted for PLAXIS Analysis of the Eastern Approach Embankment (Bridge 1763)

Soil Type	Soil Model	γ_{unsat} (kN/m^3)	γ_{sat} (kN/m^3)	S_u (kPa)	ϕ' (°)	E' (MPa)	ν'	*e_0	*C_c	*C_α	k (m/day)	OCR
Granular Fill (dense)	Mohr-Coulomb	19	21	-	38	50	0.3	-	-	-	10.00	-
Silty Sand – SM (very loose to loose)	Mohr-Coulomb	16.5	18	-	37	25	0.3	-	-	-	3154	-
Silty Sand – SM (dense)	Mohr-Coulomb	17	19	-	37	40+25(11-z)	0.3	-	-	-	31.54	-
Clay – CI (stiff to very stiff)	Soft Soil	19	19	70	22	70	0.3	2.25	0.65	0.13	$3.154x10^{-3}$	3.5
Clay – CH (hard)	Soft Soil	20	20	150	22	115	0.3	2.25	0.65	0.13	$3.154x10^{-3}$	4.5
Sand (dense)	Mohr-Coulomb	17	19	-	37	120	0.3	-	-	-	31.54	-
Sand (very dense)	Mohr-Coulomb	18	20	-	40	230	0.3	-	-	-	31.54	-
Clay – CI-MH (hard)	Soft Soil	20	20	275	22	137.5	0.3	2.25	0.65	0.13	$3.154x10^{-3}$	7.0
Sand (very dense)	Mohr-Coulomb	18	20	-	40	200	0.3	-	-	-	31.54	-

Notes: γ_{unsat} = Unsaturated soil density, γ_{sat} = Saturated soil density, S_u = Undrained shear strength, ϕ' = Effective friction angle, , E' = Drained Young's Modulus, ν' = Poisson's Ratio, e_0 = Initial void ratio, C_c = Compression index, C_α = Secondary compression co-efficient, k = Permeability, z = elevation (mAHD), OCR=Overconsolidation ratio.

$e_0 = w_0 G_s$ (where, w0 = in situ moisture content, Gs=Specific Gravity),

C_c = PI (%) / 74 (by Kulhawy and Mayne (1990))

C_α= 1/5 C_c (by Das (2011))

7.3 Approach Embankment Settlement Criteria

The following settlement criteria have been adopted for the approach embankment:

- The maximum settlement over any 12 month period is 15 mm; and
- The maximum settlement over 7 years after the construction is 50 mm.

7.4 Settlement at Eastern Approach Embankment

BH01 profile was adopted for the analysis due to the presence of clay materials in the underlying soils. However the clay materials were found to have overconsolidation ratio of greater than 3.5. Inferred ground conditions from CPTu05, CPTu06 and CPTu07 are mainly sandy materials, which are more favourable in terms of compressibility and long term settlements are not expected.

Analysis using PLAXIS 2D software indicates around 80% of the estimated total settlement of the embankment will occur immediately after the embankment load is applied. The settlement results are presented in Table 9 and as figures in Appendix G.

Table 9 Settlements at Eastern Approach Embankment

Stage	Total Settlement (mm)
Immediately after embankment construction	13
1 month after embankment construction	26
12 months after embankment construction	29
7 years after embankment construction	32

The anticipated approach embankment construction is anticipated to cause minimal ground movement; hence anticipated settlements are well within the settlement criteria limits presented in section 7.3 (to be confirmed by MRWA). As per conventional earthworks practice, removal of topsoil to approximate depths between 0.2 m and 0.4 m is required to remove soil containing roots, grass and organic matter.

7.5 Eastern Approach Embankment Stability

The factor of safety estimated by PLAXIS program for stability of eastern approach embankment is 2.34.

7.6 Monitoring

A detailed monitoring program including elevation survey points and settlement plate measurements will need to be implemented at preselected locations along the eastern and western approach embankments. This will allow assessment of the predicted settlements. Details of recommended monitoring and instrumentation can be prepared during detail design stage.

8.0 Other Engineering Considerations and Recommendations

8.1 Seismic Considerations

8.1.1 Site Sub-Soil Classification

The earthquake site subsoil class has been assessed based on the requirements of Australian Standard AS1170.4-2007, available geological maps and subsurface conditions encountered at the site. The sub-soil class for the site of Bridge 1763 at Busselton, WA, has been assessed as Class "D_e – Deep or Soft Soil Site".

8.1.2 Earthquake and Liquefaction Potential

Liquefaction is one of the principal geotechnical hazards associated with earthquakes. The term "liquefaction" is widely used to describe ground damage caused by earthquake shaking even though a number of different phenomena may cause such damage.

The response of saturated soils to cyclic loading during strong earthquakes is characterised by development of excess pore water pressures and consequent reduction in the effective stress. In the extreme case, the effective stress may drop to zero (100% excess pore pressure rise) and the soil would liquefy.

Liquefaction is associated with significant loss of stiffness and strength in the liquefied soil and consequent large ground deformation. Particularly damaging for engineering structures are cyclic ground movements during the period of shaking and excessive residual deformations such as settlements of the ground and lateral spreading.

A Geoscience Australia historical (1955 to August 2016) earthquake search was undertaken for the study area. The recorded historical earthquakes in the search area occurred between 9 June 1978 and 5 March 2005. Earthquake magnitudes ranged from 2.3 to 3.0 using the Geoscience Australia recommended scale for each event. The deepest reported depth of earthquakes in this group was 5 km. The shallowest reported depth of earthquakes in this group was 0 km. The closest recorded earthquake to the site was a 1.9 magnitude event that occurred on the 4 June 2003 off Busselton, WA, approximately 20 km west of the site.

In general, for a soil to liquefy the following criteria must typically be satisfied:

- The soil should have less than 15% finer than 0.075 mm.
- The soil is non-plastic or has a liquid limit less than 35% and plasticity index <15%.
- The soil should be saturated (or water content greater than 0.9 x Liquid Limit). The groundwater table at the bridge site held at depths between ground surface and 6 m below ground surface.
- The site should be susceptible to local earthquake magnitudes (ML) of greater than 5.0.

It is recommended to adopt an earthquake magnitude associated with a 1 in 1,000 year design event for liquefaction considering that the bridge is a normal structure and does not contain people in crowds. It is noted that recent studies (Burbidge, 2012; Dismuke and Mote, 2012) have shown that maximum likely earthquake magnitude for the Perth region is approximately Magnitude 5.0 to 5.5 for a return period of 1 in 1,000 years. At a design earthquake magnitude of 5.0, most soils will not liquefy, which is consistent with the results of the liquefaction assessment.

The liquefaction assessment has been carried out to reflect a seismic return period of 1 in 1,000 years. The adopted design earthquake magnitude for a return period of 1 in 1000 years is 5.5.

The following earthquake magnitudes with a return period of 1 in 1,000 years for the site have been suggested in the two studies at the nearby site:

- Burbidge (2012) – Earthquake Magnitude = 4.9
- Dismuke and Mote (2012) – Earthquake Magnitude = 4.5

In the analysis, AECOM adopted the higher earthquake magnitude for conservative design.

- Spectral shape factor for modal response spectrum and numerical integration time history method, Ch(0) =1.1 for De Site Subsoil Class.
- Hazard Factor (Z) for Busselton (Table 3.2 and Figure 3.2(C), AS1170.4) is 0.09. Accordingly, a peak ground acceleration of a(0) = kp x Z x Ch(0) = 1.3 x 0.09 x 1.1 = 0.1287 g is obtained.
- Groundwater level is based on the observed groundwater level during the site investigation.

AECOM has undertaken a preliminary liquefaction analysis based on CPT01, CPT02, CPT03, CPT04, CPT05B, CPT06 and CPT07. A simplified procedure based on the empirical method suggested by Robertson (2009) was used to assess the liquefaction potential for the site. The liquefaction potential in this method is defined as the ratio between the estimated soil cyclic shear resistance and earthquake cyclic shear stress. The ratio (i.e. also known as factor of safety) of less than 1.2 indicates that the material is potential liquefiable and can undergo post-earthquake settlement. When the liquefaction occurs, the impact to the surface structure is assessed from the degree of the post-earthquake settlement. Post-earthquake deformation due to lateral spread or flow is considered to have low probability since the site is relatively flat and the liquefiable soil zones are confined at significant depth.

Analysis results are presented in **Appendix H**. The analysis suggests the following:

- The shear stress ratio plot for all CPTs indicated that the cyclic stress ratio with 1.2 factor of safety ($CSR_{fs=1.2}$) are less than the cyclic resistance ratio from soils (CRR). The results indicate that overall risk of liquefaction is low along the bridge considering the factor of safety is generally higher than 1.2.
- The post-earthquake settlements were estimated to be generally less than 2 mm, which is considered to be acceptable for road and bridge infrastructures.

8.2 Foundation Soils' Aggressivity

The presence of an acidic environment or the presence of certain aggressive chemical's (Chloride, Sulphate) in the soil or rock can have deleterious effects on buried structures. Such environments are often associated with soils of high organic content and anoxic conditions.

The extent of acidity or alkalinity of a soil is commonly expressed by its pH value. Highly acidic soils represent a serious corrosion risk to common construction materials such as steel, cast iron and those with zinc coatings. Alkaline soils tend to have high sodium, potassium, magnesium and calcium contents. The latter two elements may form undesirable calcareous deposits on buried structures.

A total of six soil samples from depths between 1.5 m and 9.45 m were selected for testing to assess soils' aggressivity to steel and concrete. Soil aggressivity was assessed based on the measured pH value, sulphate (SO_4) and chloride (Cl) contents in accordance with AS 2159-2009.

Table 10 Exposure Classification for Concrete Piles – Piles in Soil (Reference: AS 2159 – 2009, Table 6.4.2 (C))

Exposure Conditions of Soil			Exposure Classification	
Sulphate (SO_4) in Soil, ppm	pH	Chloride in Groundwater, ppm	Soil Conditions A*	Soil Conditions B**
< 5,000	> 5.5	< 6,000	Mild	Non-aggressive
5,000 – 10,000	4.5 - 5.5	6,000 – 12,000	Moderate	Mild
10,000 – 20,000	4.0 – 4.5	12,000 – 30,000	Severe	Moderate
> 20,000	< 4	> 30,000	Very severe	Severe

Notes: *Soil conditions A – high permeability soils which are in groundwater,
**Soil conditions B – low permeability soils or all soils above groundwater,

Table 11 Exposure Classification for Steel Piles – Piles in Soil (Reference: AS 2159 – 2009, Table 6.5.2 (C))

Exposure Conditions of Soil			Exposure Classification	
pH	Chloride (Cl) in Soil, ppm	Resistivity, ohm.cm	Soil Conditions A*	Soil Conditions B**
> 5.0	< 5,000	> 5,000	Non-aggressive	Non-aggressive
4.0 - 5.0	5,000 – 20,000	2,000 – 5,000	Mild	Non-aggressive
3.0 – 4.0	20,000 – 50,000	1,000 – 2,000	Moderate	Mild
< 3	> 50,000	< 1,000	Severe	Moderate

Notes: *Soil conditions A – high permeability soils which are in groundwater,
**Soil conditions B – low permeability soils or all soils above groundwater,

Exposure classification stated in Tables 6.4.2 (C) and 6.5.2 (C) of AS 2159-2009 'Piling - design and installation' for soils above and below groundwater table was used to assess the soils' aggressivity (see Table 10 and Table 11). These exposure classifications are applicable to all buried concrete and steel structures. Soil aggressivity assessment for the proposed development site is shown in Table 12.

Table 12 Soil Aggressivity Assessment for Bridge 1763

Sample ID	Sample Depth (m)		pH	Chloride in Soil (ppm)	Sulphate in Soil (ppm)	Exposure Classification for	
	From	To				Concrete	Steel
BH1763-01	2.0	2.45	6.3	70	230	Non-aggressive	Non-aggressive
BH1763-01	8.0	8.3	6.7	60	<100	Mild	Non-aggressive
BH1763-02	1.5	1.95	6.2	90	<100	Non-aggressive	Non-aggressive
BH1763-02	4.0	4.1	7.7	80	<100	Mild	Non-aggressive
BH1763-02	6.5	7.0	9.5	50	50	Mild	Non-aggressive
BH1763-02	9.0	9.45	7.2	40	<100	Mild	Non-aggressive

Table 13 Groundwater Aggressivity Assessment for Bridge 1763

Sample ID	pH	Chloride in	Sulfate in	Exposure Classification for

		Groundwater (ppm)	Groundwater (ppm)	Concrete	Steel
Bridge 1763	7.39	282	53	Mild	Non-aggressive

Based on the measured pH, chloride and sulphate values, the exposure classification for steel and concrete varies between ‘non-aggressive’ and ‘mild’.

8.3 Earthworks

Recommendations on the suitability of excavated materials and general site preparation will be provided once road design alignment is confirmed.

9.0 Preliminary ASS Investigation

9.1 General

The SPOCAS method is a self-contained acid base accounting test. The complete method provides 12 individual analytes (plus five calculated parameters), which leads to a better prediction of a soil's likely acid–generating potential than the field screening techniques. The method involves the measurement of pH, titratable acidity, sulfur and cations of two soil sub samples. One soil sample is oxidised with hydrogen peroxide and the other is not. The differences between the two values of the analytes from the two sub samples are then calculated.

The titratable actual acidity (TAA) is the first component of the 'acidity trail' and provides a measure of the actual acidity (i.e. soluble and readily exchangeable acidity) present in the soil sample. The actual acidity is often a consequence of previous oxidation of sulphides and is the acidity that will be mobilised and discharged following a rainfall event.

The titratable peroxide acidity (TPA), the second part of the 'acidity trail', is the net result of the reactions between the acidifying and neutralising components in the soil (following peroxide digestion). A TPA of zero indicates that, for a finely ground sample (under laboratory oxidation conditions), the soil's buffering/acid neutralising capacity (ANC) exceeds (or equals) the potential acidity from oxidation of sulphides. A valuable feature of the TPA peroxide digestion component of the SPOCAS method is that for soils with a $pH_{OX} > 6.5$, any excess acid neutralising capacity (ANCE) can be quantified by means of a hydrochloric acid titration. This feature is useful when confirming if the soil has been neutralised sufficiently with lime (including whether an appropriate liming safety factor has been applied). The TPA, being a measure of net acidity, includes a contribution from the material's ANC.

Titratable sulfidic acidity (TSA) is calculated as: TPA minus TAA.

The 'sulfur trail' of SPOCAS (SPOS) gives a measure of the maximum 'oxidisable' sulfur (usually predominantly sulfides) present in a soil sample. As the chemical oxidising conditions employed in the laboratory are more rigorous than those experienced in the field, the SPOS result may, as a consequence, include some of the sulfur from the organic fraction in soil layers with appreciable organic matter. In such soil samples, SPOS is often slightly greater than chromium reducible sulfur (CRS) (which specifically excludes organic forms of sulfur). Generally CRS and SPOS results are well correlated for redox-reduced or PASS samples, but may differ on partially oxidised and surface samples.

In some ASS, CRS and SPOS may be below the action limit but the soil may still have an appreciable TPA. This may reflect organic acidity, but it may also reflect acidity from oxidation and/or titration of iron- containing or manganese-containing compounds. This is particularly the case in Western Australia for Bassendean Sands and coffee rock formations. Various aluminium-containing compounds, or complexes, may also contribute to this acidity. This acidity may be present whether or not there is any appreciable potential sulfidic acidity (i.e. any significant CRS or SPOS result). While this acidity is commonly not rapidly released into the environment in the short term, it is often released over a slower time-frame and should not be dismissed as being of no consequence.

9.2 Interpreting SPOCAS

Chemical analysis is undertaken as part of an ASS investigation to assess whether soils are likely to generate any net acidity and, if so, to quantify the acidity. The analytical results can be further used to calculate the amount of neutralising materials required to be added to soils to counteract any potential and existing acidity. Quantitative laboratory analyses for ASS have been developed to measure the net effect of acid generating processes in the soil balance against acid-neutralising (or basic) components that may be present, i.e. an acid-base account (ABA).

The underlying principle of acid-base accounting is outlined in the equation below:

Net Acidity = Potential Acidity + Existing Acidity – Acid Neutralising Capacity (ANC)

Where:

Existing Acidity is defined as: **Actual Acidity + Retained Acidity**

ANC is defined as: **measured ANC/ fineness factor**.

The components on the right hand side of the **Net Acidity** expression (or various combinations of these components) are assessed using appropriate laboratory methods.

9.2.1 Acid Neutralising Capacity (ANC)

ANC is a measure of a soil's inherent ability to buffer acidity and resist the lowering of the soil pH. Acid buffering in the soil may be provided by dissolution of calcium and/or magnesium carbonates (e.g. shell or limestone), cation exchange reactions and by reaction with the organic and clay fractions. The effectiveness of these buffering components in maintaining soil pH at acceptable levels will depend on the types and quantities of clay minerals in the soil and on the type, amount and particle size of the carbonates or other minerals present.

In the absence of any appreciable amount of ANC, where TSA substantially exceeds the sulfidic acidity predicted from the sulfur trail (SPOS, CRS), a precautionary approach should be adopted such as increasing the application rate of neutralising materials.

9.2.2 DEC Action Criteria

The net acidity action criteria used in this ASS Investigation are outlined in Table 11. The DEC action criteria are based on concentrations of oxidisable sulfur measured for broad categories of soil types. Works undertaken in soils that exceed these action criteria require the preparation and implementation of an acid sulfate soils management plan (ASSMP) approved by the DER. Laboratory analysis is required to assess if soil exceeds the net acidity action based criteria.

Table 14 Texture-based Acid Sulfate Soils 'Action Criteria' (DEC 2013)

Type of Material		Net Acidity Action Criteria			
		<1000 Tonnes of Material is Disturbed		>1000 Tonnes of Material is Disturbed	
Texture Range	Approximate Clay Content (%)	Equivalent Sulfur(%S) (oven-dry basis)	Equivalent Acidity (mol H+/t) (oven-dry basis)	Equivalent Sulfur(%S) (oven-dry basis)	Equivalent Acidity (mol H+/t) (oven-dry basis)
Coarse texture sands to loamy sands	<5	0.03	18.7	0.03	18.7
Medium texture sandy loams to light clays	5 to 40	0.06	37.4	0.03	18.7
Fine texture medium to heavy clays and silty clays	> 40	0.1	64.8	0.03	18.7

The adopted assessment criteria for most samples in this investigation is 0.03 equivalent sulfur (%S) due to there being greater than1000 tonnes of material that is likely to be disturbed by the overall duplication project.

9.3 Acid Sulfate Soil Results

A summary of field test results and copies of laboratory Certificates of Analysis are provided in **Appendix D**.

9.3.1 Field Screening Tests

The field screen test results were compared to the assessment criteria outlined in Section 4.4.2 to provide an indication of whether there may be actual ASS (AASS) or potential ASS (PASS) at this site. The results suggest the following:

- No samples had a pH_F less than four, suggesting that the likelihood of AASS is minimal.
- Fifteen (of eighteen) samples had none or one of the field test indicators, suggesting that the samples have a low likelihood of PASS.
- One sample (BH1763-01_5.0-5.45) had a pH_{FOX} less than three and a difference between pH_F and pH_{FOX} greater than three (two indicators), suggesting a medium likelihood of PASS.
- One sample (BH1763-02_5.0-5.1) had a difference between pH_F and pH_{FOX} greater than three and a strong reaction to hydrogen peroxide (two indicators), suggesting a medium likelihood of P ASS.
- One sample (BH1763-01_6.5-6.95) had a pH_{FOX} less than three, a difference between pH_F and pH_{FOX} greater than three and an extreme reaction to hydrogen peroxide (three indicators), suggesting a high likelihood of PASS.

9.3.2 Laboratory SPOCAS Testing

A total of three primary samples were submitted to the laboratory for quantitative analysis for net acidity by SPOCAS. The samples were submitted based upon the results of the ASS field screening tests and spread to obtain analytical results for the range of near-surface soil horizons encountered in the boreholes.

Two SPOCAS samples, BH1763-01_0.5-0.95 and BH1763-6.5-6.95, reported net acidity at or above the adopted criterion of 0.03 %S, with reported net acidity values of 0.03%S and 0.04%S, respectively. Based on these reported results, the samples are considered to be ASS.

9.4 Conclusions

Based on the results of the limited ASS investigations, it is concluded that:

- A degree of ASS risk has been identified in selected samples from the field investigation.
- The bridge works will involve installation of steel casing followed by drilling of material within steel pile sections. The pile core cuttings may contain ASS Ground. Therefore, in accordance with the DEC 2015 ASS Guideline Series, an ASS Management Plan (ASSMP) is required detailing soil management procedures to be undertaken during bridge and embankment construction works.
- It is likely that the ASS management options will be limited to either on-site treatment (lime neutralision) of cuttings prior to re-use or removal of cuttings off-site (within 18 hours) to a licenced soil treatment facility.

The issue of management of ASS should be considered as part of the overall strategy for management of ASS on southern approach embankment. It is recommended to develop a combined plan for overall management of all ASS associated with the project.

9.5 Recommendations

In accordance with DER 2015 guidelines, an ASSMP should be prepared for the site.

The objective of this ASSMP should be to detail the management and mitigation measures required to minimise the potential impacts to onsite and offsite environments from the proposed construction activities and propose measures to:

- control, minimise and avoid (where possible) the disturbance of ASS;
- ensure compliance with statutory requirements and DER guidelines; and
- prevent or minimise potential environmental impacts.

Should construction methodology change and require dewatering, a dewatering management plan (DMP) is likely to be required.

10.0 Limitations of Use

The ground is a product of continuing natural and man-made processes and therefore exhibits characteristics and properties which vary from place to place and can change with time. Geotechnical site investigation involves gathering and assimilating limited facts about these characteristics and properties in order to better understand or predict the behaviour of the ground at a particular site under certain conditions.

It should be noted that the subsurface conditions encountered by the limited number of CPTs, boreholes, and geophysical survey, undertaken as part of this geotechnical site investigation represents the ground conditions at the locations where the samples were taken and where tests have been undertaken and as such are an extremely small proportion of the site to be developed. The facts reported in this document may have been obtained by inspection, excavation, drilling, probing, sampling, testing or other means of investigation. They are directly relevant only to the ground at the place where, and time when, the investigation was carried out and are believed to be reported accurately. Given the limited number of field tests and laboratory testing carried out with respect to the overall site area, variations between investigation locations is likely and ground conditions different to those presented in this report may be present within the subject site area. The risk associated with this variability and the impact it will have on the proposed development should be carefully considered.

The level of geotechnical investigation that has been completed to date is considered appropriate for planning and designing of the project structures. If Main Roads WA (MRWA), its subcontractors, agents or employees use this factual information for any other purpose for which it was not intended, then MRWA, its subcontractors, agents or employees does so at its own risk and AECOM will not and cannot accept liability in respect of the advice, whether under law of contract, tort or otherwise.

Any interpretation or recommendation given in this report is based on judgement and experience and not on greater knowledge of the facts reported.

AECOM Australia Pty Ltd does not represent that the information or interpretation contained in this report addresses completely the existing features, subsurface conditions or ground behaviour at the subject site.

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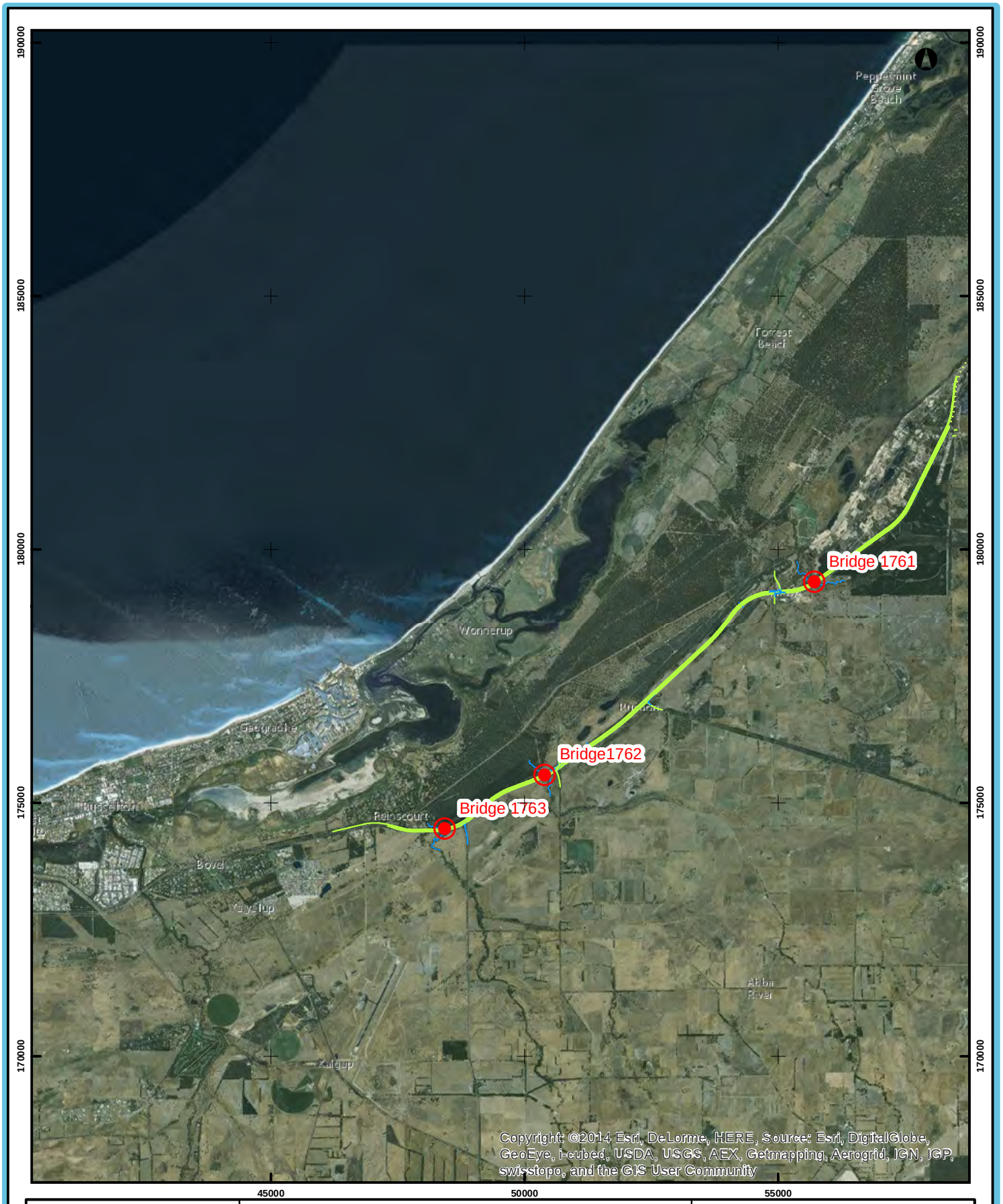
Appendix A

Figures



Bussell Highway Duplication Bridge Locations

Figure 1

Coordinate System: BCG94

0 1 2 3 4

Kilometres
1:100,000

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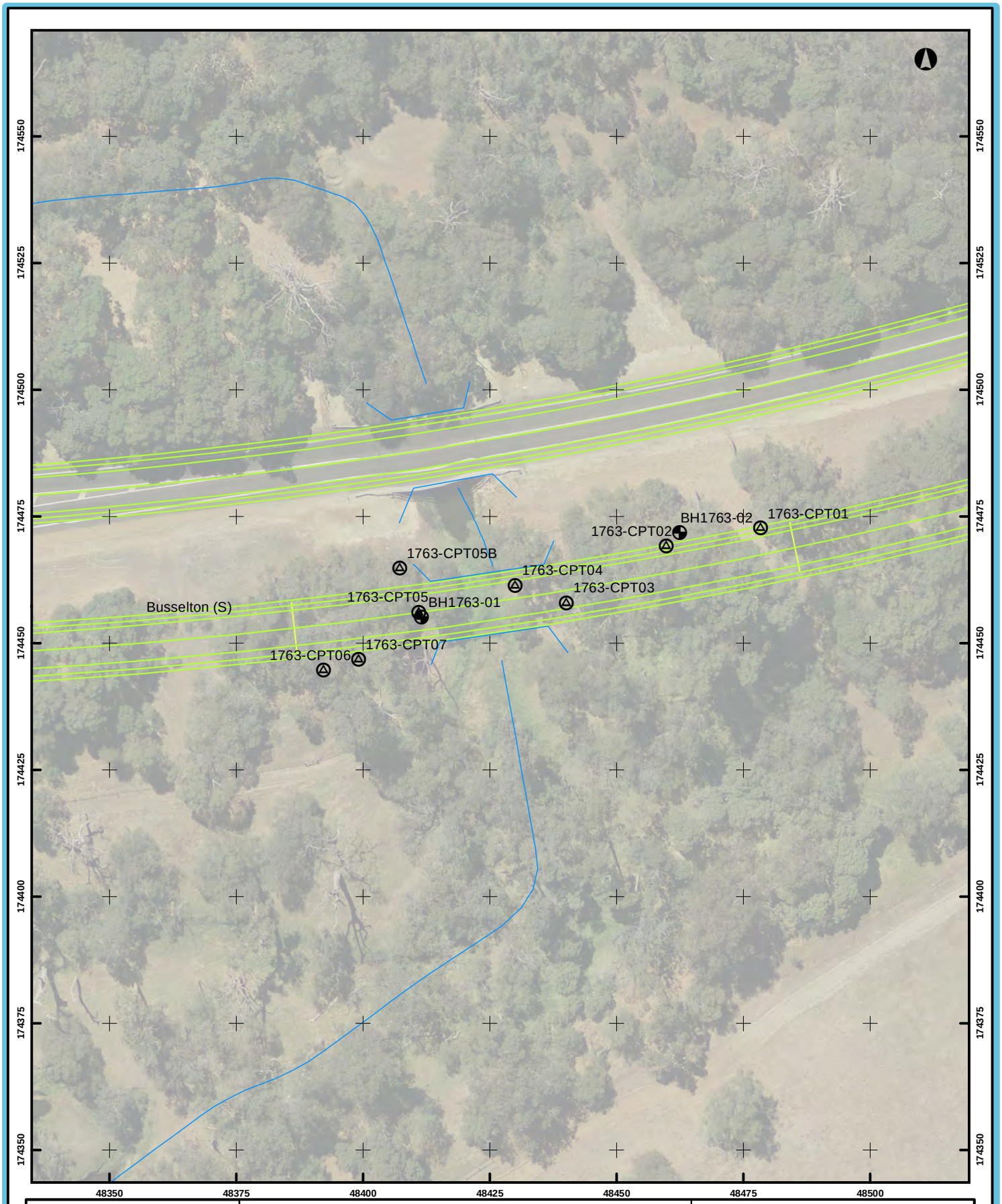

Bridge 1763 Geotechnical Investigation Locations

Figure 2

Coordinate System: BCG94

0 5 10 15 20 25

Metres

1:1,000

LEGEND

Geotechnical Investigation Hole Type

- Borehole
- EFCPTu

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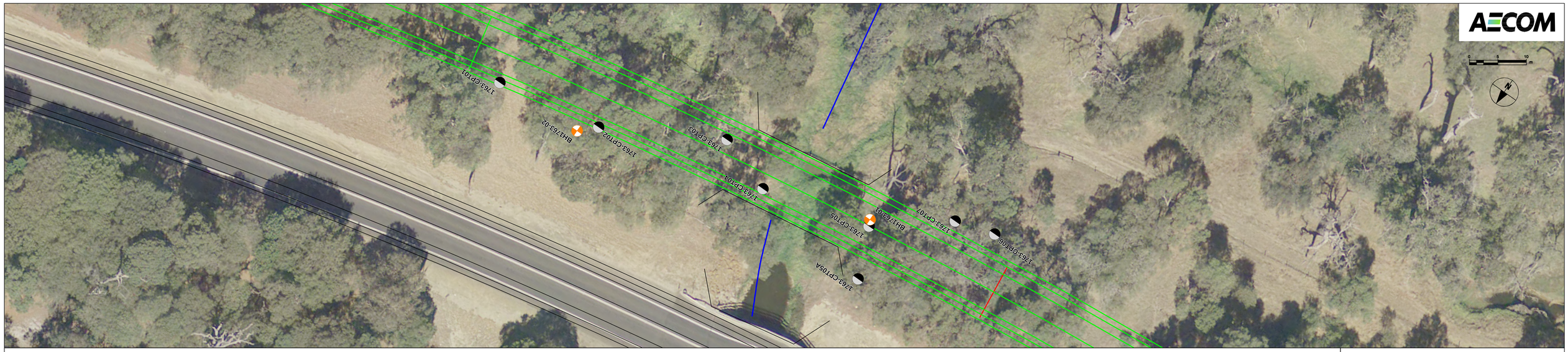

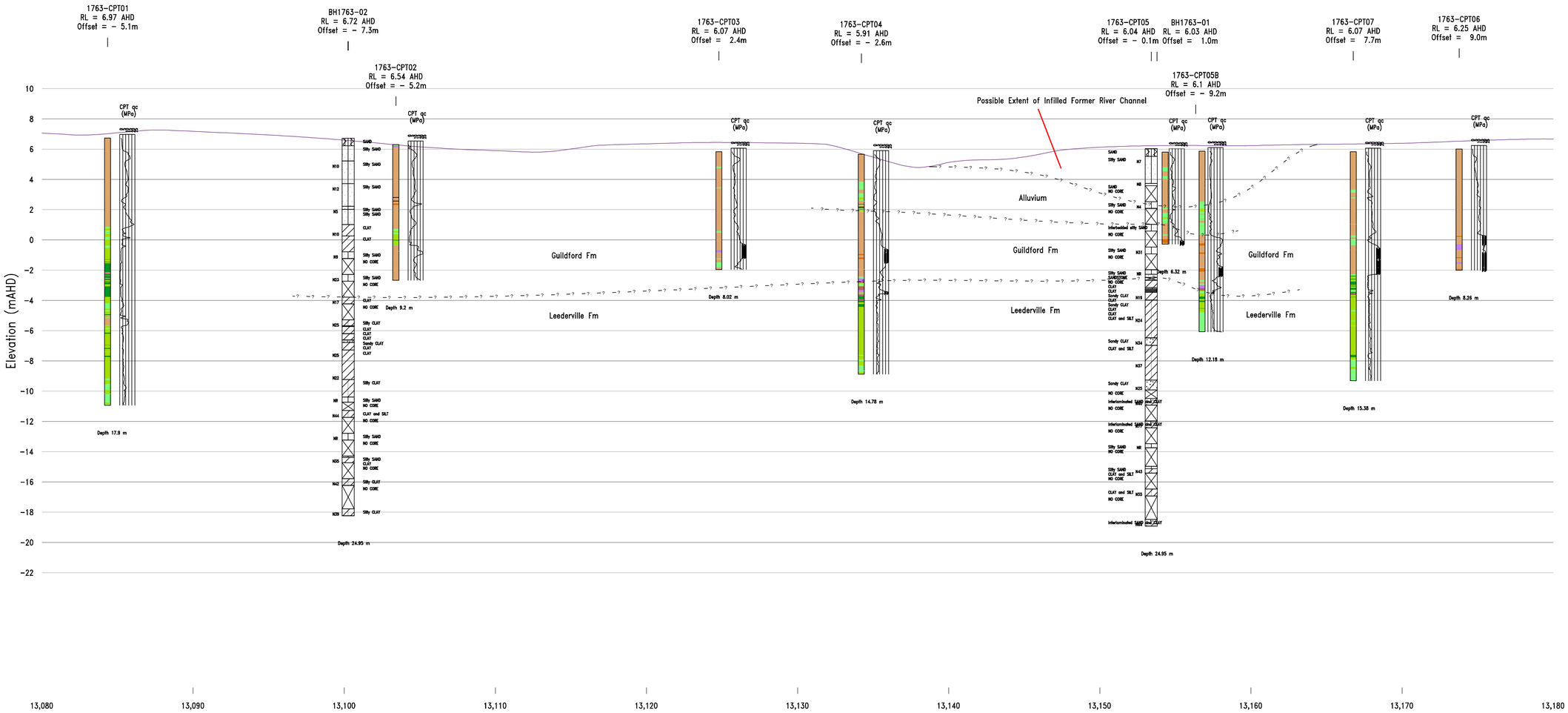

CPTu INTERPRETED SOIL TYPE BASED ON SBTn CLASSIFICATION

- SBTn0 – No Data
- SBTn1 – Sensitive Fine Grained
- SBTn2 – Organic Material
- SBTn3 – Clay to Silty Clay
- SBTn4 – Clayey Silt to Silty Clay
- SBTn5 – Silty Sand to Sandy Silt
- SBTn6 – Clean Sand to Silty Sand
- SBTn7 – Gravely Sand to Sand
- SBTn8 – Very Stiff Sand to Clayey Sand
- SBTn9 – Very Stiff Fine Grained

BOREHOLE LEGEND

- CLAY
- CLAYEY SAND
- GRAVELLY CLAY
- NO CORE
- PEAT
- SAND
- SANDY CLAY
- SANDY SILT
- SILTY CLAY
- SILTY SAND
- TOPSOIL

Ground surface based on available LiDAR data

N Uncorrected SPT 'N' value (blows/300mm)

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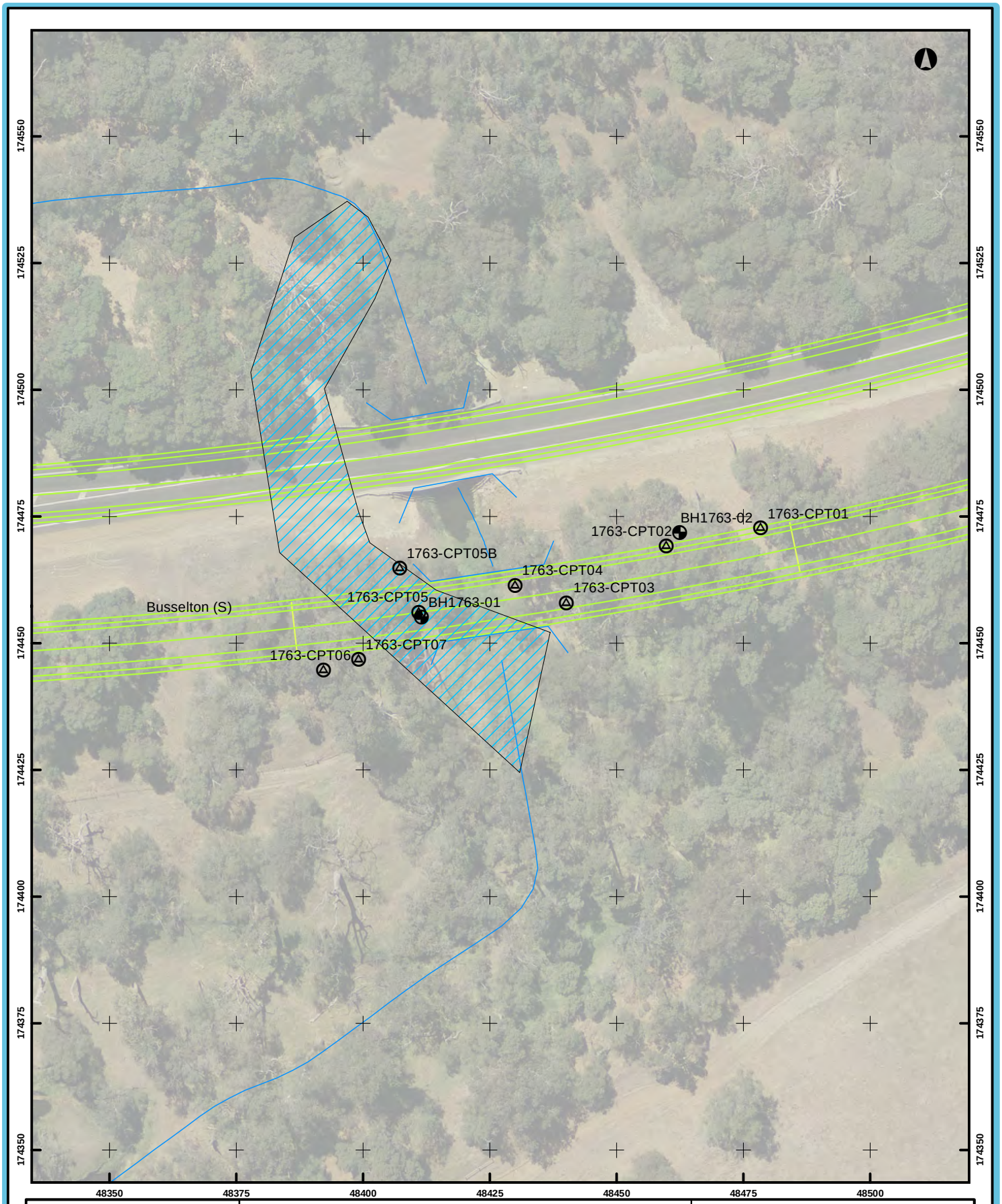
60344161 Bridge 1763 Bussell Highway

Geological Section

Figure 3



Bridge 1763
Route of Former River Prior to 1993

Figure 4

Coordinate System: BCG94

0 5 10 15 20 25
Metres
1:1,000

LEGEND

Geotechnical Investigation Hole Type

- Borehole
- EFCPTu
- Former River Route as identified on MRWA Drawing 9202-1080

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Appendix B

Borehole Logs and Core Photographs

1.0 Explanatory Notes and Abbreviations

General

Soil and rock descriptions on the engineering log sheets are generally in accordance with the recommendations of AS1726 - 1993. The sequence of descriptive terms used to describe soil and rock on the engineering log sheets is outlined below.

Soil

SOIL NAME: plasticity and particle characteristics, colour, structure, secondary and other minor components. The AS1726 Group Symbol, consistency/density and moisture condition are listed as abbreviations in separate columns. Geological origin and additional observations as required such as soil origin i.e. FILL, ALLUVIUM and other significant details are recorded in a separate column.

Rock

ROCK NAME: grain size, colour, texture and fabric, structure, bedding dip and geological formation. The rock mass defect spacing and defect descriptions are listed under separate columns. If the defect is greater than 100 mm thick it is described using relevant soil properties in the description column of the engineering log sheet.

Field Samples and Tests

Field samples and tests are recorded in the relevant column using abbrieviations described in Section 6.0.

Sample recovery is indicated on the log by a bar marker extending over a proportion of the sample interval.

Field tests have been used to assess soil consistency/density and rock strength, and unless specifically stated otherwise, have been transferred directly to the engineering log sheets and not modified to coincide with laboratory results. Field descriptions may be used as an independent estimate of material properties which can be correlated with other data.

Moisture Condition

Term	Symbol	Description	
		Cohesive	Granular
Dry	D	Cohesive; hard and friable or powdery, dry of Plastic Limit (PL)	Cohesion-less and free running
Moist	M	Soil feels cool, darkened in colour, can be moulded, near PL	Soil feels cool, darkened in colour, tends to cohere
Wet	W	Soil feels cool, dark, usually weakened, free water, >> PL	Soil feels cool, darkened in colour, tends to cohere, free water

Colour

Colour has been assessed in the “moist” condition using basic colours and the modifiers pale, dark and mottled. Borderline colours are described as a combination of the two colours (e.g. red-brown). When describing the colour of defect infill, the following abbreviations are used in the defect description column.

Table 1 Colour abbreviations

Term	Abbreviation
Brown	br
Grey	gy
Black	bk
White	wh
Blue	bl
Green	gr
Yellow	yl
Orange	or
Red	rd
Pale	pl
Dark	dk
Mottled	mtld

Structure

The structure of soil (or rock) is usually applicable to cohesive soils or rock. Typical terms that are used on the engineering log sheets include;
Fissured – Breaks into blocks along unpolished discontinuities.
Sheared – Breaks into blocks along polished discontinuities.
Voided, **vesicular** – open or infilled voids.
Cemented – chemically hardened by (e.g. by carbonate, iron or silica).
Layer - continuous across exposure or sample.
Lens - a discontinuous layer of different material, with lenticular shape.
Pocket - an irregular inclusion of different material.
Interbedded/interlaminated – alternating layers of different types prequalified by thickness term if in eqaul proportions otherwise thickness of spacing between subordinate layer should be defined.

Bedding and laminations are described based on their thickness as follows:

Thickness	Description
2 - 6 mm	Thinly laminated (thinly interlaminated)
6 - 20 mm	Thickly laminated (thickly interlaminated)
20 - 60 mm	Very thinly bedded (very thinly interbedded)
60 - 200 mm	Thinly bedded (thinly interbedded)
200-600mm	Medium bedded (medium interbedded)

Geological Origin

Term		Description
Weathered in Place Material	Extremely weathered material	Structure and fabric of parent rock visible
	Residual soils	Structure and fabric of parent rock not visible
Transported Soils	Aeolian soil	Deposited by wind
	Alluvial soil	Deposited by streams and rivers
	Colluvial soil	Deposited on slopes (transported downslope)
	Lacustrine soil	Deposited by lakes
	Marine soil	Deposited in oceans, bays, beaches and estuaries
Fill Materials	Soil Fill	Soil placed by humans in either controlled or uncontrolled conditions
	Rock Fill	Rock placed by humans in either controlled or uncontrolled conditions
	Waste Fill	Refuse from domestic or industrial sources

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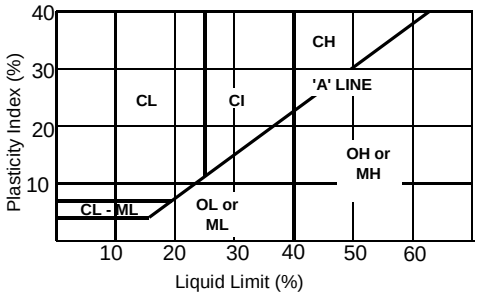
2.0 Soil Classification

Field Identification Procedures (Excluding particles larger than 60mm and basing fractions on estimated mass)				Group Symbol	Typical Names	Laboratory Classification Criteria
Coarse Grained Soils More than 50% of material less than 63 mm is larger than 0.075 mm	GRAVELS More than 50% of coarse fraction is larger than 2.36mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	GW	Well graded gravels, gravel-sand mixtures, little or no fines	Grain size curve used in identifying the fractions as given under field identification
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels	Determine percentages of gravel and sand from grain size curve Depending on percentage smaller than 0.06mm size coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12 % GM, GC, SM, SC 5% to 12% Borderline cases requiring use of dual symbols
		GRAVELS WITH FINES (Appreciable amount of fines)	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	GM	Silty gravels, gravel-sand-silt mixtures	$C_u = \frac{D_{60}}{D_{10}}$ Cu ≥4 $C_c = \frac{(D_{30})^2}{D_{10} x D_{60}}$ Cc=1 – 3
			'Dirty' materials with excess of plastic fines, medium to high dry strength	GC	Clayey gravels, gravel-sand-clay mixtures	Not meeting all gradation requirements for GW.(i.e. Cu < 4 or Cc ≠ 1 – 3)
	SANDS More than 50% of coarse fraction is smaller than 2.36mm	CLEAN SANDS (little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	SW	Well graded sands, gravelly sands, little or no fines	Atterberg limits below 'A' line or I_p less than 4. / Atterberg limits above 'A' line with I_p greater than 7. — Above 'A' line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	$C_u = \frac{D_{60}}{D_{10}}$ Cu ≥6 $C_c = \frac{(D_{30})^2}{D_{10} x D_{60}}$ Cc=1–3
		SANDS WITH FINES (Appreciable amount of fines)	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	SM	Silty sands, sand-silt mixtures	Not meeting all gradation requirements for SW. (i.e. Cu < 6 or Cc ≠ 1 – 3)
			'Dirty' materials with excess of plastic fines, medium to high dry strength	SC	Clayey sands, sand-clay mixtures	Atterberg limits below 'A' line or I_p less than 4. / Atterberg limits above 'A' line with I_p greater than 7. — Above 'A' line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
Fine Grained Soils More than 50% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEEDURES ON FRACTIONS < 0.2 mm					
		DRY STRENGTH	DILATANCY	TOUGHNESS		
	SILTS AND CLAYS Liquid limit less than 50	None to low	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with low plasticity. Silts of low to medium Liquid Limit.
		Medium to high	None to very slow	Medium	CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		Low to medium	Slow	Low	OL	Organic silts and organic silt-clays of low to medium plasticity
	SILTS AND CLAYS Liquid limit greater than 50	Low to medium	Slow to none	Low to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, silts of high Liquid Limit
		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
		Medium to high	None to very slow	Low to medium	OH	Organic clays of medium to high plasticity, organic clays
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			Pt	Peat and other highly organic soils



Plasticity chart for classification of fine-grained soils

Boundary classifications – Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.

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3.0 Soil Description

Soil Type

Classification of soils for engineering purposes is based on *AS1726 - 1993*.

Graphic Symbols

Primary Component	Secondary Component	Other Graphics	
Boulders	Bouldery	Ash	Fill
Cobbles	Cobbly	Bituminous Seal	No Core
Gravel	Gravelly	Calcrete	Silcrete
Sand	Sandy	Concrete	Talus
Silt	Silty	Crushed Rock	Timber
Clay	Clayey	Ferricrete	Topsoil
Peat	Peaty		

Minor Components

Modifier	% Fines (coarse grained soils)	% Coarse (fine grained soils)	Field Guide
Trace	≤ 5	≤ 15	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary components
With	> 5 ≤ 12	> 15 ≤ 30	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component
Prefix with Clayey/Silty or Sandy/Gravelly as appropriate	> 12	> 30	Presence very easily detected by feel or eye, typically has some influence on soil properties

Plasticity

Descriptive Term	Range of Liquid Limit (%)
Low plasticity	≤ 35
Medium plasticity	> 35 ≤ 50
High plasticity	> 50

Grain Size

Soil Type		Grain Size (mm)	Shape Texture	Field Guide
Clay		< 0.002		Shiny, Not visible under 10x
Silt		0.002 - 0.075		Dull, Visible under 10x
Sand	Fine	0.075 - 0.2	angular / subangular / subrounded / rounded low/high sphericity	Visible by eye
	Medium	0.2 - 0.6		Visible at < 1 m
	Coarse	0.6 - 2.36		Visible at < 3 m
Gravel	Fine	2.36 - 6		Visible at < 5 m
	Medium	6 - 20		Road gravel
	Coarse	20 - 63		Rail ballast
Cobbles		63 - 200		Beaching

Grain Shape

Term	High Sphericity	Low Sphericity
Angular		
Sub-angular		
Sub-rounded		
Rounded		

Organic and Artificial Material

Organic and artificial material cannot be adequately described using the terms above. They are mentioned, at the end of the description using qualitative terms such as "**rare**", "**occasional**" or "**frequent**", e.g. "SAND with rare gravel size brick fragments". These qualitative terms are relative, for which no definition of percentage is given.

Organic matter is described using terms such as charcoal, wood fragments, roots (>2mm diameter) or rootlets(<2mm diameter).

Peat or organic rich soils consists predominantly of plant remains. It can be further described according to its degree of decomposition and strength:
Firm - Fibres already compressed together
Spongy - Very compressible and open structure
Plastic - Can be moulded in hand and smears in fingers
Fibrous - Plant remains recognisable and retain some strength
Amorphous: No recognisable plant remains

Waste fill is described using terms such as domestic refuse, oil, bitumen, brickbats, concrete rubble, fibrous plaster, wood pieces, wood shavings, sawdust, iron filings, drums, steel bars, steel scrap, bottles, broken glass, or leather.

Density (non-cohesive soils)

Based on range of SPT blow counts for fine to medium grained sands

Term	Very Loose	Loose	Medium Dense	Dense	Very Dense
Symbol	VL	L	MD	D	VD
SPT (N) Blowcount	0 - 4	4 - 10	10 - 30	30 - 50	> 50
Density Index (%)	≤ 15	> 15 ≤ 35	> 35 ≤ 65	> 65 ≤ 85	> 85
Field Guide	Ravels	Shovels easily	Shovelling very difficult	Pick required	Pick difficult

Consistency (cohesive soils)

Based on undrained strength (S_u) (estimated in field from pocket penetrometer or shear vane)

Term	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard
Symbol	VS	S	F	St	VSt	H
Undrained Shear Strength (kPa)	≤12	>12 ≤ 25	>25 ≤ 50	>50 ≤100	>100 ≤ 200	>200
SPT (N) Blowcount*	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	> 30
Field Guide	Exudes between the fingers when squeezed	Can be moulded by light finger pressure	Can be moulded by strong finger pressure	Cannot be moulded by fingers. Can be indented by thumb	Can be indented by thumb nail	Can be indented with difficulty with thumb nail

*Based on HB 160-2006, Soils Testing, Standards Australia.

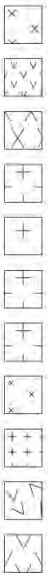
4.0 Non Carbonate Rock Description

Graphic Symbols

Sedimentary (Clastic)

Sedimentary (Non-Clastic)

Igneous



Metamorphic

Strength

Term	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High
SYMBOL	EL	VL	L	M	H	VH	EH
$I_{s\,(50)}$ (MPa)	≤ 0.03	> 0.03 ≤ 0.1	> 0.1 ≤ 0.3	> 0.3 ≤ 1	> 1 ≤ 3	> 3 ≤ 10	> 10
FIELD GUIDE	Easily remoulded by hand to a material with soil properties	Material crumbles under firm blow with sharp end of pick. Can be peeled with a knife. Too hard to cut a triaxial sample by hand. Pieces up to 3 cm thick can be broken by finger pressure.	Easily scored with a knife. Indentations of 1mm - 3mm in the specimen with firm blows of the pick point. Has dull sound under hammer. A piece of core 150 mm long 50 mm diameter may be broken by hand	Readily scored with a knife. A piece of core 150 mm long 50 mm diameter can be broken by hand with difficulty	A piece of core 150 mm long 50 mm diameter cannot be broken by hand but can be broken with by a pick with a single firm blow. Rock rings under hammer	Hand specimen breaks with a pick after more than one blow. Rock rings under hammer	Specimen requires many blows with a geological pick to break through intact material. Rock rings under hammer

Note:
1. $I_{s(50)}$ is in accordance with AS1726-1993.
2. The strength noted above is a measure of the strength of the rock material not the rock mass
3. Anisotropy of rock material samples may affect the field assessment of strength
4. The unconfined compressive typically ranges from 10 to 20 times the $I_{s(50)}$ but the multiplier may vary widely for different rock types

Degree of Weathering

Degree of Weathering		Symbol		Weathering Description
Residual Soil		RS		Soil developed from weathering of rock in-situ. The mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Rock		XW		Rock is weathered to such an extent that it has soil properties. With chemical weathering it disintegrates or can be remoulded in water. It shows a rock fabric but is described as a soil. Mechanical weathering may reduce hard rock to a gravel.
Distinctly Weathered	Highly Weathered Rock	DW	HW	Secondary minerals often weathered to a clay. Staining of most grain boundaries and some disintegration due to weakening of grain bonds. Often significant loss of strength. However cementing of joints can occasionally lead to strengthening.
	Moderately Weathered Rock		MW	Staining and pitting of most secondary minerals and other grain boundaries. The loss of strength depends on the weathering and extent of secondary minerals in the rock matrix. The rock substance may be highly discoloured, usually by ironstaining.
Slightly Weathered Rock		SW		Secondary minerals are stained but not pitted, slight staining at some grain boundaries. Slight loss of strength indicated by amount of colour change.
Fresh Rock		FR		Rock is uniform and shows no sign of decomposition or staining. Relatively strong.

DW = Distinctly Weathered indicates a distinct change in colour, hardness and/or friability and is not separable into HW or MW

AECOM

Grain Size, Defect Spacing and Planar Structure (Rock Description Only)

Size/Spacing Thickness	Soil Grain Size Term	Rock Type		Defect Spacing Term	Symbol	Bedding Thickness Term
		Sedimentary	Igneous Metamorphic			
< 2 µm	CLAY	CLAYSTONE	FINE			
2 - 60 µm	SILT	SILTSTONE				
0.06 - 0.2 mm	fine grained SAND	SANDSTONE	MEDIUM			
0.2 - 0.6 mm	medium grained SAND					
0.6 - 2.0 mm	coarse grained SAND					
2 - 6 mm	fine grained GRAVEL	CONGLOMERATE (rounded boulders, cobbles and gravel cemented in a finer matrix) *or* BRECCIA (irregular rock fragments in a finer matrix)	COARSE			THINLY LAMINATED
6 - 20 mm	medium grained GRAVEL			EXTREMELY CLOSE	EC	LAMINATED
20 - 60 mm	Coarse grained GRAVEL			VERY CLOSE	VC	VERY THINLY
60 - 200 mm	COBBLES			CLOSE	C	THINLY
0.2 - 0.6 m	small BOULDERS			MEDIUM	M	MEDIUM
0.6 - 2m	medium BOULDERS			WIDE	W	THICKLY
> 2m	large BOULDERS			VERY WIDE	VW	VERY THICKLY

Vesicularity

Symbol	Description	Porosity
D	Dense	Negligible
NV	Non-vesicular	< 10%
SV	Slightly vesicular	10 - 20%
HV	Highly vesicular	> 20%

Common Defects in Rock Masses

Defects are described in the description column in the following order, defined by abbreviations:

- Type, dip/direction, planarity, roughness, infill/coating, colour. To indicate the defect has been healed, (healed) is printed at the end of the description. E.g. B,30/145°,PL,ro,1mm,CH,gy indicates a bedding joint with 30° dip, 145° dip direction, planar rough surfaces, 1mm thick, filled with grey high plasticity clay.

Defects up to 10 mm thick are described as bedding joints or joints. Defects 10mm to 100mm thick are described as seams. Defects greater than 100mm thick are described as a new material strata.

Defect Type

Log Symbol	Term	Definition
B	**Bedding Joint**	A discontinuity or crack, parallel or sub-parallel to layering, across which the rock has little or no tensile strength.
J	**Joint**	A discontinuity or crack, planar, curved or irregular across which the rock usually has little tensile strength.
SH	**Sheared Seam**	Seam of roughly parallel boundaries of rock substance cut by closely spaced joints or cleavage surfaces.
CR	**Crushed Seam**	Seam with roughly parallel boundaries composed of mainly angular fragment of the host rock substance.
NF	**Infilled Seam**	Seam with distinct roughly parallel boundaries. The infill is caused by migration of soil into open joints.
EW	**Extremely Weathered Seam**	Seam of soil substance weathered from host rock.
MB	**Mechanical Break**	A break in rock mass not caused by natural effects. Example causes include drilling, testing and storage

Defect Planarity

Symbol	Description
PL	planar
UN	undulating
CU	curved
ST	stepped
IR	irregular

Defect Roughness

Symbol	Description
sm	smooth
ro	rough
sl	slickensided

Infill/Coating

Symbol	Description
cn	clean
sn	stained
vn	veneered
co	coated
op	open/voided
Ca	Calcium Carbonate
Fe	Iron Oxide
Ch	Chlorite
Qtz	Quartz

6.0 General Symbols and Abbreviations

Field Sampling and Testing Abbreviations

Symbol	Description
V	Uncorrected Vane Shear (kPa) – Peak/Residual
PP	Pocket Penetrometer (kPa)
SPT	Standard Penetration Test
N	Uncorrected SPT blow count for 300 mm
N*	SPT with sample collected
RW	SPT rod weight only (SPT N < 1)
HW	SPT rod and hammer weight (SPT N < 1)
HB	SPT Hammer Bouncing
FPM	Field Permeability
Lu	Lugeon/Packer Test (L/m/min)
$Is_{(50)}$(A)	Axial Point Load Strength Index (MPa)
$Is_{(50)}$(D)	Diametral Point Load Strength Index (MPa)
$Is_{(50)}$(I)	Irregular Point Load Strength Index (MPa)
U(X)	Undisturbed Sample (X) mm diameter
UP	Undisturbed Piston Sample
DS	Disturbed Sample
BS	Bulk Sample
E	Environmental Sample
RQD	Rock Quality Designation (%)
SCR	Solid Core Recovery (%)
TCR	Total Core Recovery (%)
DCP	Dynamic Cone Penetration Resistance (blows/100 mm)
PSP	Perth Sand Penetrometer Resistance (blows/ 150 mm)
PID	Photoionisation Detector

Water

Symbol	Description
	Water level (static)
	Water level (during drilling)
	Water inflow
	Water outflow
	Complete water loss

Drilling Method

Drilling Method Symbol	Description
AD	Auger Drilling
AS	Auger Screwing
V	V-Bit*
WB	Wash Boring
B	Blank Bit*
T	Tungsten Carbide Bit*
RR	Rock Roller/Tricone
DHH	Down Hole Hammer
PD	Percussion Drilling
CT	Cable Tool
HA	Hand Auger
DT	Diatube
NMLC	NMLC Size Core –Triple Tube (50mm diameter)
NQ, HQ, PQ	Wireline Size Core – Triple Tube (45mm, 61mm, 83mm diameter)
RC	Reverse Circulation
CA	Casing Advancer
VC	Vibro Coring
SC	Sonic Coring
GP	Geoprobe Continuous Sampling

*Drill bit symbol used as suffix to drilling method symbol, e.g. ADV indicates auger drilling with V-bit

Drilling Support

Symbol	Description
U	Unsupported
C	Casing
M	Mud
W	Water

Engineering Log

Borehole No. BH1763-01
Sheet: 1 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data								Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB			NOT OBSERVED	Ds E	6.5	0.5		SP-SM	SAND: Subangular to subrounded, fine to medium grained, dark brown, with silt, trace-with organic fines, abundant becoming occasional grass rootlets.		M		Alluvium driller notes full flush returns throughout hole.
HQ3				E N* 1,3,4 N=7	7.0	1.0		SM	Silty SAND: Subangular to subrounded, fine to medium grained, dark brown, trace organic fines.			L	
	M			Ds	7.5	1.5							
					8.0	2.0						L	
SPT				E N* 1,3,5 N=8	8.5	2.5		SP	SAND: Subangular to rounded, medium to coarse grained, pale grey and pale yellow brown, trace silt.				
HQ3					9.0	3.0			NO CORE: No recovery.				
					9.5	3.5		SM	Silty SAND: Subangular to subrounded medium to coarse grained predominantly coarse grained, dark brown, trace organic fines, occasional rotten root fragments.			VL-L	
SPT				E N* 1,3,1 N=4	10.0	4.0							

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Borehole No. BH1763-01
Sheet: 2 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
HQ3	M				10.5	4.5			NO CORE: Recovered 0.1m of rotten wood. *continued*			Alluvium *continued*
SPT				E N*	11.0	5.0		SP-SM	Interbedded silty SAND: Subangular to subrounded, fine to medium grained, dark grey with two 20mm beds of red brown very weakly cemented sandstone [coffee rock], trace black organics.			Guildford Fm
HQ3					11.5	5.5			NO CORE: Recovered as 50mm of sandy clay.			
SPT				E N* 10,15,16 N=31	12.0	6.0		SM	Silty SAND: Subangular to subrounded, fine to coarse grained, mid grey, non plastic.		D	
HQ3					12.5	6.5			NO CORE: No recovery.			
					13.0	7.0						
					13.5	7.5						
					14.0	8.0						

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Borehole No. BH1763-01
Sheet: 3 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
SPT				E N* 21,50/150 N=R coffee rock				SM	Silty SAND: Subrounded to rounded, medium to coarse grained, predominantly coarse grained, red brown, trace gravel, suspected coffee rock horizon.		VD	Guildford Fm *continued*
									SANDSTONE: Ferrungized sandstone (coffee rock) - fine to medium grained, medium strength, blackish brown mottled red brown.			
					14.5	8.5			NO CORE: Assumed zone of core loss.			
HQ3				PP= 210, 240, 140	15.0	9.0		CI	CLAY: Medium plasticity, mid grey, rare mottles of red brown and orange brown, trace to with sand [mica, quartz] , stiff based on tactile assessment.		St	Leederville Fm
								CI	CLAY: Red brown, hard.			
								CI	Sandy CLAY: Medium plasticity, sand is fine to medium grained, micaceous, multi-coloured.			
								CI	CLAY: Red brown, hard.			
					15.5	9.5		CI	Sandy CLAY: Medium plasticity, sand is fine to medium grained, micaceous, multi-coloured.			
SPT				N* 3,6,13 N=19				CI	CLAY: Red brown, hard.		VSt	
									CLAY: Medium plasticity, trace sand of mica, dark brown, thinly laminated, fissured.			
					16.0	10.0			Becoming multi-coloured locally highly micaceous.			
	M			PP= 450, 540, >600				CH-ML	CLAY and SILT: Variable plasticity, dark brown, occasionally mottled dark red brown and dark yellow brown, trace sand of mica, hard based on tactile assessment.		H	
HQ3				PP= >600, >600, >600	16.5	10.5					H	
				C								
				PP= >600, >600, >600	17.0	11.0					H	
SPT				N* 5,10,14 N=24							VSt	
					17.5	11.5			Medium plasticity, occasional fragments of charcoal.			
HQ3				PP= >600, >600, >600							H	
					18.0	12.0						

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Borehole No. BH1763-01
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Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m) / Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure		Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
HQ3				PP= >600, >600, >600			CH-ML	CLAY and SILT: Variable plasticity, dark brown, occasionally mottled dark red brown and dark yellow brown, trace sand of mica, hard based on tactile assessment. *continued*			H	Leederville Fm *continued*
				PP= >600, >600, >600	18.5 / 12.5						H	
SPT				N* 6,16,18 N=34	19.0 / 13.0		CI	Sandy CLAY: Medium plasticity, dark grey, sand is predominantly mica, minor quartz. Faintly thinly laminated, trace charcoal.			H	
HQ3	M			PP= >600, >600, >600	19.5 / 13.5		CI-MH	CLAY and SILT: Medium plasticity, dark brown, trace sand of mica, occasional fragments of charcoal, consistency assessed as hard based on tactile assessment.			H	
				C PP= >600, >600, >600								
				PP= >600, >600, >600	20.0 / 14.0						H	
SPT				N* 6,16,21 N=37	20.5 / 14.5						H	
HQ3				PP= >600, >600, >600	21.0 / 15.0						H	
				PP= >600, >600, >600	21.5 / 15.5		CI	Sandy CLAY: Medium plasticity, dark grey, sand is fine to medium grained, predominantly of mica, minor quartz. Faintly thinly laminated, trace charcoal. Occasional laminae of sand/silt.			H	
SPT				N* 5,12,13 N=25	22.0 / 16.0						VSt	

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Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB					22.5	16.5			NO CORE: Wash boring, no recovery except handful of fine gravel of coal. Suspected cohesive strata based on drilling progress. *continued*			Leederville Fm *continued*
SPT				N* 8,16,24 N=40	23.0	17.0			Interlaminated SAND and CLAY: Clay is low plasticity, sand is fine to medium grained predominantly of quartz and mica, dark grey, occasional fragments of charcoal.		D	
WB	M				23.5	17.5			NO CORE: Wash boring, no recovery except handful of fine gravel of coal. Suspected sandy strata based on drilling progress/cuttings.			
SPT				N* 10,28,49 N=77	24.0	18.0			Interlaminated SAND and CLAY: Clay is low plasticity, sand is fine to medium grained predominantly of quartz and mica, dark grey, occasional fragments of charcoal. To 18.45m bed of sand with clay.		VD	
WB					24.5	18.5			NO CORE: Wash boring, no recovery except handful of coarse quartz sand. Suspected sandy strata based on drilling progress/cuttings.			
SPT				N* 17,42/120 N=R	25.0	19.0		SM	Silty SAND: Fine to medium grained, non plastic, dark grey, sand is of quartz, occasional coal fragments. Faintly laminated.		VD	
WB					25.5	19.5			NO CORE: Wash boring, no recovery except handful of coarse quartz sand. Suspected sandy strata based on drilling progress/cuttings.			
					26.0	20.0						

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Borehole No. BH1763-01
Sheet: 6 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB					26.5	20.5			NO CORE: Wash boring, no recovery except handful of coarse quartz sand. Suspected sandy strata based on drilling progress/cuttings. *continued*			Leederville Fm *continued*
					27.0	21.0						
SPT				N* 11,17,26 N=43 only 21.15-21.45m sampled				SM	Silty SAND: Fine to medium grained, non plastic, dark grey, sand is of quartz, occasional coal fragments. Faintly laminated.		H	
					27.5	21.5		CI-MH	CLAY and SILT: Medium plasticity, dark brown, trace sand of mica, occasional fragments of charcoal, consistency assessed as hard based on tactile assessment.			
WB	M								NO CORE: Wash boring, no recovery except handful of clay. Suspected cohesive strata based on drilling progress.			
					28.0	22.0						
SPT				N* 10,24,31 N=55	28.5	22.5		CI-MH	CLAY and SILT: Medium plasticity, dark brown, trace sand of mica, occasional fragments of charcoal, consistency assessed as hard based on tactile assessment.		H	
					29.0	23.0						
WB									NO CORE: Wash boring, no recovery except handful of clay. Suspected cohesive strata based on drilling progress.			
					29.5	23.5						
					30.0	24.0						

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Engineering Log

Borehole No. BH1763-01
Sheet: 7 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: BF
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 29/03/2016
End Date: 30/03/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48411.5m
RL: 6.03m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174455.1m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB									NO CORE: Wash boring, no recovery except handful of clay. Suspected cohesive strata based on drilling progress. *continued*			Leederville Fm *continued*
	M					24.5						
SPT				N* 9,19,45 N=64					Interlaminated SAND and CLAY: Clay is low plasticity, sand is fine to medium grained predominantly of quartz and mica, dark grey, occasional fragments of charcoal.		VD	
						25.0			*BH1763-01 terminated at 24.95m.*			
						25.5						
						26.0						
						26.5						
						27.0						
						27.5						
						28.0						

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

Engineering Log

Cored Borehole No. BH1763-01

Sheet: of 8

Client:	MRWA Bussell Highway Duplication	**Project No:**	60344161.100 - 243.01.1761.EN
Project:	Bridge 1761-1763	**Logged by:**	BF
Location:	Bussell Hwy near Busselton	**Start Date:**	29/03/2016
		Checked by:	
		End Date:	30/03/2016

Driller:	TB/BR	**Hole Diameter:**	96mm	**Easting:**	48411.5m	**RL:**	6.03m
Drill Rig:	Geoprobe 7822DT	**Inclination:**	90	**Northing:**	174455.1m	**Ver Datum:**	AHD
		Bearing:		**Hor. Datum:**	Local	**Surface:**	Grass

BH1763-01 8.30m - 12.50m

BH1763-01 12.50m - 16.00m

AECOM Engineering Log

Borehole No. BH1763-02
Sheet: 1 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description		Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
GP					7.0	0.5		SP-SM	SAND: Subangular to subrounded, fine to medium grained, dark brown, with silt, trace-with organic fines, abundant becoming occasional grass rootlets.			Alluvium
GP					7.5	1.0		SM	Silty SAND: Subangular to subrounded, fine to medium grained, brown, non-plastic, sand is of quartz, trace organics.			0.5-1.5m 1.0m recovery.
				E					From 1.0m colour change to brown, red-brown.			
				Ds	8.0							
				E		1.5						
SPT	M			E N* 3,4,6 N=10	8.5			SM	Silty SAND: Subangular to subrounded, fine to medium grained, pale brown, non-plastic, sand is of quartz.		L-MD	Guildford Fm 1.95-3.0m 1.05m recovery.
				E		2.0						
GP					9.0							
				E		2.5						
				Ds	9.5							
				E		3.0						
SPT			02/05/2016	E N* 3,6,6 N=12	10.0			SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, grey and brown sand is of quartz.		MD	
GP						3.5						3.45-4.5m 1.05m recovery.
					10.5							
						4.0						

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

AECOM Engineering Log

Borehole No. BH1763-02
Sheet: 2 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
GP				E	11.0	4.5		SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, grey and brown sand is of quartz. *continued*			Guildford Fm *continued*
SPT				E Ds N 2,2,3 N=5 Ds	11.5	5.0		SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, orange-brown, trace coal fragments.		L	
GP	M			E Ds	12.0	5.5		SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, grey and brown sand is of quartz.			4.95-6.0m 1.05m recovery.
				PP= 275, 280, 250							VSt	
SPT				Ds PP= 310, 280, 320 Ds PP= 310, 280, 320 N* 3,5,5 N=10	12.5 13.0	6.0 6.5		CH	CLAY: High plasticity, grey, occasional red-brown, mottles, with calcrete of soil strength, moderate to high effervescence with HCL, trace fine to medium grained, sand.		VSt St	
GP				Ds PP= 290, 250, 280 E PP= 290, 250, 280	13.5 14.0	7.0 7.5		CI	CLAY: Medium plasticity, mid grey, rare mottles of red brown and orange brown, trace to with sand (mica, quartz), trace organic fibres, firm based on tactile assessment.		VSt	6.45-7.0m 1.05m recovery. At 7.0m swap to wash boring.
SPT				N* 2,4,5 N=9	14.5	8.0		SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, grey and brown, sand is quartz, mica.		L	

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

AECOM Engineering Log

Borehole No. BH1763-02
Sheet: 3 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB					15.0	8.5			NO CORE: No recovery. *continued*			Guildford Fm *continued*
					15.5	9.0						
SPT				E N* 22,13,10 N=23	16.0	9.5		SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, orange-brown, with black fine grained gravel of suspected coffee rock, sand is of quartz,.		MD	
WB	M				16.5	10.0			NO CORE: No recovery.			
					17.0	10.5						
SPT				N* 5,7,10 N=17	17.5	11.0		CL	CLAY: Medium plasticity, to high plasticity, grey-brown, mottles of red-brown, trace root fibres, firm based on tactile assessment.		VSt	Leederville Fm
WB					18.0	11.5			NO CORE: No recovery.			
					18.5	12.0						

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

Engineering Log

Borehole No. BH1763-02
Sheet: 4 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
SPT				Ds N 5,12,13 N=25	19.0				Silty CLAY: Medium plasticity, brown, red-brown and purple brown, with fine grained micaceous sand,		VSt	Leederville Fm *continued* At 12.0m swap to HQ coring.
				Ds				Cl	CLAY: Medium plasticity, trace sand of mica, dark brown, thinly laminated.			
HQ3	M				12.5			Cl	CLAY: Medium plasticity, dark brown, consistency assessed as hard based on tactile assessment.			12.45-14.0m 1.05m recovery.
				C	19.5							
					13.0			Cl	CLAY: Medium plasticity, multi-coloured, consistency assessed as hard based on tactile assessment.			
				PP= >600, >600, >600	20.0							
								Cl	Sandy CLAY: Medium plasticity, sand is fine to medium grained, micaceous, multi-coloured.		H	
					13.5			Cl	CLAY: Medium plasticity, multi-coloured, consistency assessed as hard based on tactile assessment.			
				PP= >600, >600, >600							H	
					20.5							
					14.0			Cl	CLAY: Medium plasticity, dark brown, trace micaceous fine grained sand.		VSt	
SPT				N* 5,11,14 N=25	21.0							
					14.5							14.45-15.5m 1.05m recovery.
HQ3				PP= >600, >600, >600	21.5						H	
					15.0							
				PP= >600, >600, >600							H	
					22.0							
				C								
					15.5						VSt	
SPT				N* 2,10,12 N=22	22.5							
					16.0							

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

AECOM Engineering Log

Borehole No. BH1763-02
Sheet: 5 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
HQ3	M			PP= >600, >600, >600	23.0				Silty CLAY: Medium plasticity, dark brown, trace fine grained, micaceous sand. *continued*			15.95-17.0m 1.05m recovery. Leederville Fm *continued*
				PP= >600, >600, >600	16.5						H	
				PP= >600, >600, >600	23.5						H	
					17.0							
SPT				Ds							VD	At 17.0m swap to wash boring.
				N 11,26,50/120 N=R Ds	24.0			SM	Silty SAND: Angular to subrounded, fine to medium grained, non-plastic, grey-brown, sand is of mica / quartz, interbedded with silty clay low to medium plasticity, trace coal fragments.			
WB					17.5				NO CORE: No recovery.			
					24.5							
SPT				N* 12,19,25 N=44	18.0			CI-MH	CLAY and SILT: Medium plasticity, dark brown, trace sand of mica, occasional fragments of charcoal, consistency assessed as hard based on tactile assessment.		H	
					25.0							
WB					18.5				NO CORE: No recovery.			
					25.5							
					19.0							
					26.0							
SPT				N* 19,16,50/130 N=R	19.5			SM	Silty SAND: Angular to subrounded, fine to coarse grained, non-plastic, grey-brown, with coal fragments.		VD	
					26.5							
					20.0							

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

Engineering Log

Borehole No. BH1763-02
Sheet: 6 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB					27.0	20.5			NO CORE: No recovery. Lots of coal fragments recovered from cuttings, driller reported possible beds of coal. *continued*			Leederville Fm *continued*
					27.5	21.0						
SPT				N 14,14,21 N=35 21-21.1 not sampled Ds	28.0	21.5		SM	Silty SAND: Angular to subrounded, fine to coarse grained, non-plastic, grey-brown, with coal fragments.		H	
								CL	CLAY: Medium plasticity, grey, hard.			
WB	M				28.5	22.0			NO CORE: No recovery.			
					29.0	22.5						
SPT				N* 8,16,26 N=42	29.5	23.0			Silty CLAY: Medium plasticity, grey-brown, with thin lenses of fine grained, micaceous sand, consistency assessed as hard based on tactile assessment.		H	
WB					30.0	23.5			NO CORE: No recovery.			
					30.5	24.0						

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

Engineering Log

Borehole No. BH1763-02
Sheet: 7 of 8

Client: MRWA Bussell Highway Duplication
Project No: 60344161.100 - 243.01.1761.EN
Project: Bridge 1761-1763
Logged by: SK
Checked by:
Location: Bussell Hwy near Busselton
Start Date: 4/04/2016
End Date: 4/04/2016

Driller: TB/BR
Hole Diameter: 96mm
Easting: 48462.4m
RL: 6.72m
Drill Rig: Geoprobe 7822DT
Inclination: 90
Northing: 174471.8m
Ver Datum: AHD
Bearing:
Hor. Datum: Local
Surface: Grass

Field Data							Material Description			Soil Condition		Comments
Method	Support	Well Graphic	Ground Water	Field Samples and Tests	Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	SOIL NAME: plasticity/particle characteristics, colour, secondary and other minor components, structure	Moisture Condition	Density / Consistency	Additional Observations (Geological Origin)
WB	M								NO CORE: No recovery. *continued*			Leederville Fm *continued*
						24.5						
SPT				N* 9,12,27 N=39					Silty CLAY: Medium plasticity, grey-brown, with thin lenses of fine grained, micaceous sand, consistency assessed as hard based on tactile assessment.		H	
						25.0			*BH1763-02 terminated at 24.95m.*			
						25.5						
						26.0						
						26.5						
						27.0						
						27.5						
						28.0						

ANZ_BOREHOLE BRIDGE 1761-1763.GPJ 60343330 STADIUM RAIL_CAMFIELDDRV.GPJ aecom2012 MAY 2016 LIBRARY TEMPLATE REV4.GLB 3.5.2016

Engineering Log

Cored Borehole No. BH1763-02

Sheet: of 8

Client:	MRWA Bussell Highway Duplication	**Project No:**	60344161.100 - 243.01.1761.EN
Project:	Bridge 1761-1763	**Logged by:**	SK
Location:	Bussell Hwy near Busselton	**Start Date:**	4/04/2016
		End Date:	4/04/2016

Driller:	TB/BR	**Hole Diameter:**	96mm	**Easting:**	48462.4m
Drill Rig:	Geoprobe 7822DT	**Inclination:**	90	**Northing:**	174471.8m
		Bearing:		**Hor. Datum:**	Local

RL:	6.72m
Ver Datum:	AHD
Surface:	Grass

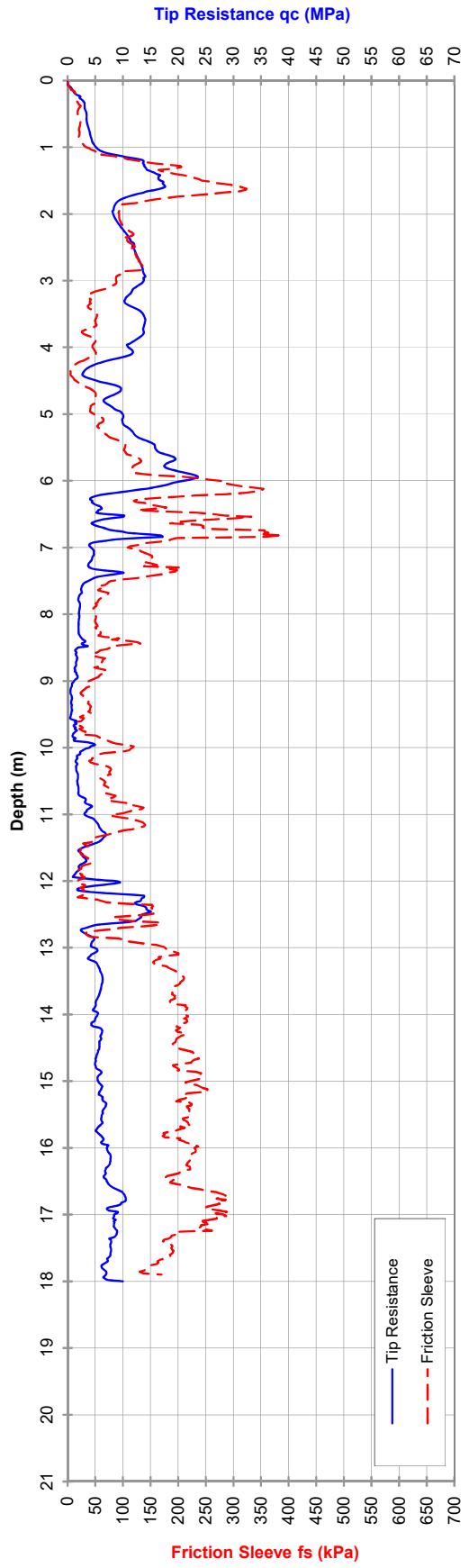
BH1763-02 13.00m - 17.00m

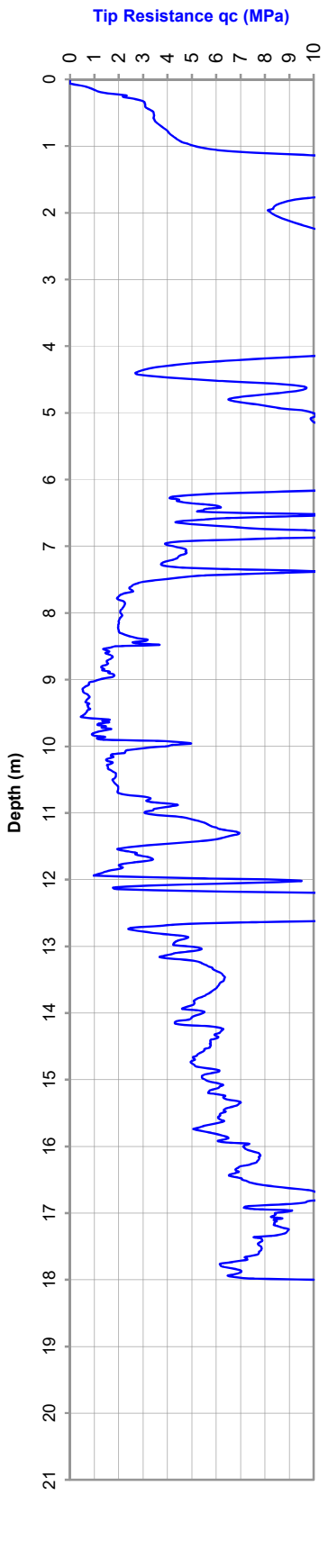
Appendix C

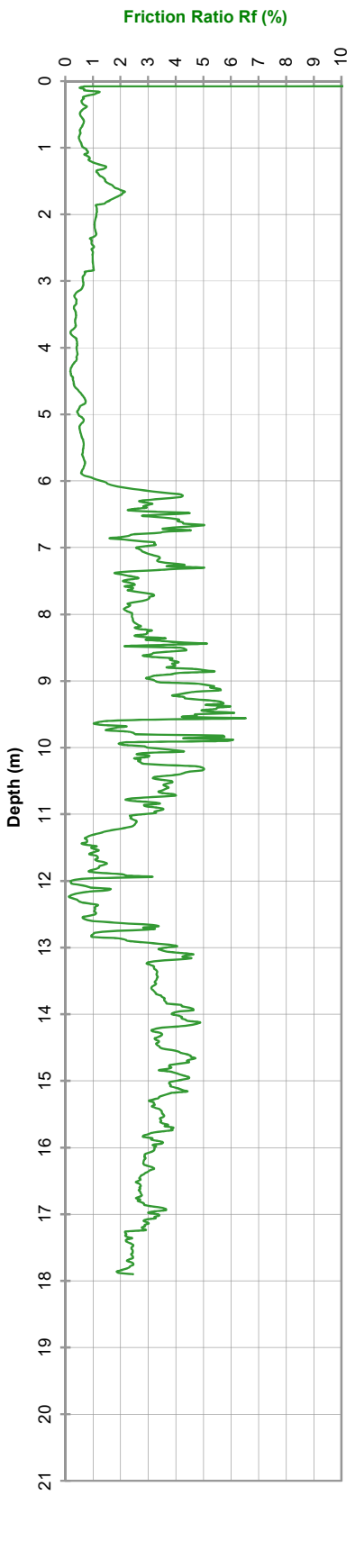
Cone Penetration Tests

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT01U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 3.1

Dummy probe to (m):

Refusal: 10MPa + Rod Friction

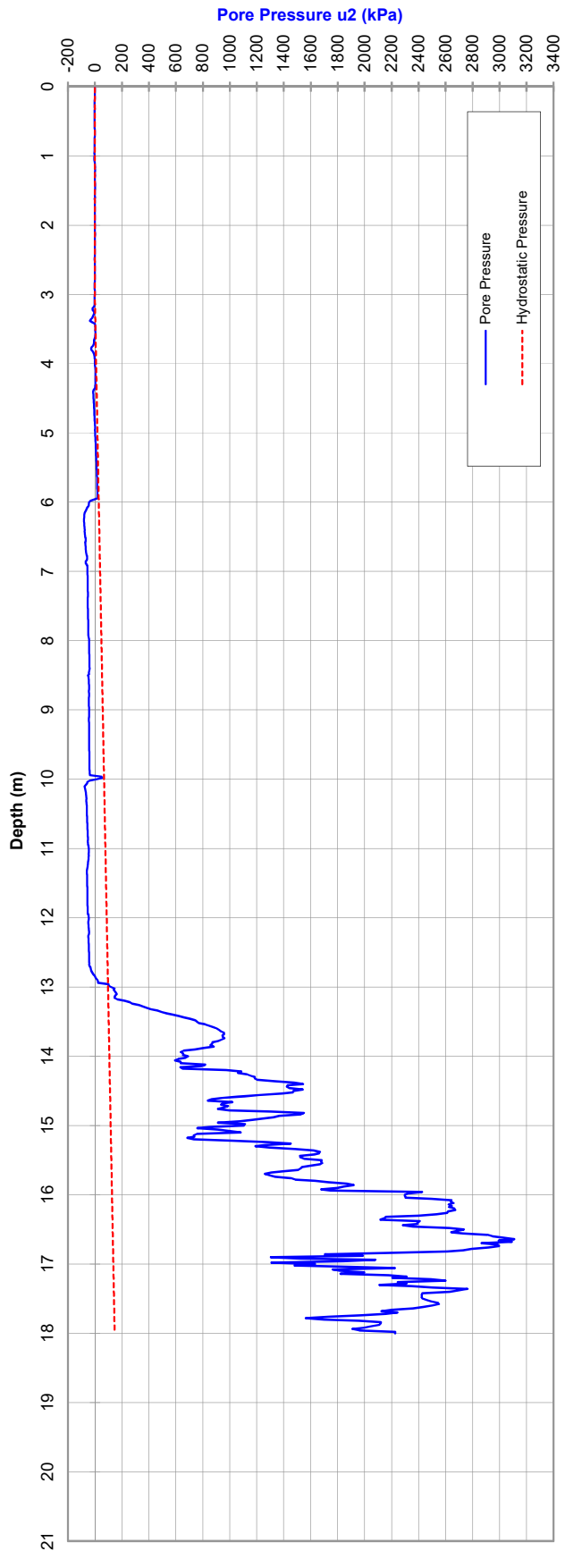
Cone I.D.: EC26

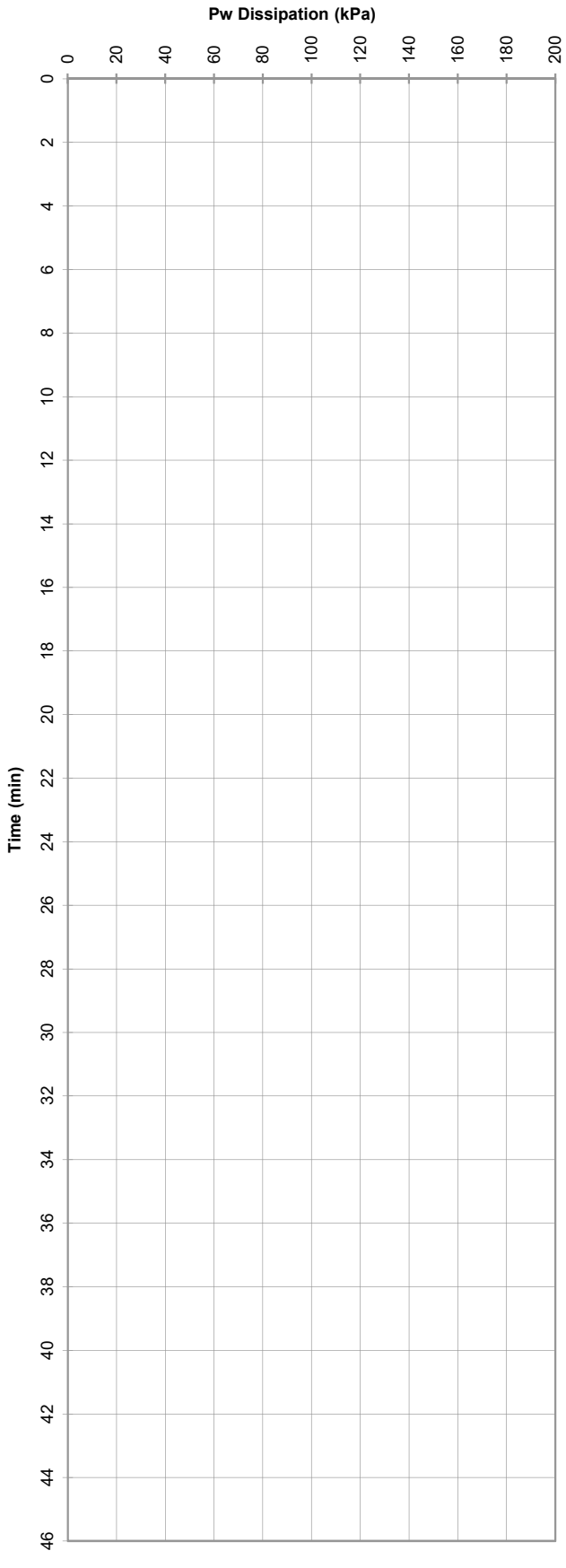
File: HG0336M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT01U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

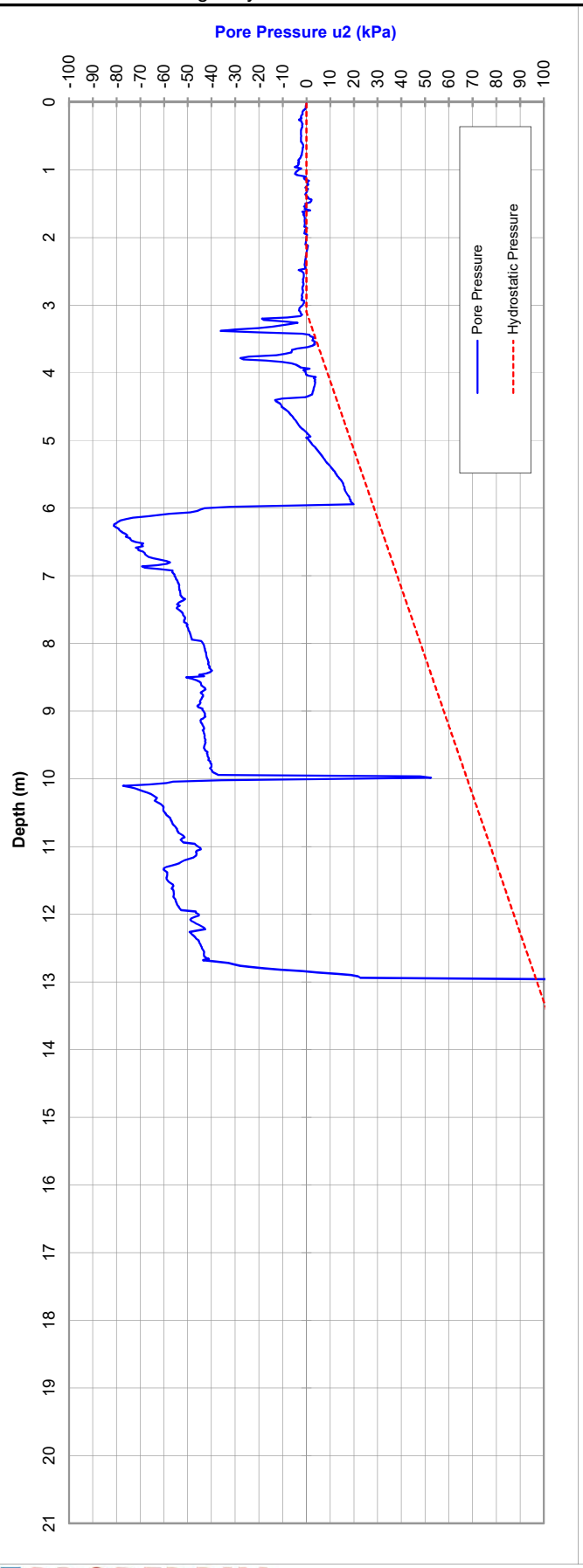
Approx. Water (m): 3.1

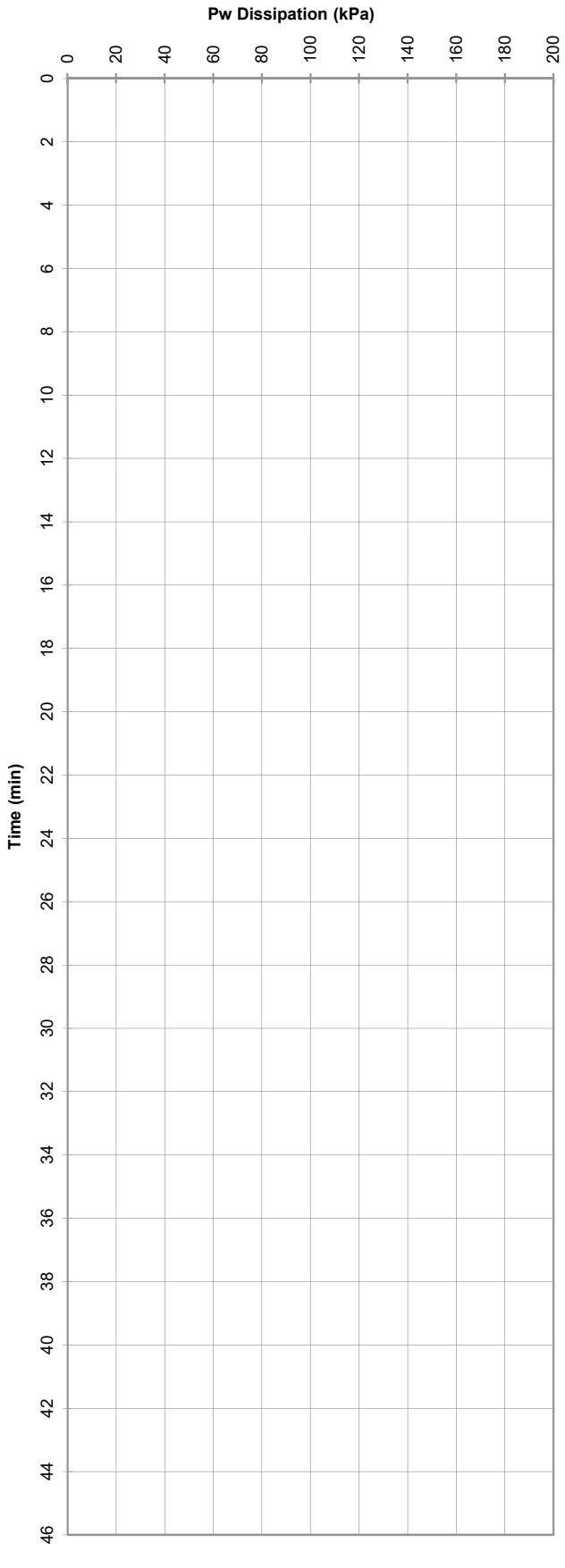
File: HG0336M.txt

Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT01U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

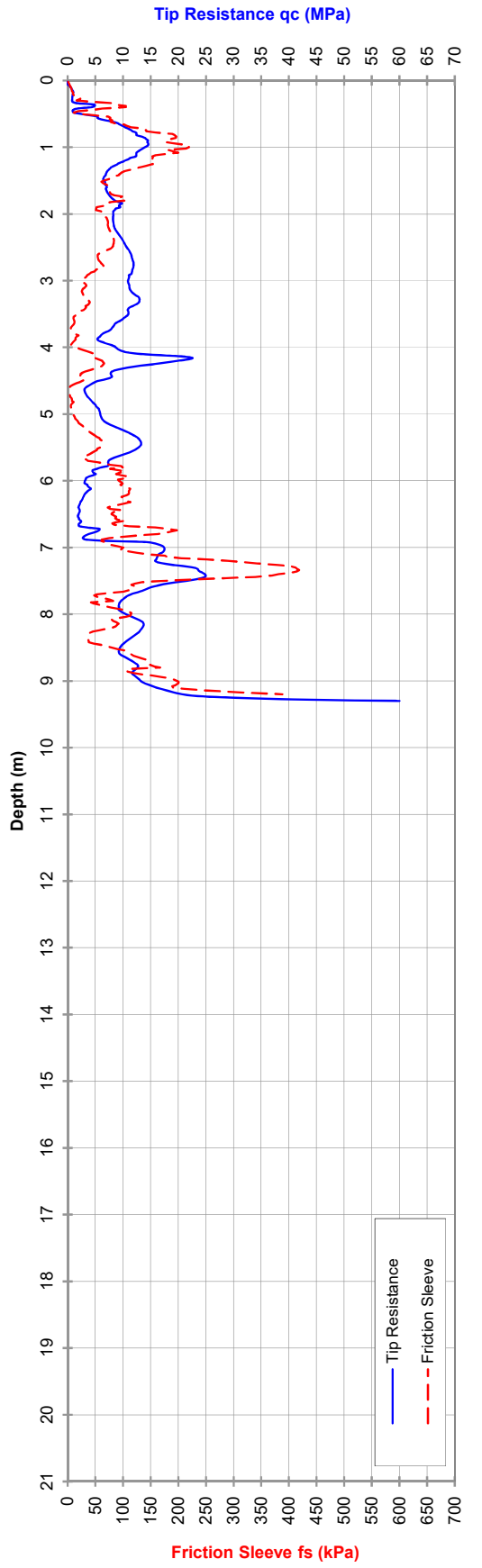
Approx. Water (m): 3.1

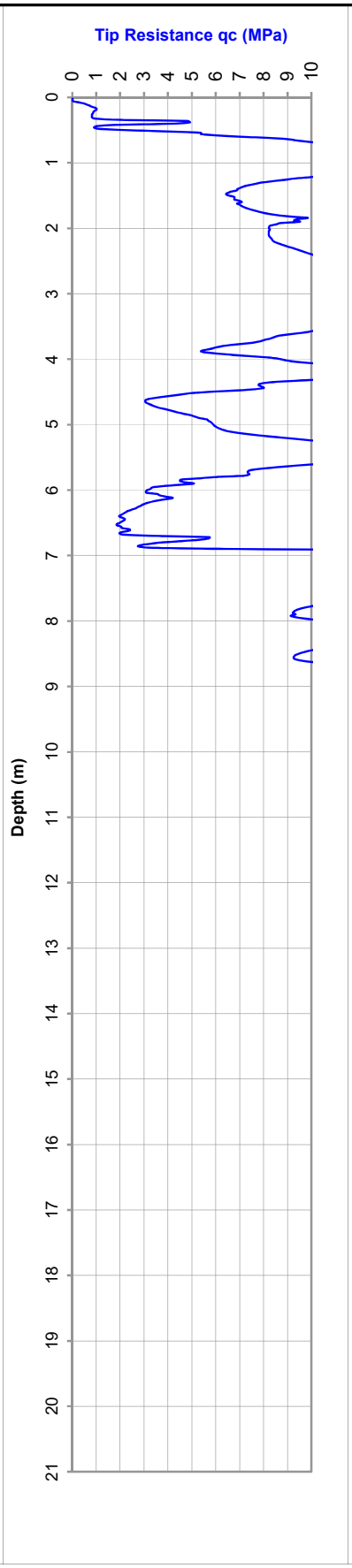
File: HG0336M.txt

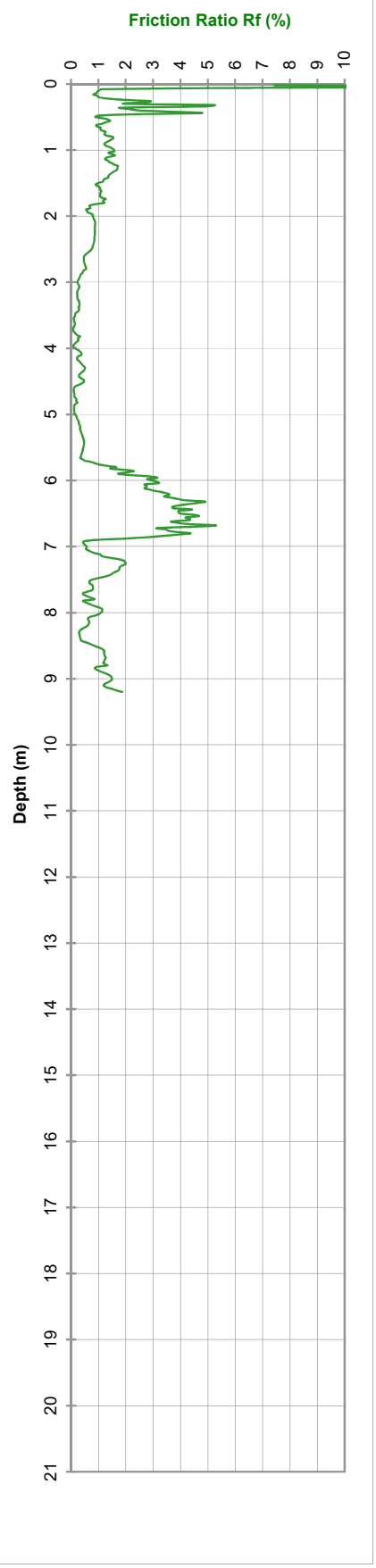
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT02U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 2.8

Dummy probe to (m):

Refusal: 60MPa

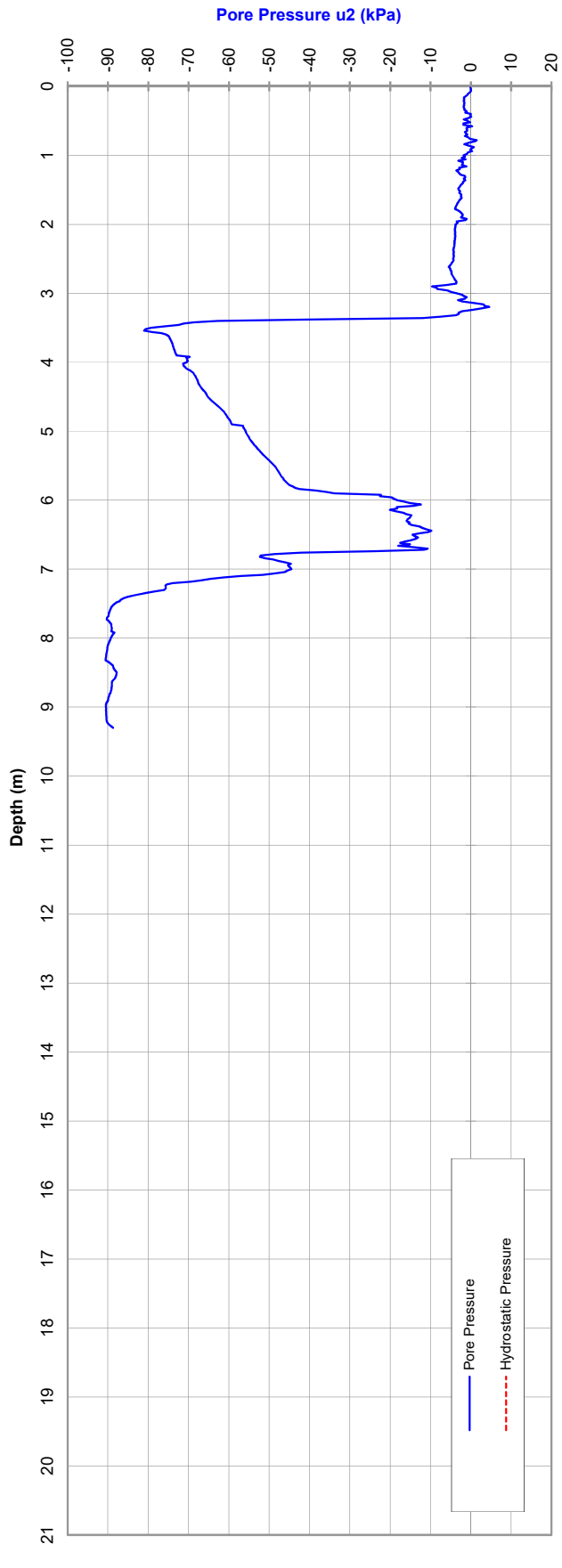
Cone I.D.: EC26

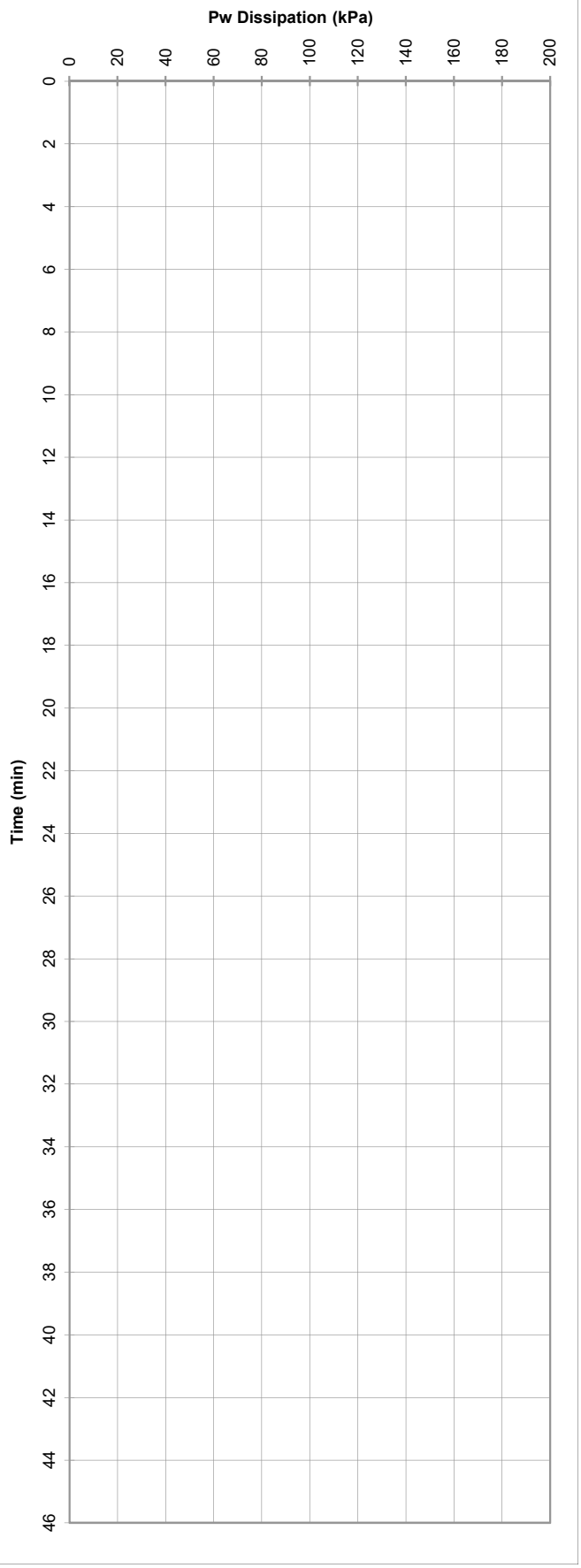
File: HG0337M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT:	GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT02U**
LOCATION:	Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

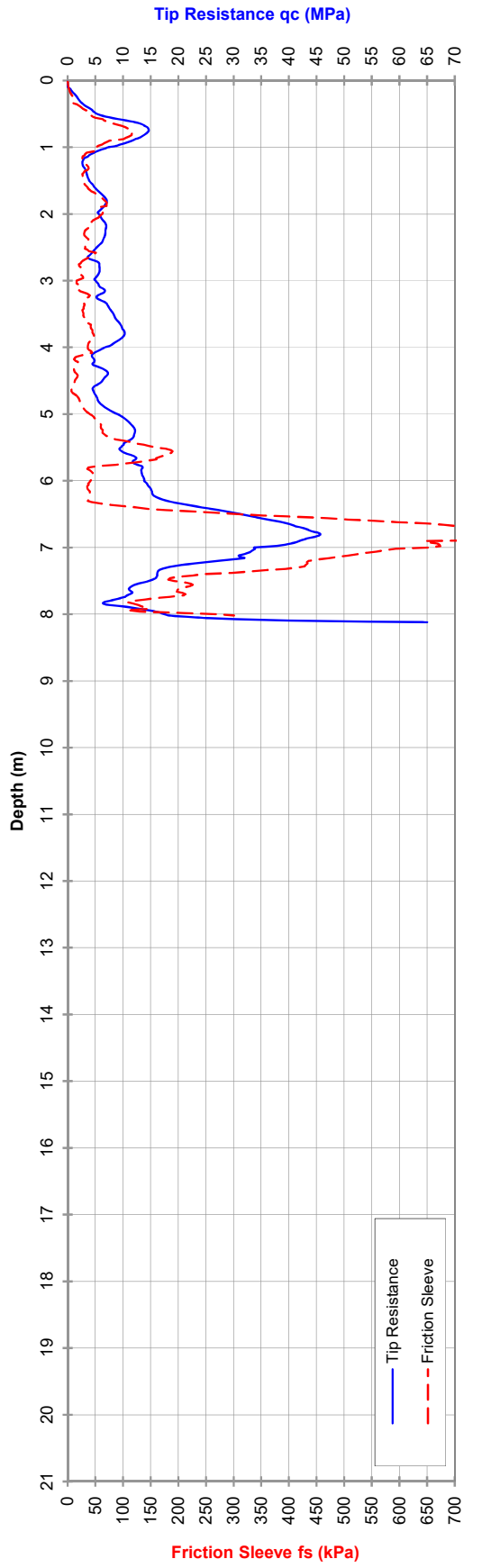
Approx. Water (m): Dry to 2.8

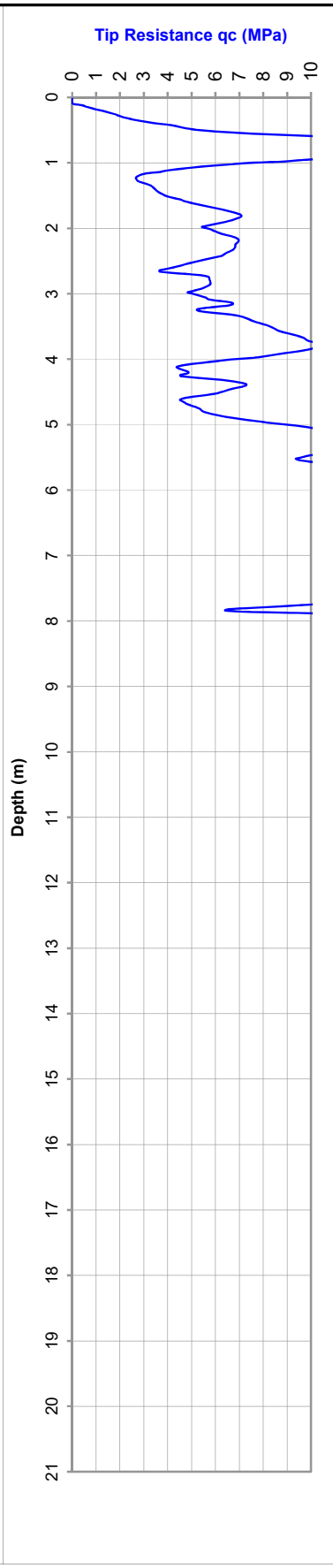
File: HG0337M.txt

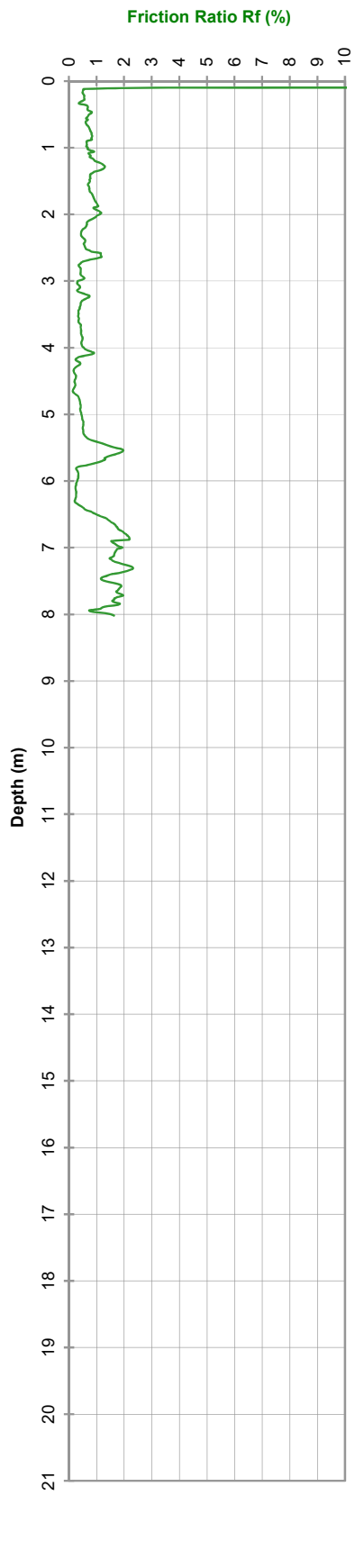
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT03U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.5

Dummy probe to (m):

Refusal: 65MPa

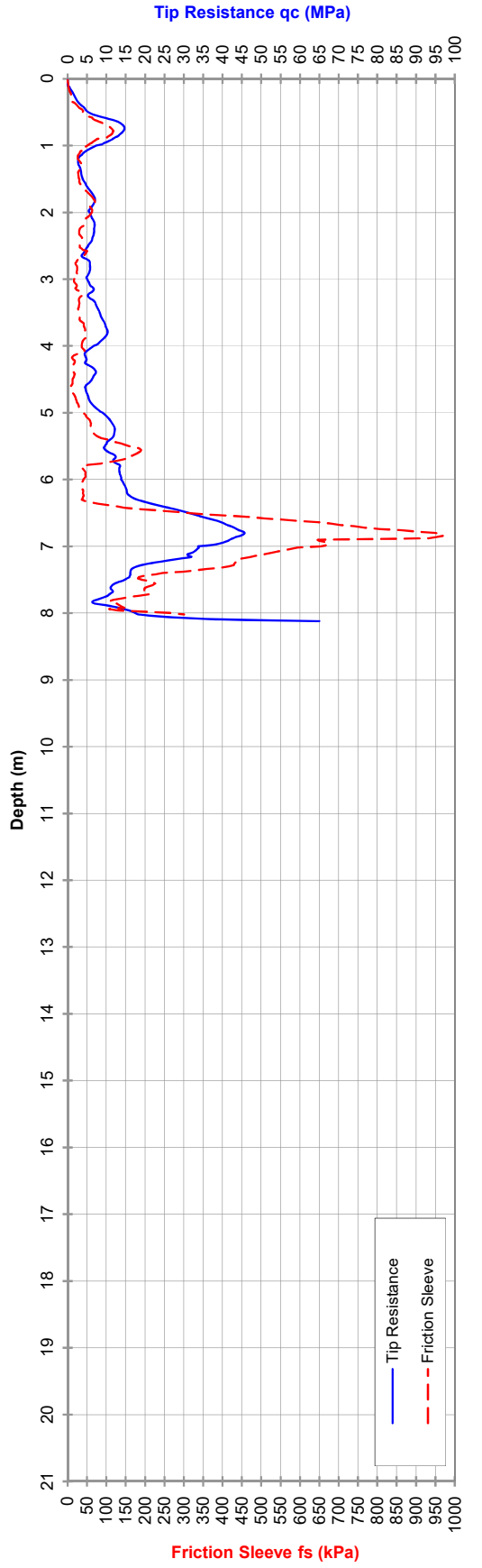
Cone I.D.: EC26

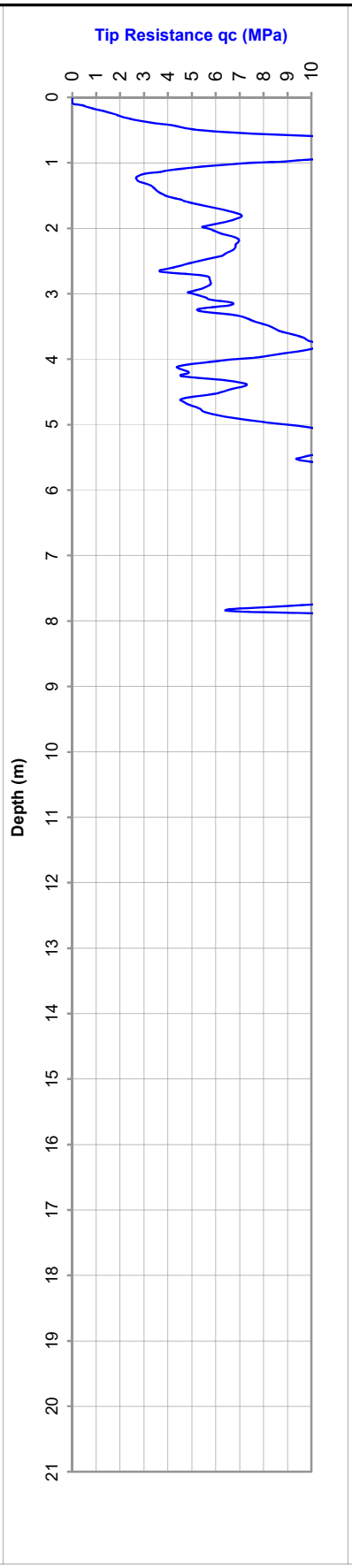
File: HG0338M

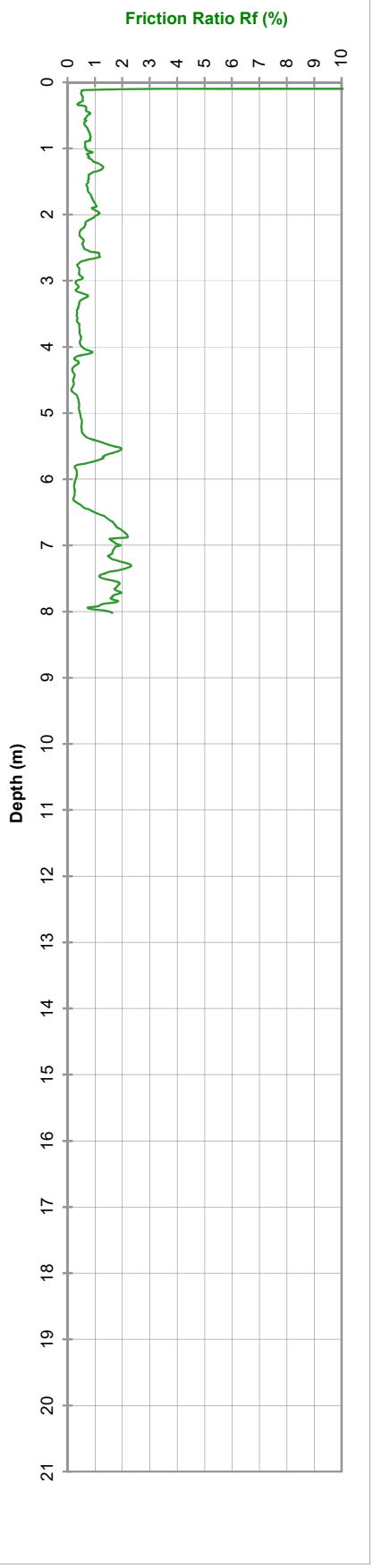
Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT03U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.5

Dummy probe to (m):

Refusal: 65MPa

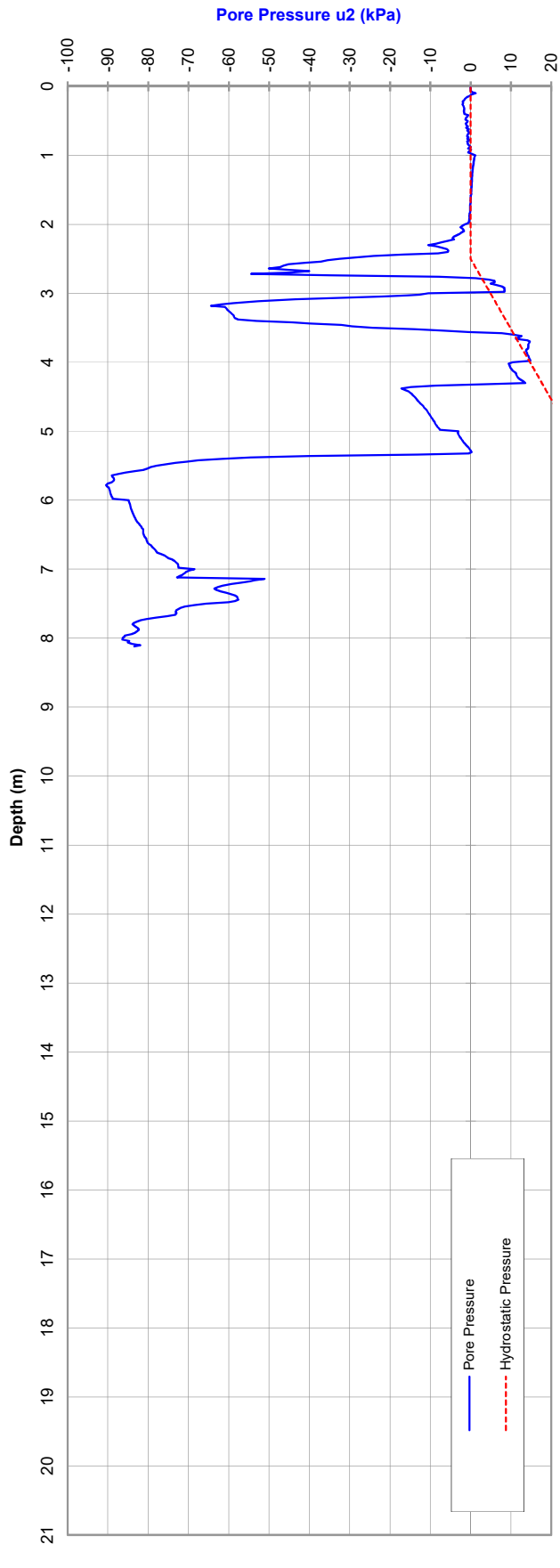
Cone I.D.: EC26

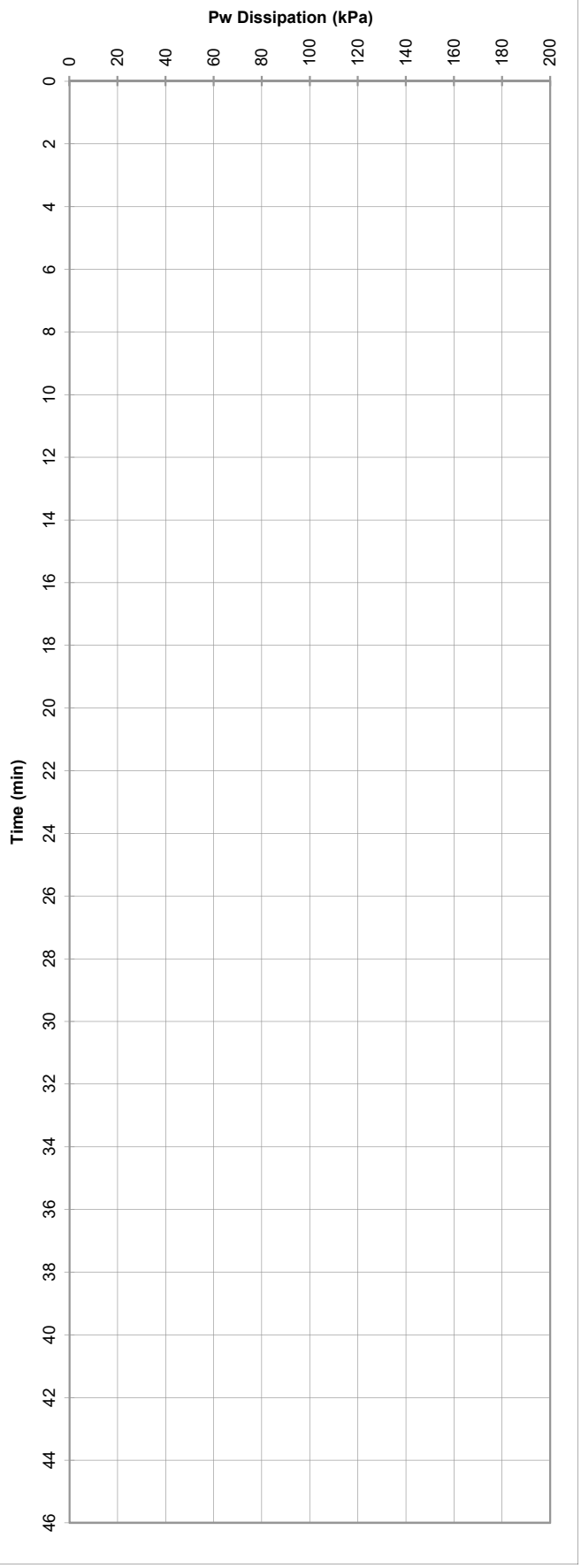
File: HG0338M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT:	GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT03U**
LOCATION:	Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

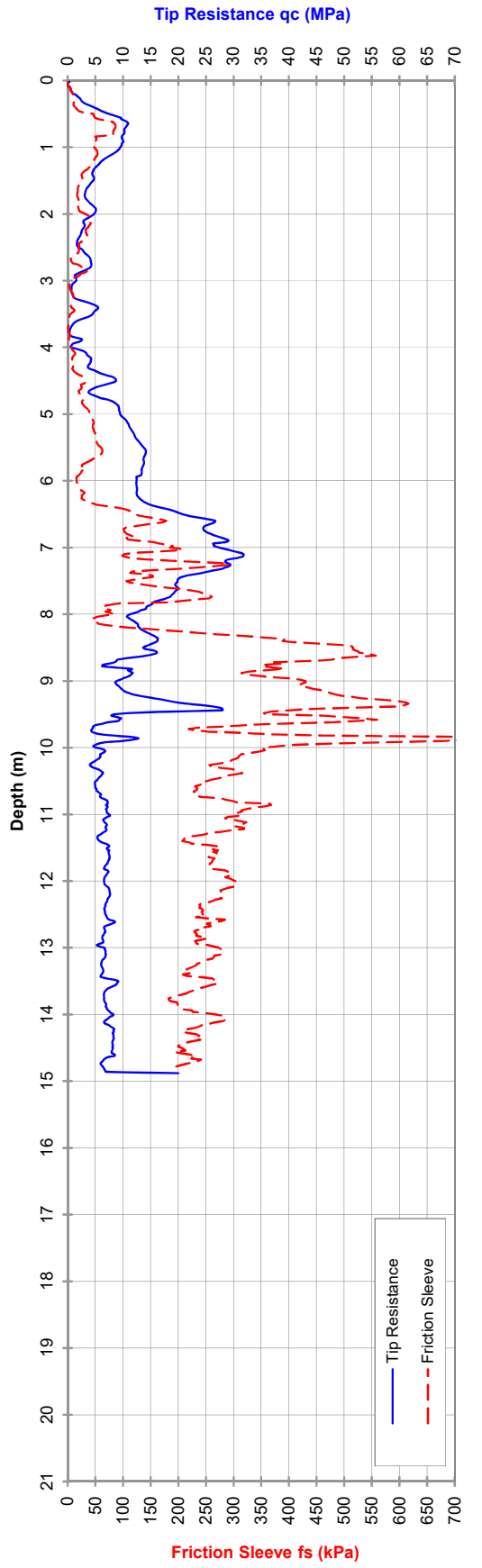
Approx. Water (m): 2.5

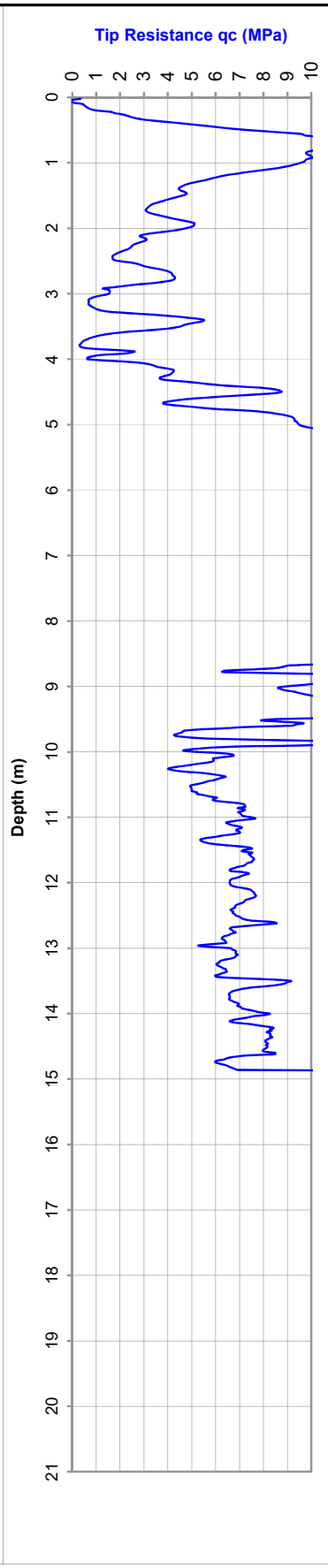
File: HG0338M.txt

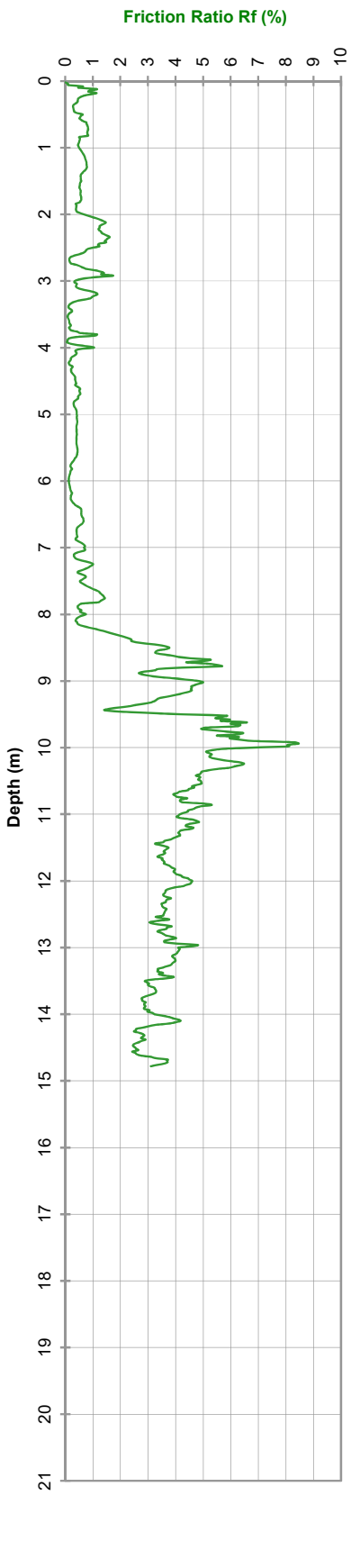
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT04U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.7

Dummy probe to (m):

Refusal: 20MPa + Rod Friction

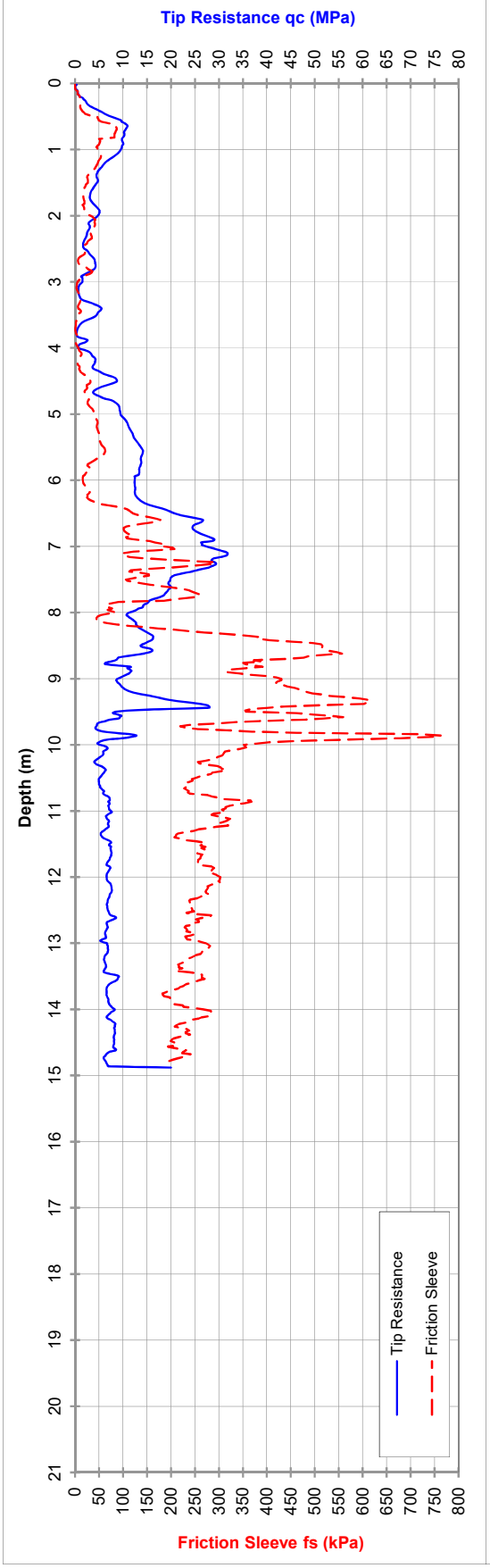
Cone I.D.: EC26

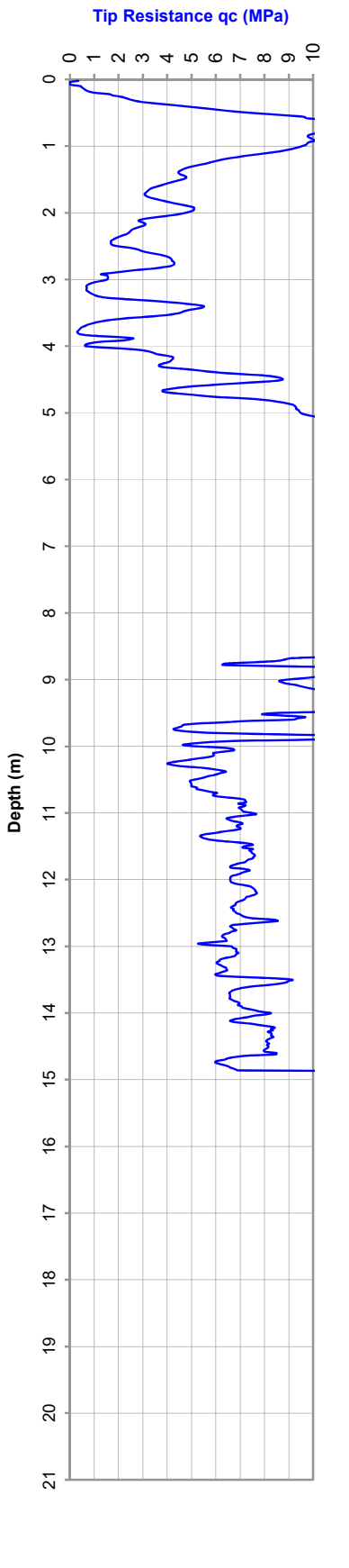
File: HG0339M

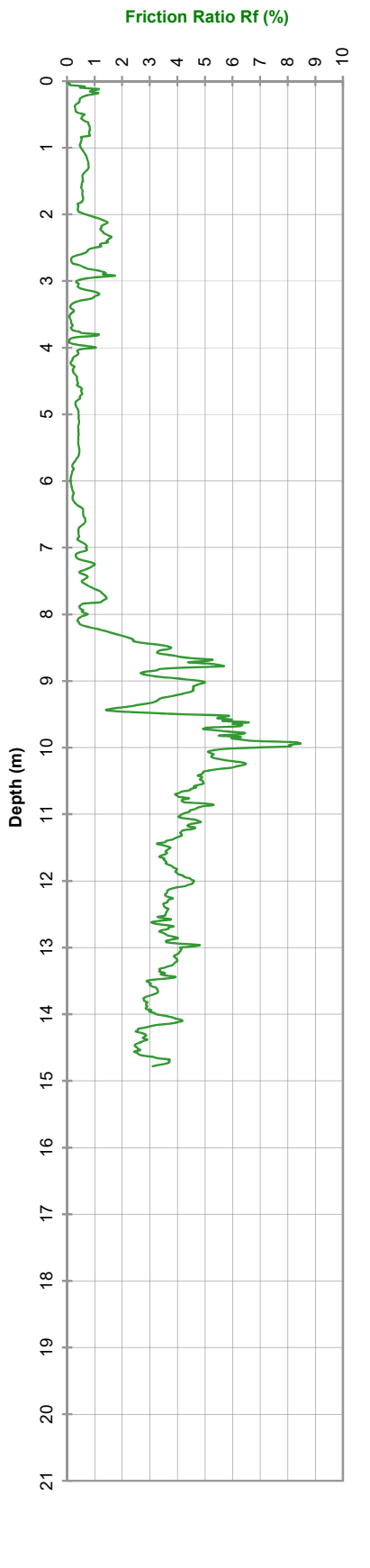
Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT04U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.7

Dummy probe to (m):

Refusal: 20MPa + Rod Friction

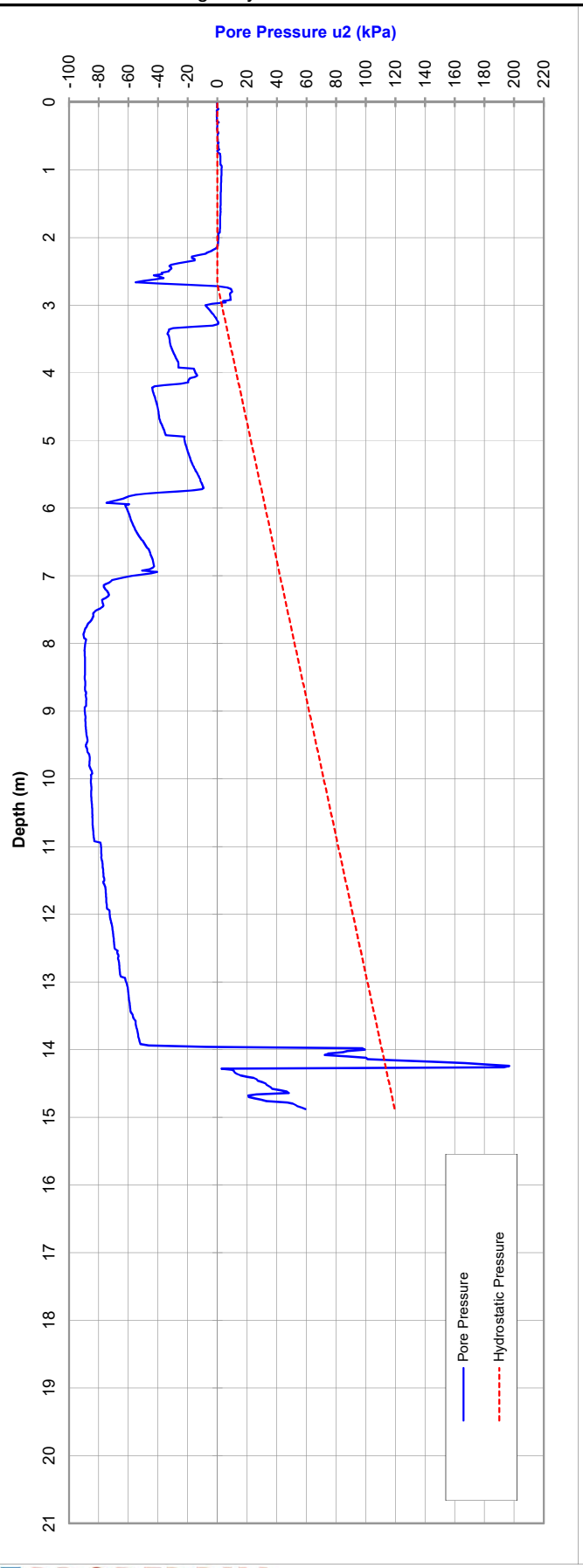
Cone I.D.: EC26

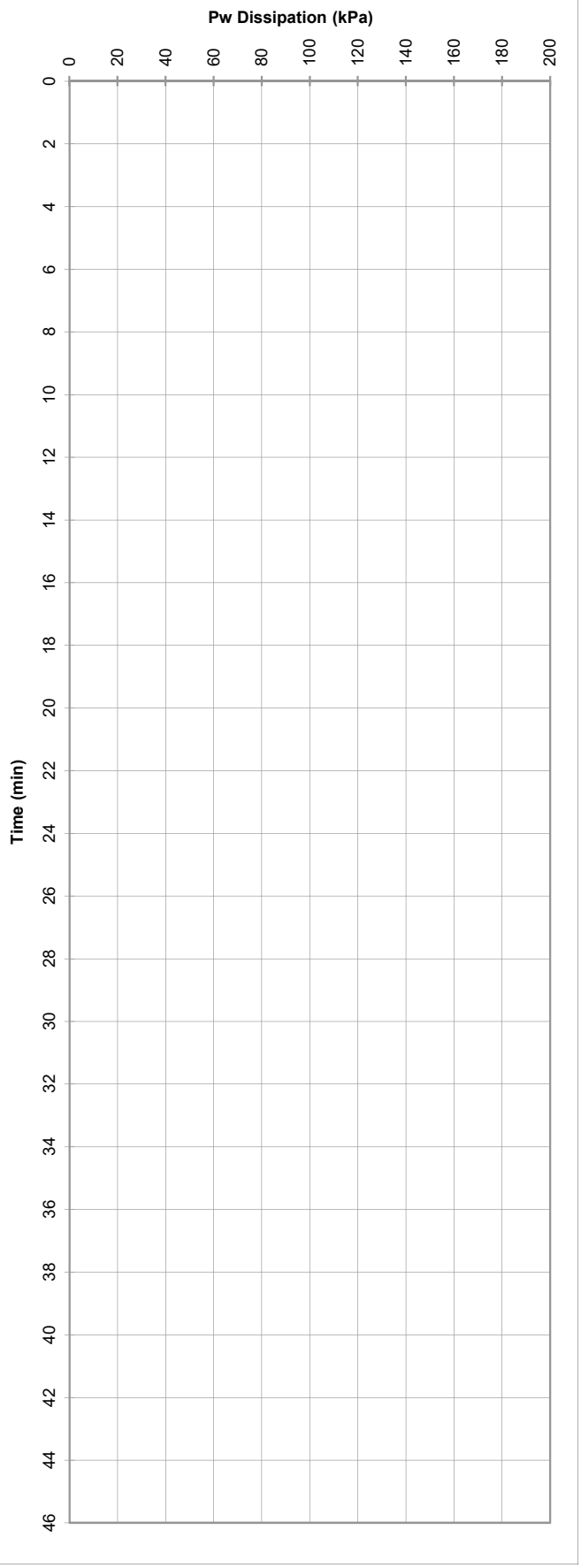
File: HG0339M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT04U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

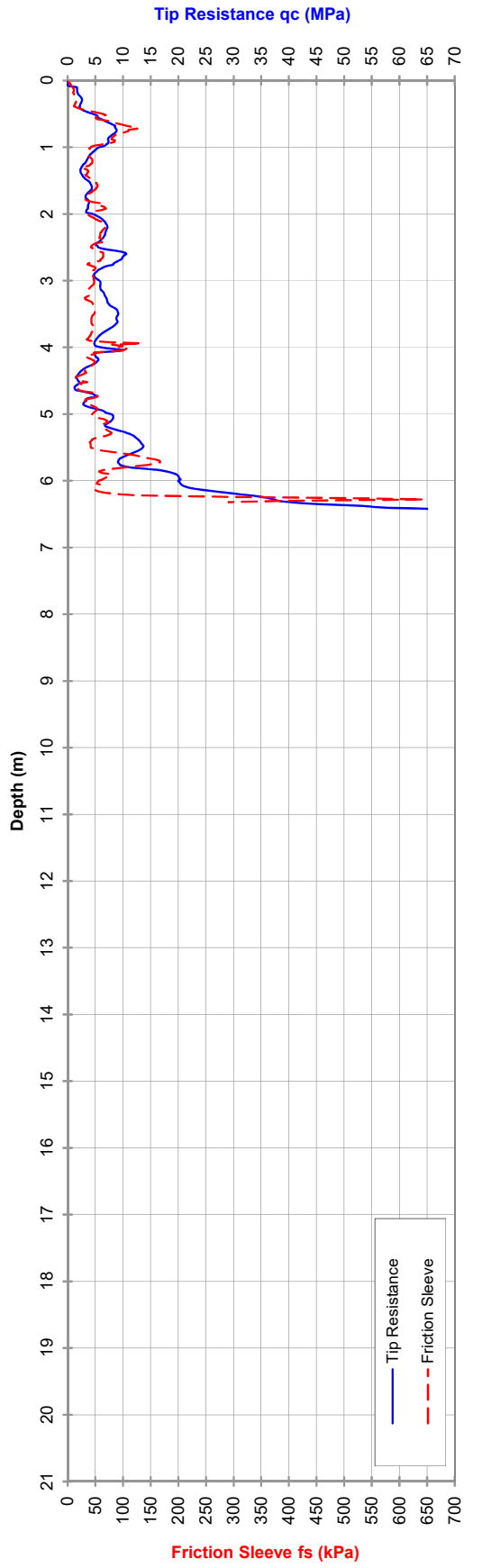
Approx. Water (m): 2.7

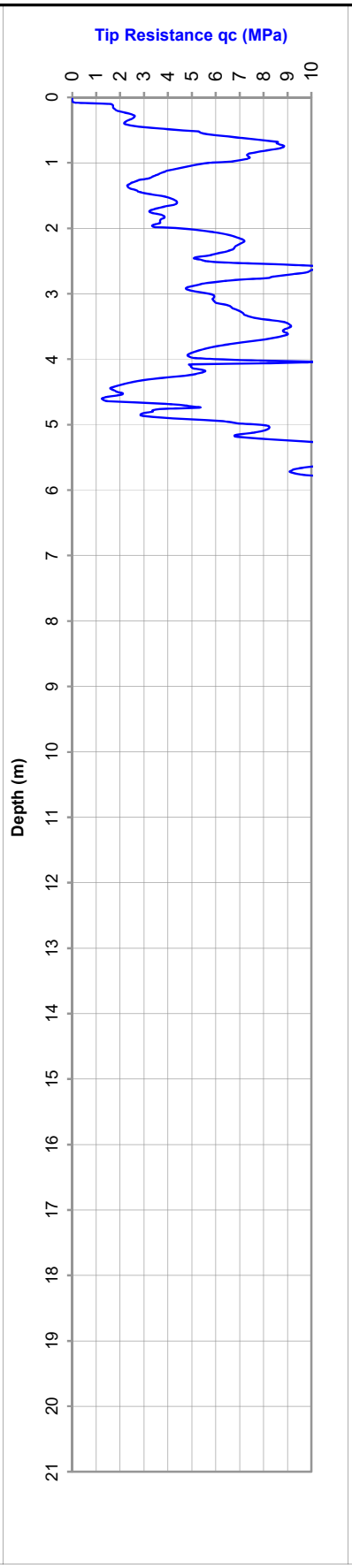
File: HG0339M.txt

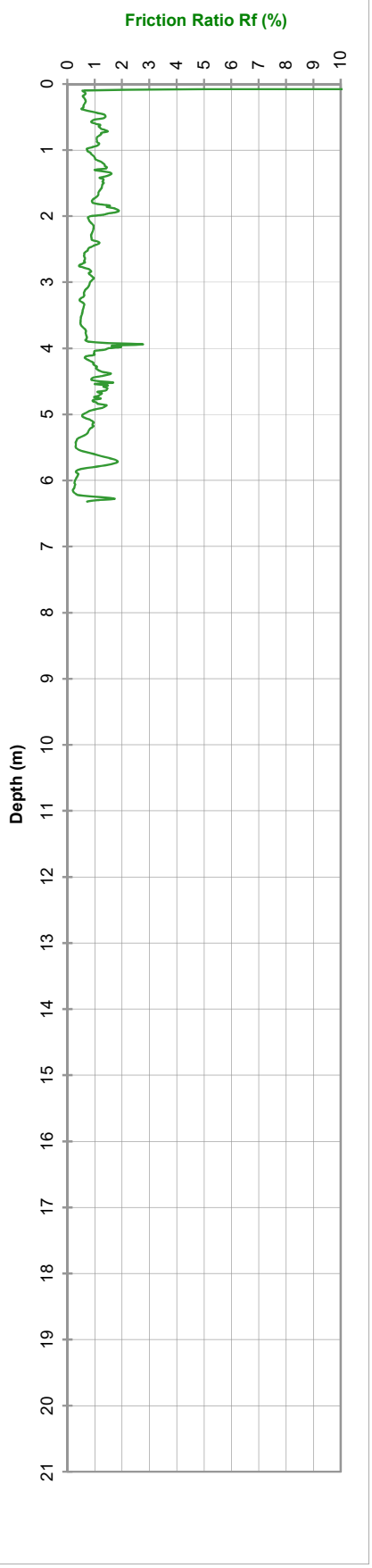
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.6

Dummy probe to (m):

Refusal: 65MPa

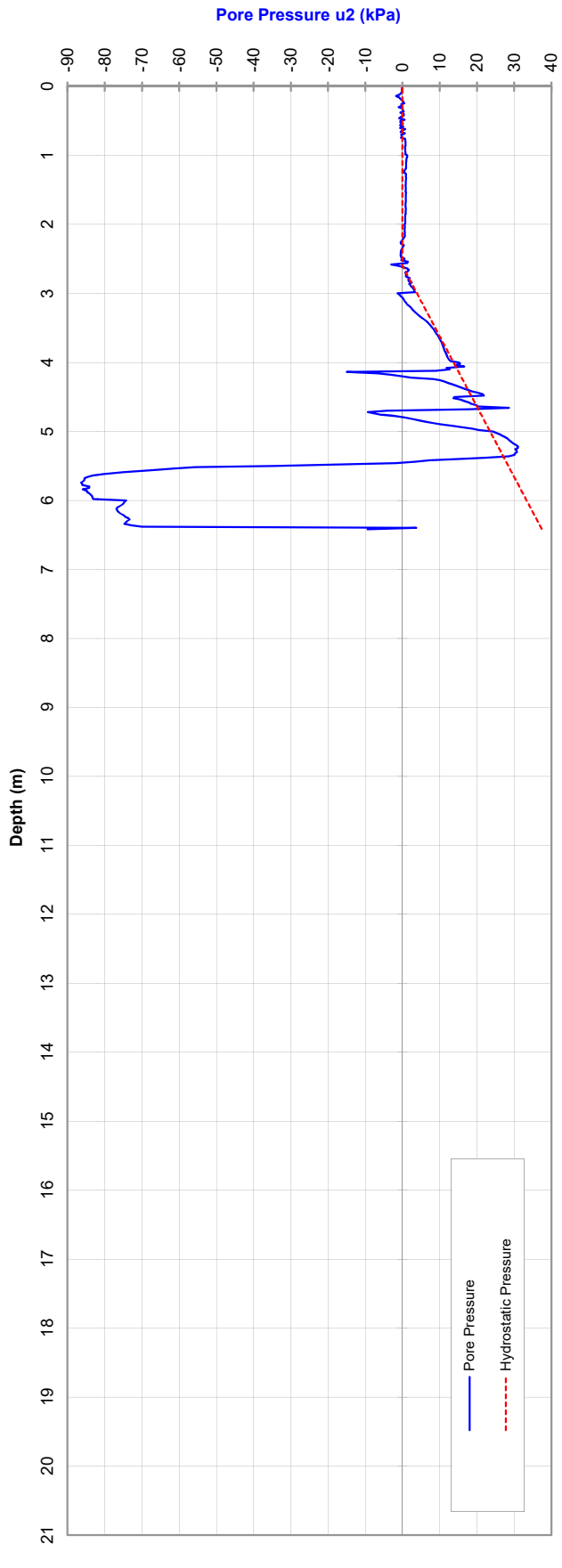
Cone I.D.: EC26

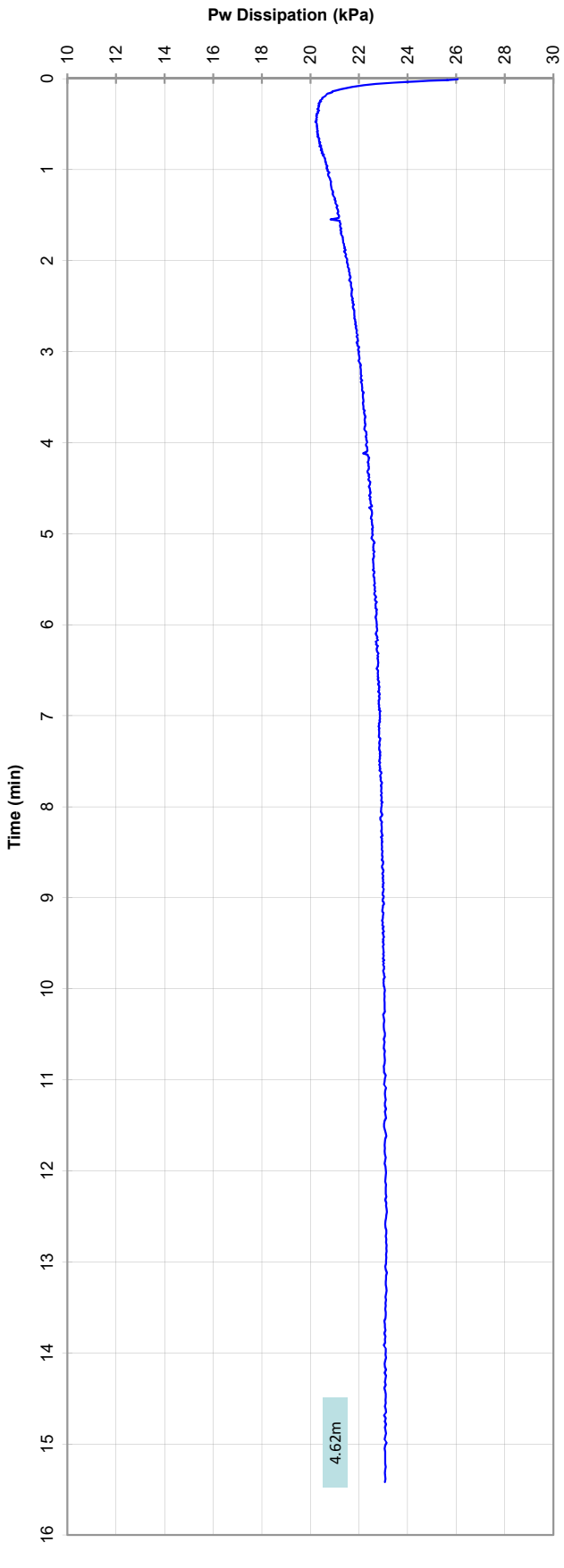
File: HG0340M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT:	GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05U**
LOCATION:	Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

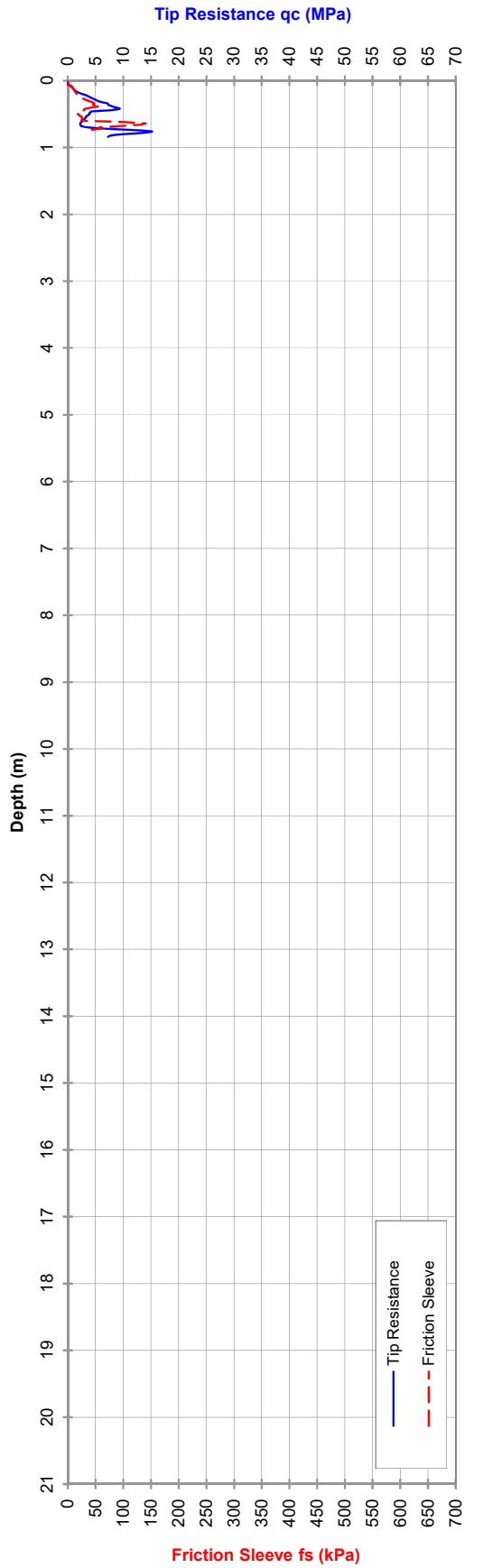
Approx. Water (m): 2.6

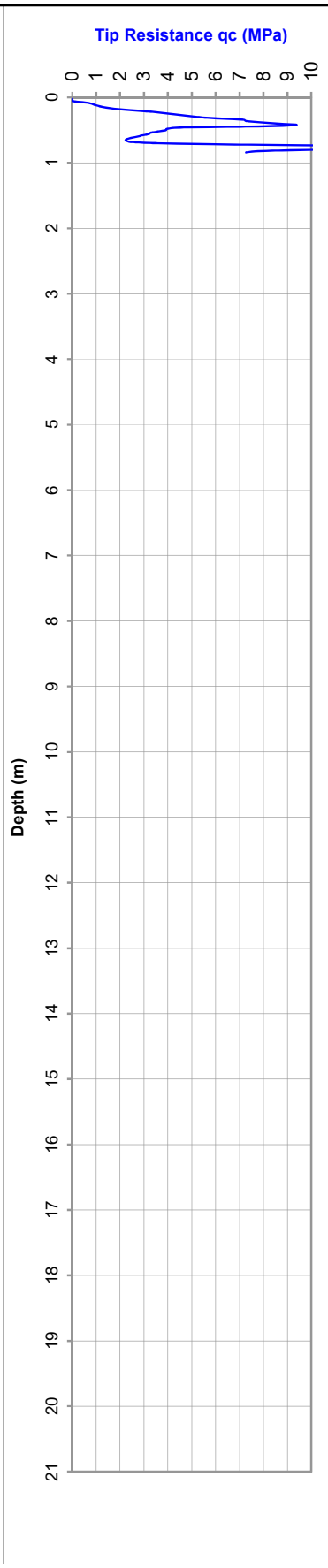
File: HG0340M.txt

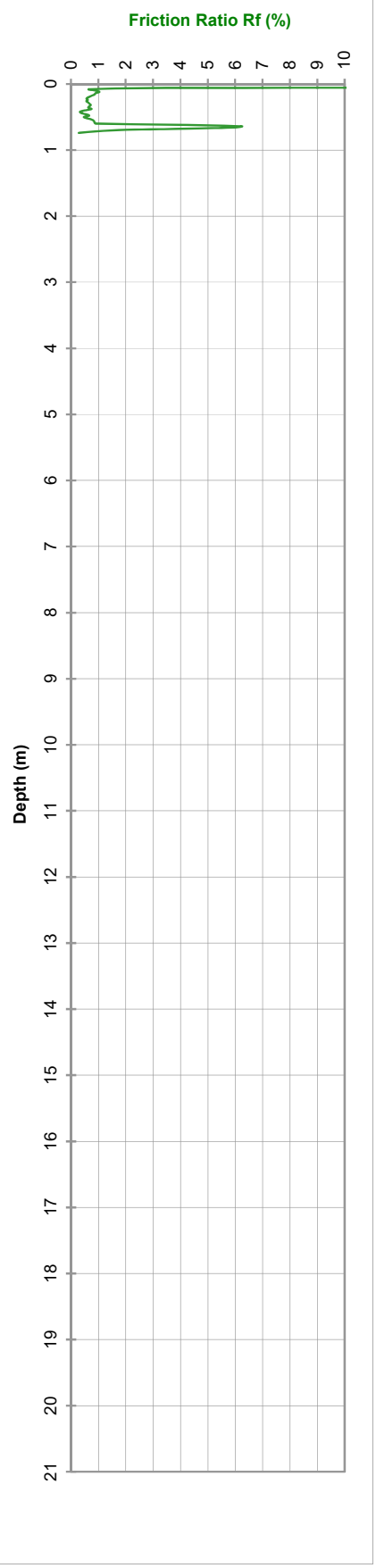
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05UA**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): -

Dummy probe to (m):

Refusal: Inclination

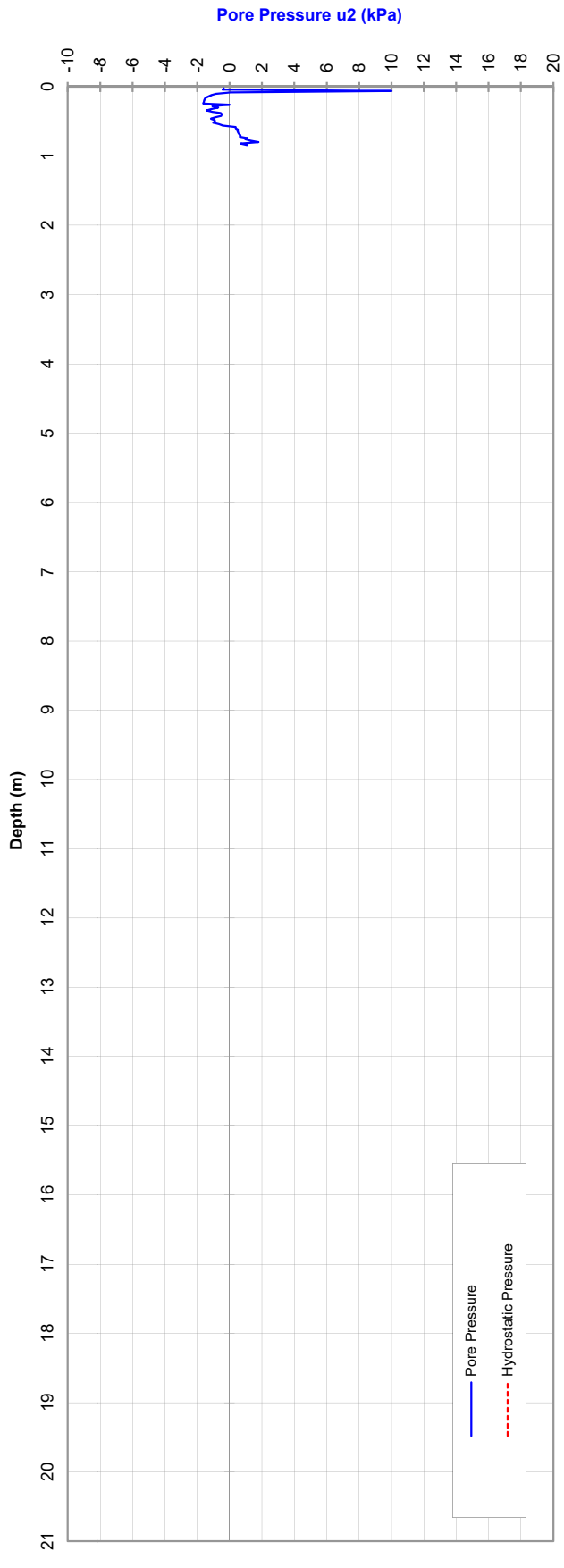
Cone I.D.: EC26

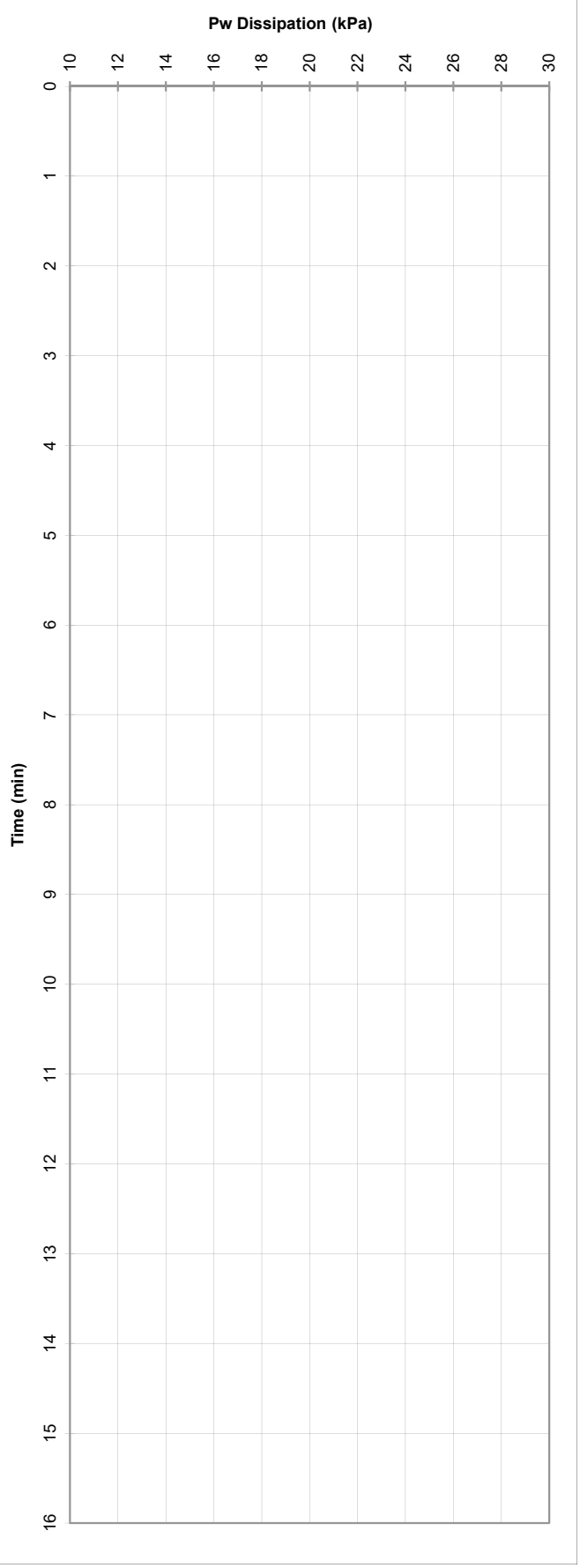
File: HG0341M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05UA**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

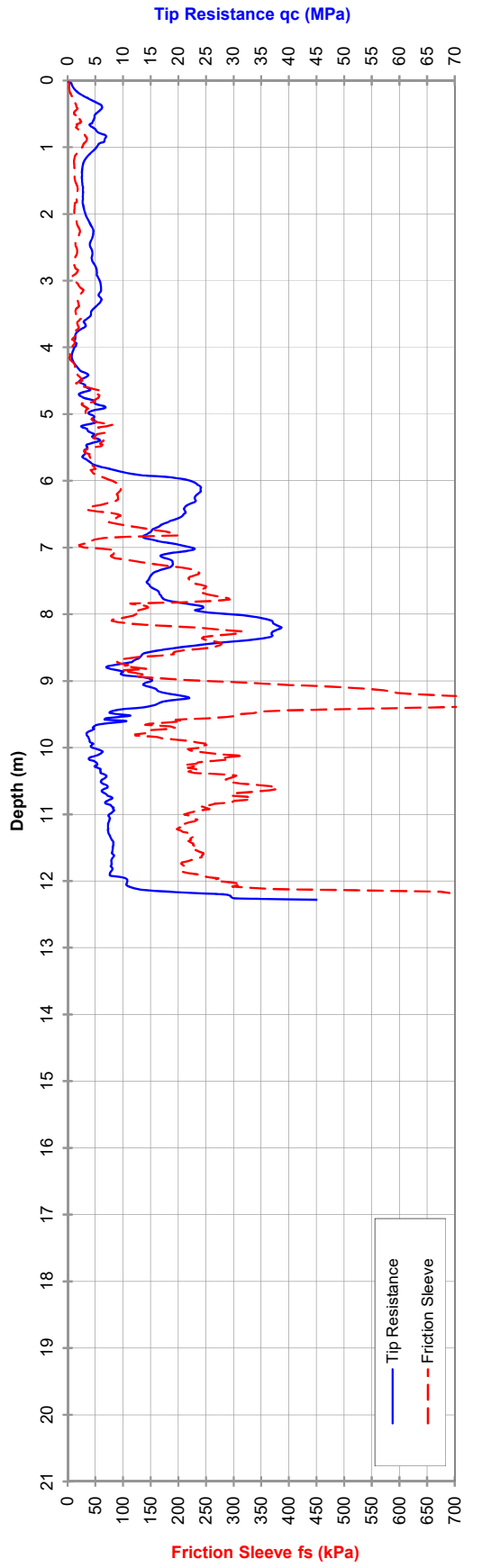
Approx. Water (m):

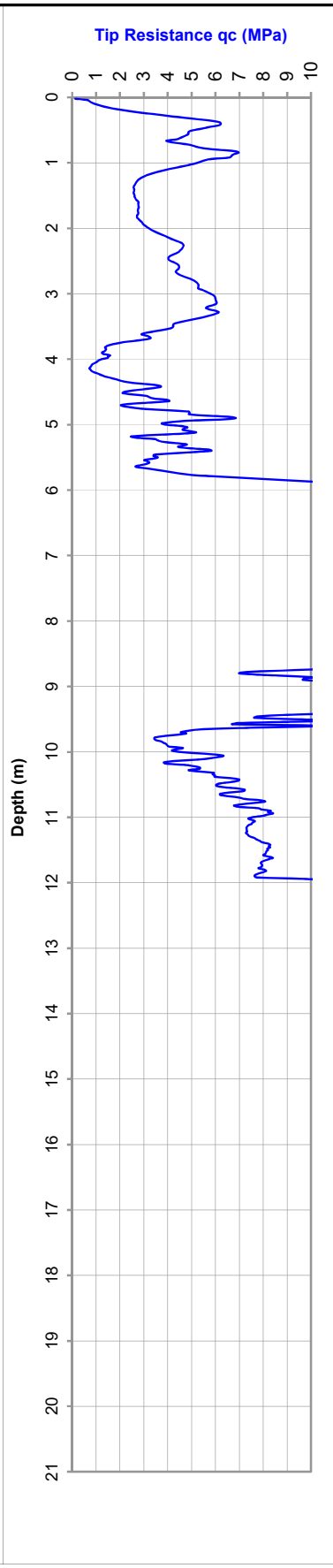
File: HG0341M.txt

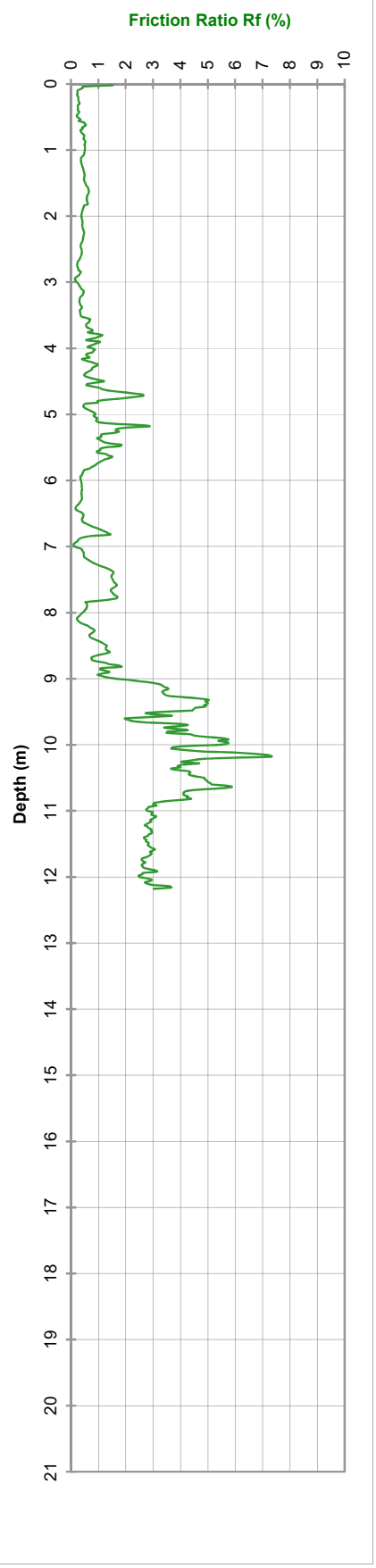
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05UB**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.7

Dummy probe to (m):

Refusal: 45MPa

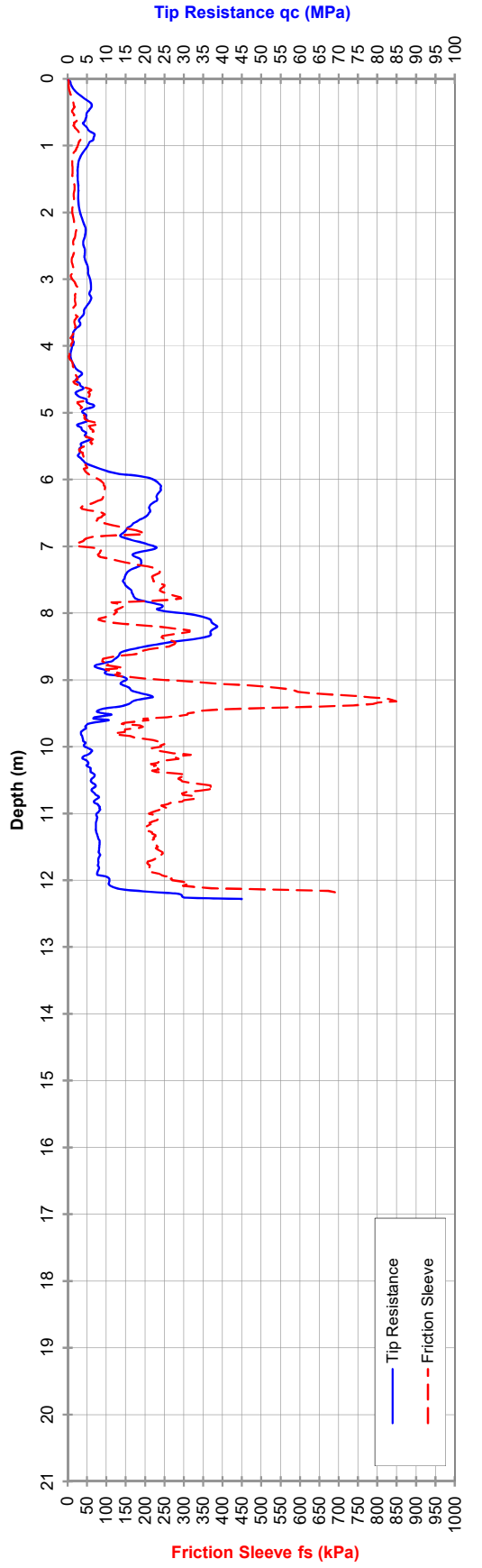
Cone I.D.: EC26

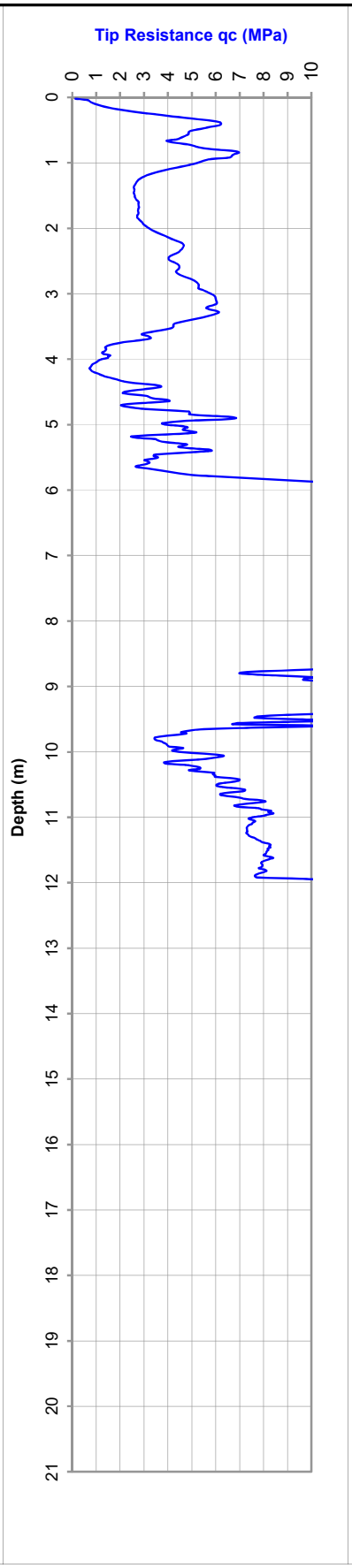
File: HG0342M

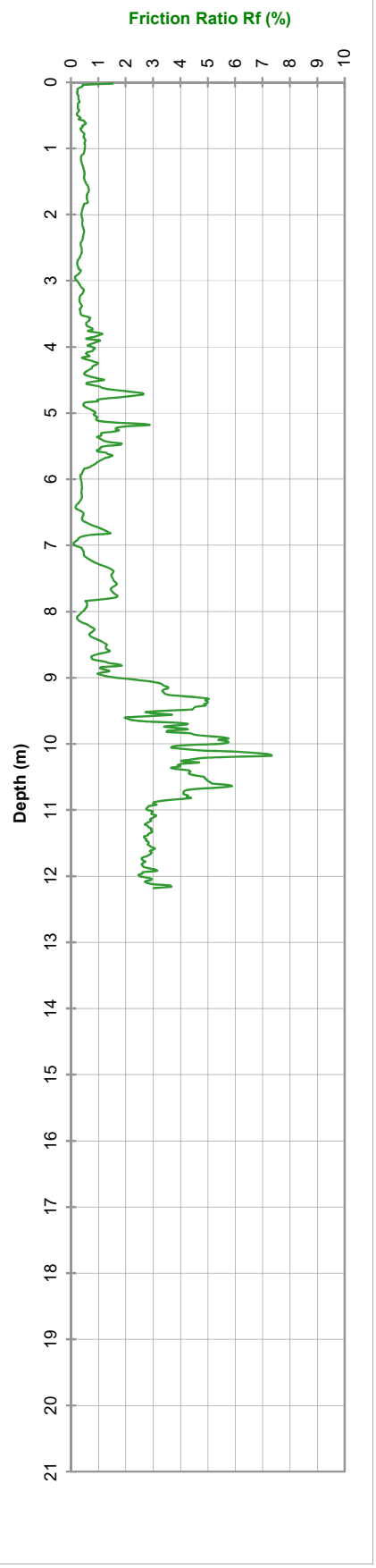
Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05UB**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 2.7

Dummy probe to (m):

Refusal: 45MPa

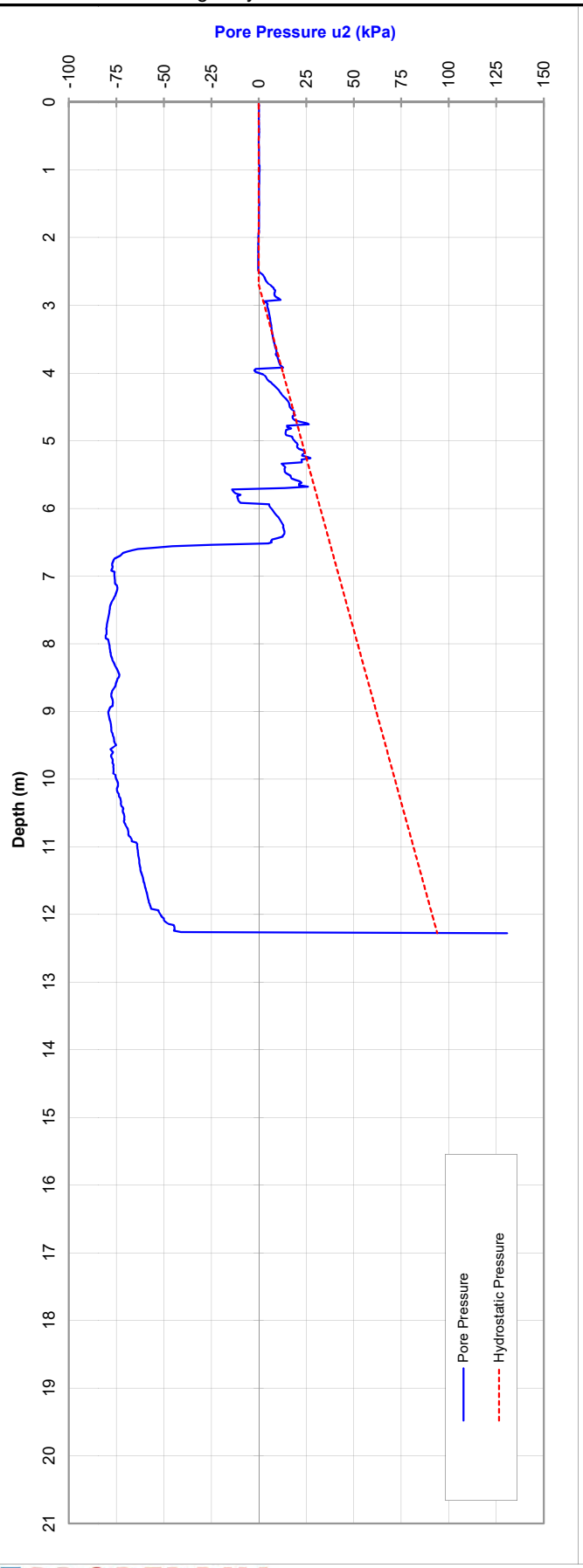
Cone I.D.: EC26

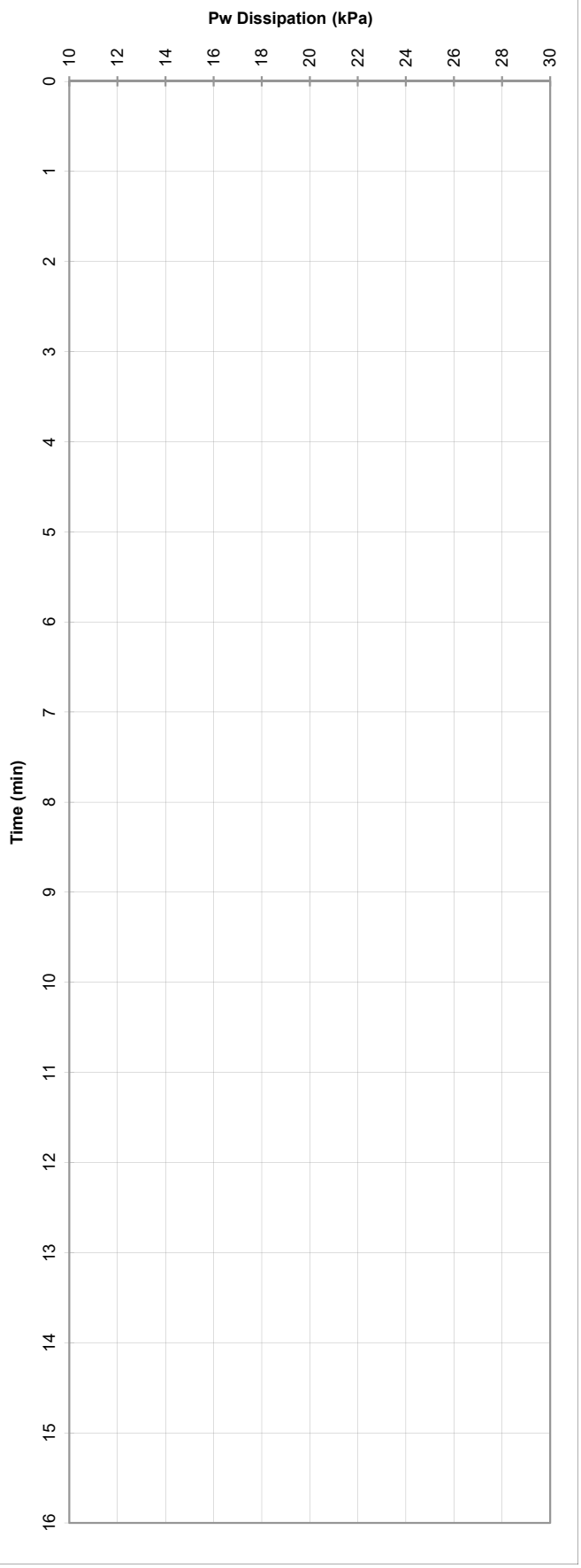
File: HG0342M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT:	GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT05UB**
LOCATION:	Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

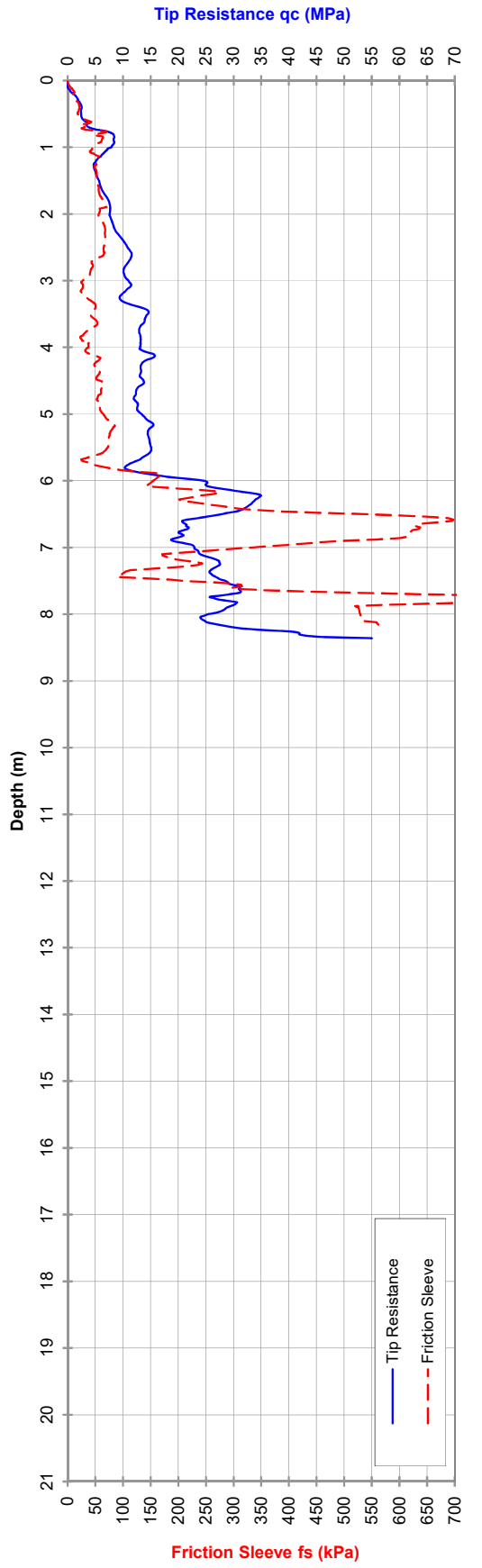
Approx. Water (m): 2.7

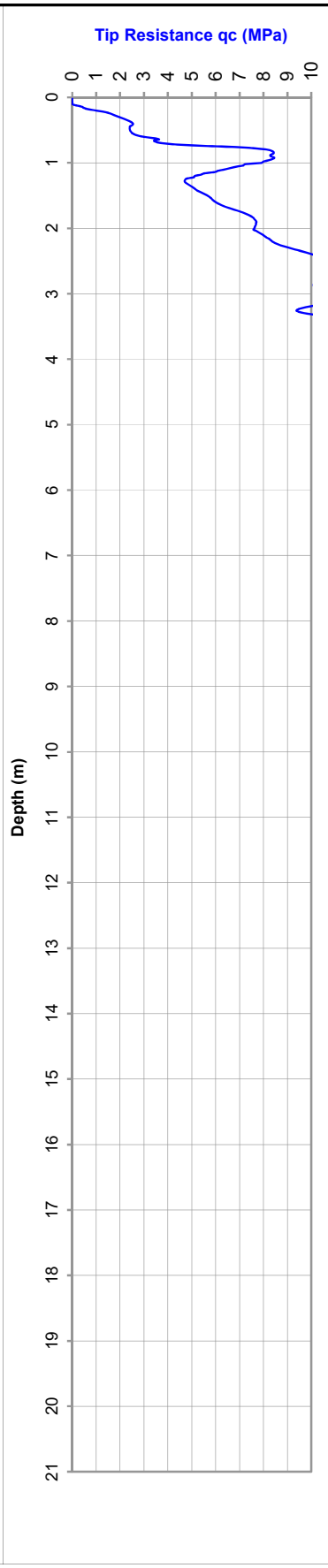
File: HG0342M.txt

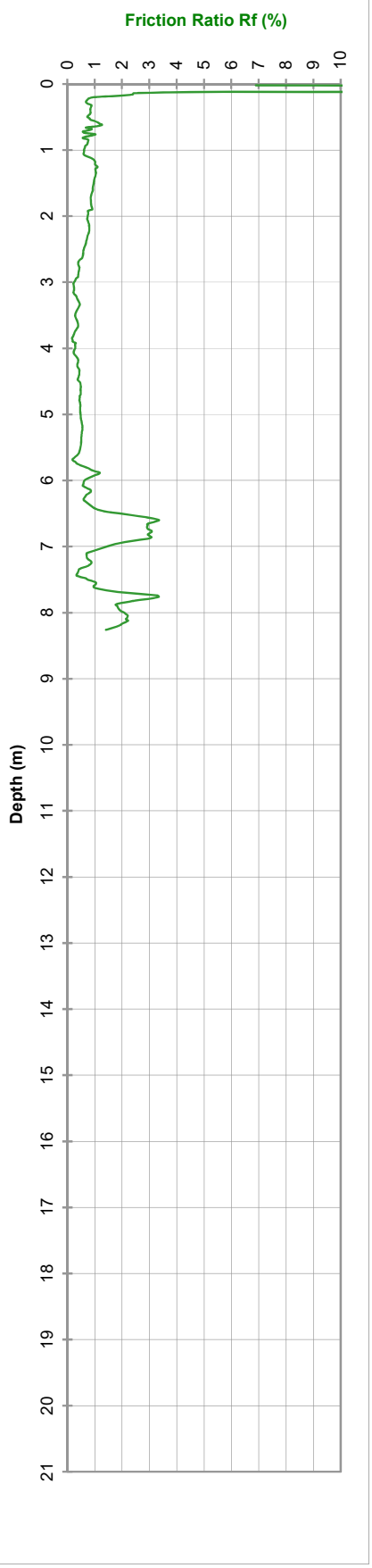
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT06U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 2.8

Dummy probe to (m):

Refusal: 55MPa

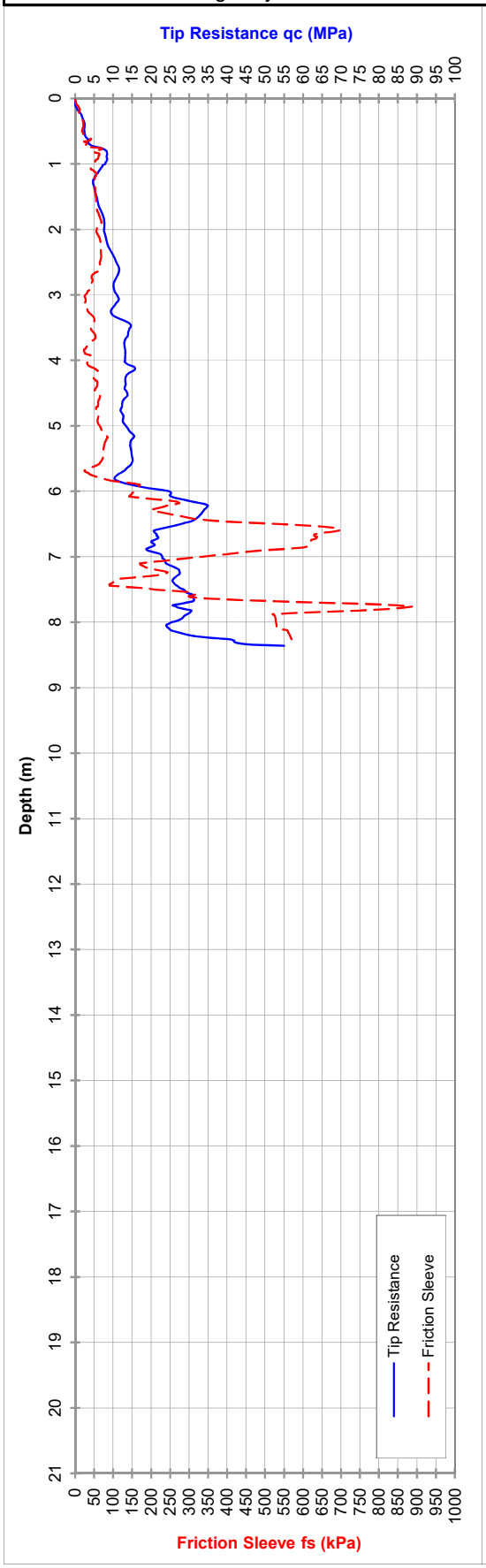
Cone I.D.: EC26

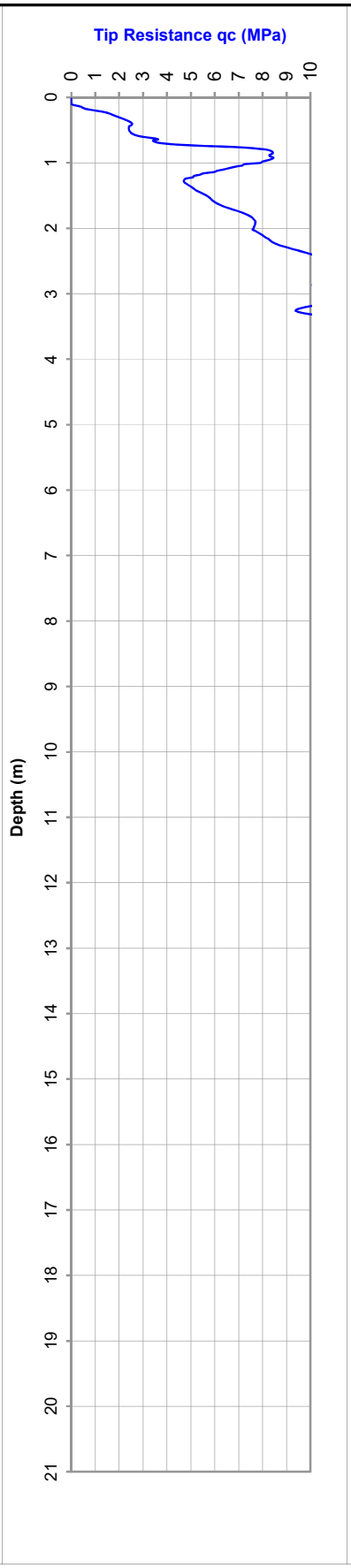
File: HG0343M

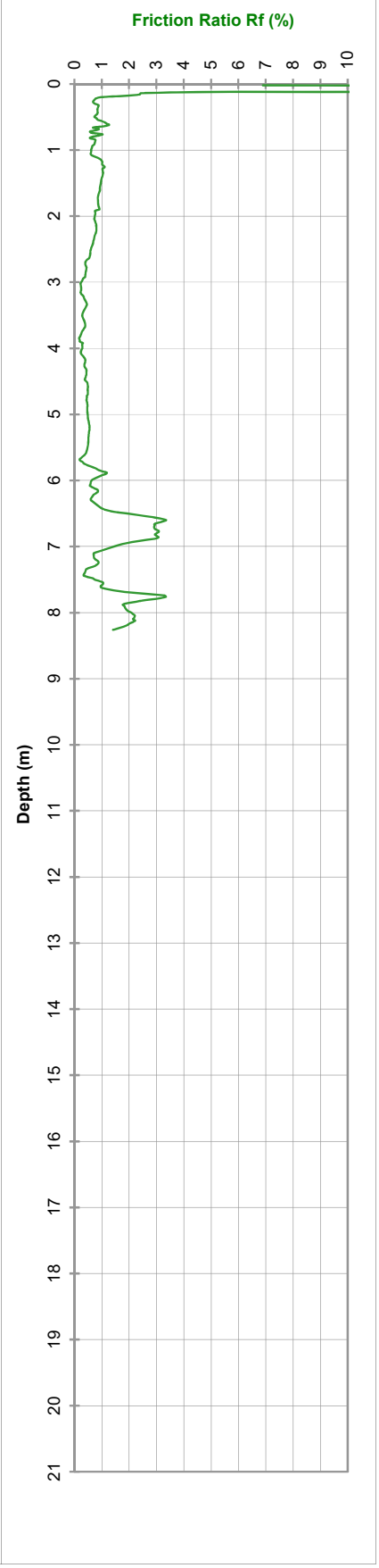
Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT06U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 2.8

Dummy probe to (m):

Refusal: 55MPa

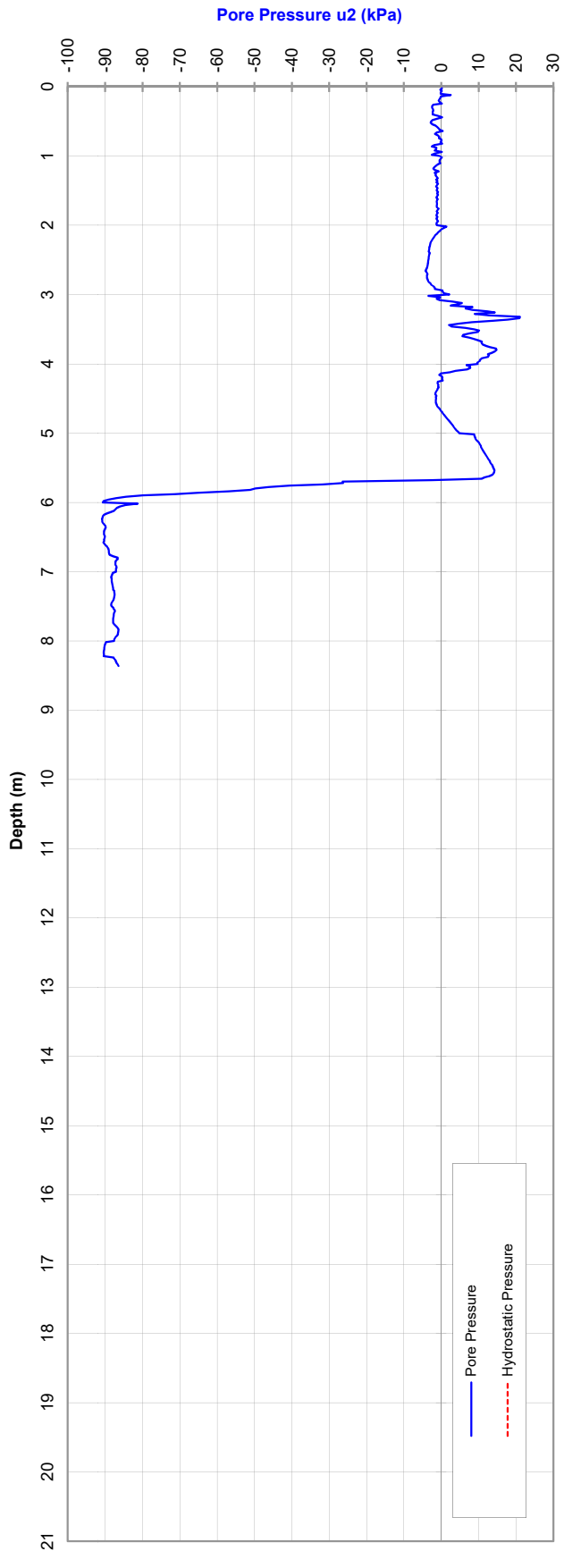
Cone I.D.: EC26

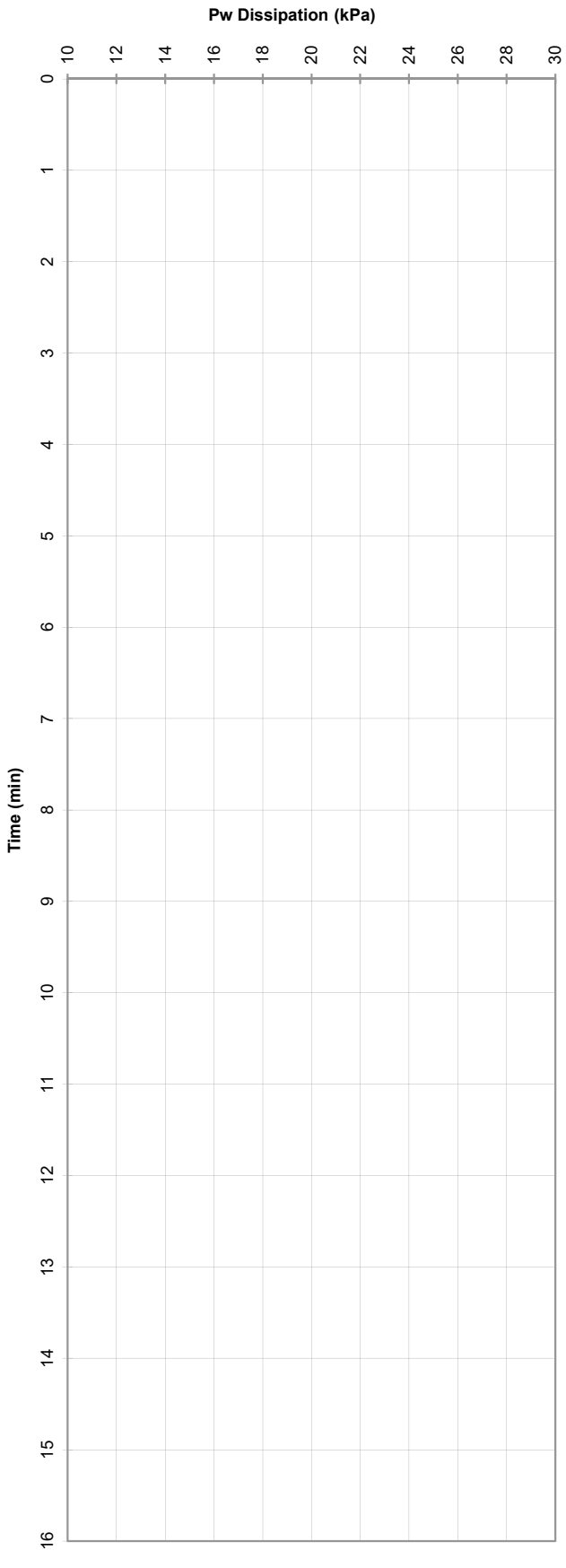
File: HG0343M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT06U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16





PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Please note: Hydrostatic Line is taken from the water level manually dipped by the CPT Operator following completion of the probe and, as such, should be used as a guide only.

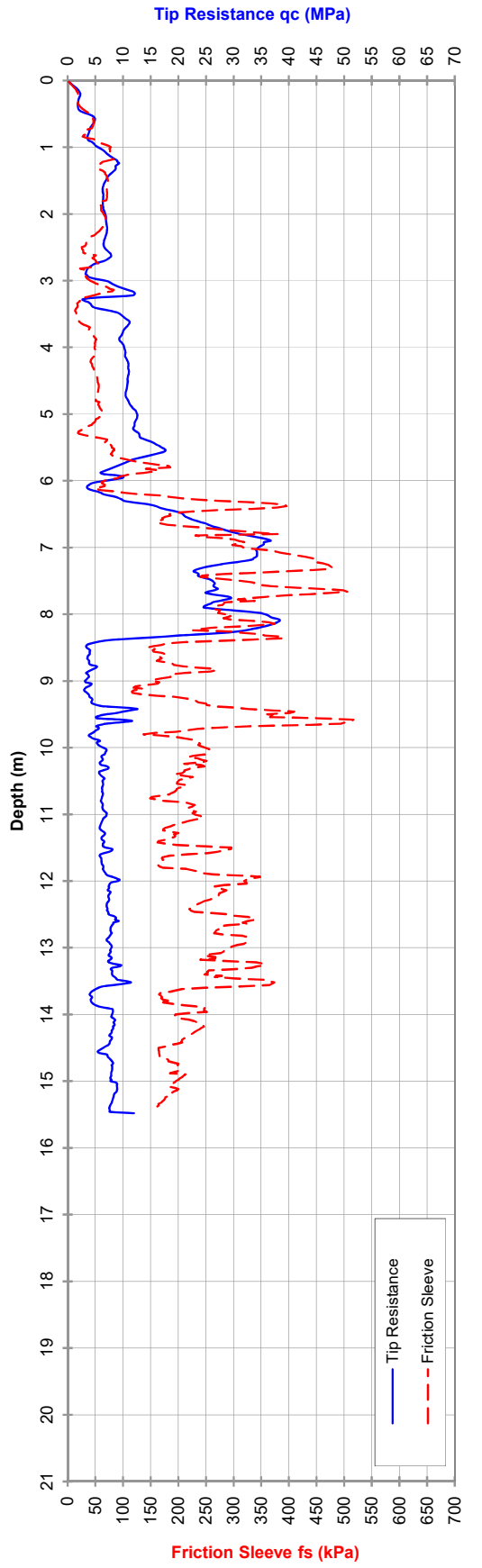
Approx. Water (m): Dry to 2.8

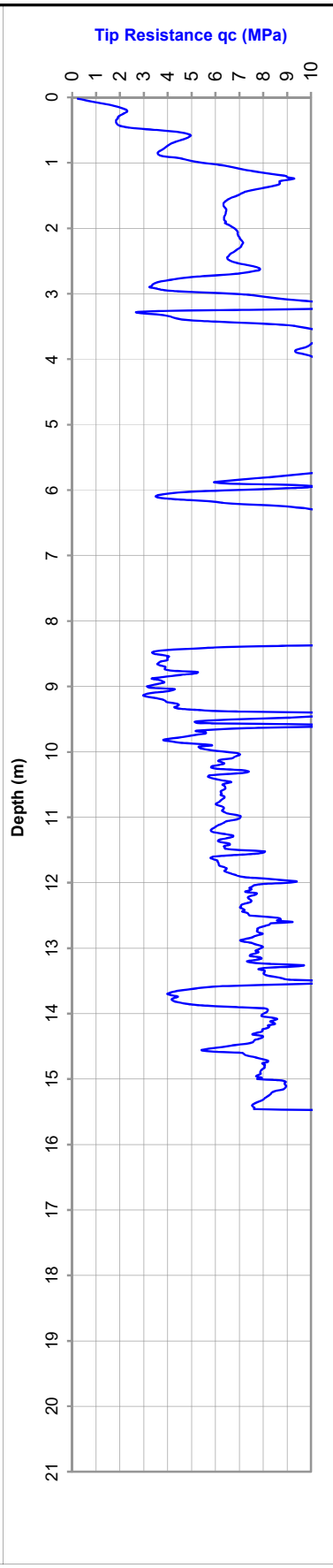
File: HG0343M.txt

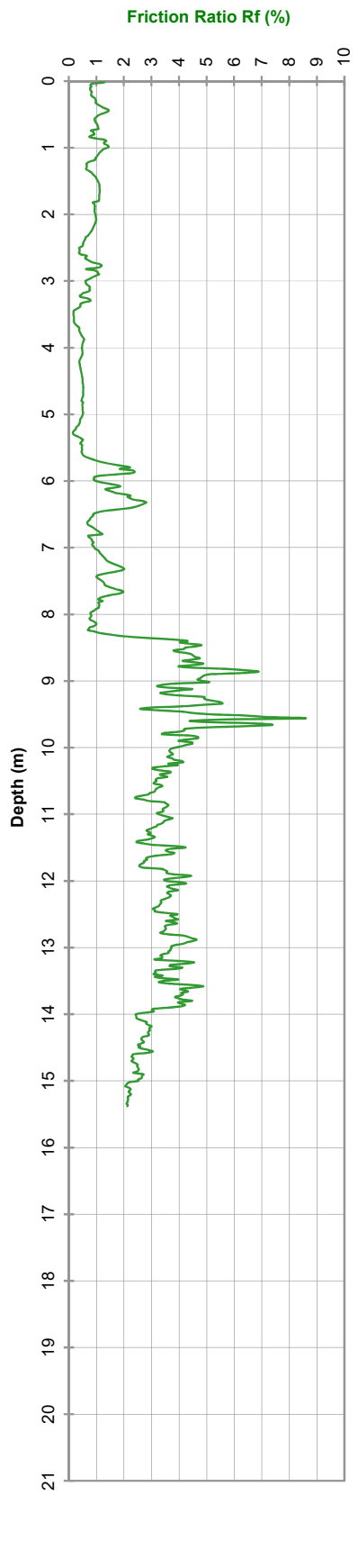
Rig type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Main Roads Western Australia	Job No.: 60344161.100	Probe I.D
PROJECT: GI for Bridges 1761, 1762 & 1763	RL (m):	**1763-CPT07U**
LOCATION: Bussell Highway	Co-ords:	31-Mar-16







PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): 3.0

Dummy probe to (m):

Refusal: 12MPa + Rod Friction

Cone I.D.: EC26

File: HG0344M

Rig Type: 12 tonne track (M1)

Appendix D

Appendix E

Pile Capacity Estimates

Borehole	Top Depth	Bottom Depth	Mid Depth	Top Elev.	Bottom Elev.	Mid Elev.	Sample Type	Soil Type	Stratigraphy	SPT 'N' Value	Gravel	Sand	Fines	LL	PL (limit)	PI	LS	MC	Organic Content	Particle Density
	m	m	m	mAHD	mAHD	mAHD				b/300	%	%	%	%	%	%	%	%	%	g/cm3
BH1763-01	0.5	0.95	0.73	5.53	5.08	5.31	N*	Silty SAND	Alluvium	7										
BH1763-01	0.95	2	1.48	5.08	4.03	4.56	Ds	Silty SAND	Alluvium		7	74	19	21.2	NP	NP	0	21.9		2.46
BH1763-01	2	2.45	2.23	4.03	3.58	3.81	N*	Silty SAND	Alluvium	8										
BH1763-01	3.5	3.95	3.73	2.53	2.08	2.31	N*	Silty SAND	Alluvium	4										
BH1763-01	6.5	6.95	6.73	-0.47	-0.92	-0.69	N*	Silty SAND	Guildford Fm	31	0	92	8							
BH1763-01	8	8.3	8.15	-1.97	-2.27	-2.12	N*	Silty SAND	Guildford Fm	R										
BH1763-01	9.5	9.95	9.73	-3.47	-3.92	-3.7	N*	CLAY	Leederville Fm	19										
BH1763-01	10.65	10.82	10.74	-4.62	-4.79	-4.71	C	CLAY and SILT	Leederville Fm		0	18	82	63.6	28.8	34.8	12	28.2		2.35
BH1763-01	11	11.45	11.23	-4.97	-5.42	-5.2	N*	CLAY and SILT	Leederville Fm	24										
BH1763-01	12.5	12.95	12.73	-6.47	-6.92	-6.7	N*	Sandy CLAY	Leederville Fm	34										
BH1763-01	13.5	13.65	13.58	-7.47	-7.62	-7.55	C	CLAY and SILT	Leederville Fm		0	3	97	60.9	29	31.8	9.4	28.3		2.41
BH1763-01	14	14.45	14.23	-7.97	-8.42	-8.2	N*	CLAY and SILT	Leederville Fm	37										
BH1763-01	15.5	15.95	15.73	-9.47	-9.92	-9.7	N*	Sandy CLAY	Leederville Fm	25										
BH1763-01	16.5	16.95	16.73	-10.47	-10.92	-10.7	N*	Interlaminated SAND and CLAY	Leederville Fm	40										
BH1763-01	18	18.45	18.23	-11.97	-12.42	-12.2	N*	Interlaminated SAND and CLAY	Leederville Fm	77										
BH1763-01	19.5	19.77	19.64	-13.47	-13.74	-13.61	N*	Silty SAND	Leederville Fm	R										
BH1763-01	21	21.45	21.23	-14.97	-15.42	-15.2	N*	CLAY and SILT	Leederville Fm	43										
BH1763-01	22.5	22.95	22.73	-16.47	-16.92	-16.7	N*	CLAY and SILT	Leederville Fm	55										
BH1763-01	24.5	24.95	24.73	-18.47	-18.92	-18.7	N*	Interlaminated SAND and CLAY	Leederville Fm	64										
BH1763-02	1.5	1.95	1.73	5.22	4.77	5	N*	Silty SAND	Guildford Fm	10										
BH1763-02	2.5	3	2.75	4.22	3.72	3.97	Ds	Silty SAND	Guildford Fm		0	93	7	NO	NP	NP	0	4.3		2.6
BH1763-02	3	3.45	3.23	3.72	3.27	3.5	N*	Silty SAND	Guildford Fm	12										
BH1763-02	4.5	4.95	4.73	2.22	1.77	2	N	Silty SAND	Guildford Fm	5										
BH1763-02	5	5.5	5.25	1.72	1.22	1.47	Ds	Silty SAND	Guildford Fm		0	90	10	24.9	NP	NP	0	14.8		2.65
BH1763-02	6	6.45	6.23	0.72	0.27	0.5	N*	CLAY	Guildford Fm	10										
BH1763-02	6.5	7	6.75	0.22	-0.28	-0.03	Ds	CLAY	Guildford Fm		0	34	66	67.6	19.5	48.1	11.2	36.9	0.1	2.29
BH1763-02	7.5	7.95	7.73	-0.78	-1.23	-1.01	N*	Silty SAND	Guildford Fm	9										
BH1763-02	9	9.45	9.23	-2.28	-2.73	-2.51	N*	Silty SAND	Guildford Fm	23										
BH1763-02	10.5	10.95	10.73	-3.78	-4.23	-4.01	N*	CLAY	Leederville Fm	17										
BH1763-02	12	12.45	12.23	-5.28	-5.73	-5.51	N	Silty CLAY	Leederville Fm	25										
BH1763-02	12.75	13	12.88	-6.03	-6.28	-6.16	C	CLAY	Leederville Fm					63.4	27.6	35.8	9.1	30.2		
BH1763-02	14	14.45	14.23	-7.28	-7.73	-7.51	N*	CLAY	Leederville Fm	25										
BH1763-02	15.3	15.4	15.35	-8.58	-8.68	-8.63	C	CLAY	Leederville Fm					70	26.6	43.4	12.6	29.6		
BH1763-02	15.5	15.95	15.73	-8.78	-9.23	-9.01	N*	CLAY	Leederville Fm	22										

Borehole	Top Depth	Bottom Depth	Mid Depth	Top Elev.	Bottom Elev.	Mid Elev.	Sample Type	Soil Type	Stratigraphy	SPT 'N' Value	Gravel	Sand	Fines	LL	PL (limit)	PI	LS	MC	Organic Content	Particle Density
	m	m	m	mAHD	mAHD	mAHD				b/300	%	%	%	%	%	%	%	%	%	g/cm3
BH1763-02	17	17.45	17.23	-10.28	-10.73	-10.51	N	Silty SAND	Leederville Fm	R										
BH1763-02	18	18.45	18.23	-11.28	-11.73	-11.51	N*	CLAY and SILT	Leederville Fm	44										
BH1763-02	19.5	19.95	19.73	-12.78	-13.23	-13.01	N*	Silty SAND	Leederville Fm	R										
BH1763-02	21	21.45	21.23	-14.28	-14.73	-14.51	N	CLAY	Leederville Fm	35										
BH1763-02	22.5	22.95	22.73	-15.78	-16.23	-16.01	N*	Silty CLAY	Leederville Fm	42				57.9	25.1	32.8	11.8	25.4		
BH1763-02	24.5	24.95	24.73	-17.78	-18.23	-18.01	N*	Silty CLAY	Leederville Fm	39										

Notes: NP = Non-Plastic, N/A = Not Applicable, LL = Liquid limit, PI = Plasticity Index, LS = Linear Shrinkage, MC = Field Moisture Content, OMC = Optimum Moisture Content, $CaCO_3$ = Calcium Carbonate, Organic Cont. = Organic content, Sp. Gravity = Specific Gravity, Su = Undrained Shear Strength, UU Triaxial = Unconsolidated Undrained Triaxial Test, Cl = Chloride, SO_4 = Sulphate, TSS = Total Soluble Solids, N/O = Not Obtainable, NP = Non Plastic.

BH No.	Top	Base	Field Screening				Lab pH		Suspension Peroxide Oxidation-Combined Acidity and Sulfate (SPOCAS)										Other Tests				
			pH or pH (F)	pH (Fox)	pH (F) - pH (Fox)	Reaction Rate	pH (KCl)	pH (Ox)	Sulfidic - Titratable Actual Acidity	Sulfidic - Titratable Peroxide Acidity	Sulfidic - Titratable Sulfidic Acidity	Peroxide Oxidisable Sulfur	Sulfidic - Excess Acid Neutralising Capacity	Liming Rate	Net Acidity (acidity units)	Net Acidity (sulfur units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	Organic Matter	Chloride	Sulphate (as SO4-)	Total Soluble Salts	Moisture Content
			pH Unit	pH Unit	pH Unit		pH Unit	pH Unit	% pyrite S	% pyrite S	% pyrite S	% S	%S	kg CaCO3/t	mole H+/t	%S	mole H+/t	% S	%	mg/kg	mg/kg	mg/kg	%
			LOR	0.1	0.1		0.1	0.1	0.005	0.005	0.005	0.005	0.02	1	10	0.02	10	0.02	0.5	10	100	5	1
BH1763-01	0	0.2	6.40	4.20	2.20	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-01	0.5	0.95	6.70	3.40	3.30	Moderate	5.70	4.40	0.02	0.13	0.11	0.02	-	1	19	0.03	19	0.03	-	-	-	-	-
BH1763-01	2	2.45	6.70	3.90	2.80	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-01	2	2.45	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70	230	301	-
BH1763-01	5	5.45	6.40	2.10	4.30	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-01	6.5	6.95	7.00	2.50	4.50	Extreme	7.00	3.70	<0.005	0.03	0.03	0.04	-	2	22	0.03	26	0.04	-	-	-	-	-
BH1763-01	8	8.3	6.90	4.50	2.40	Strong	6.80	5.60	<0.005	<0.005	<0.005	0.01	-	<1	<10	<0.02	<10	<0.02	-	-	-	-	-
BH1763-01	8	8.3	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	<100	254	-
BH1763-02	1	1.1	7.00	4.70	2.30	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	1.4	1.5	6.70	4.90	1.80	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	1.5	1.95	6.20	4.50	1.70	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	90	<100	322	1.1
BH1763-02	2	2.1	6.30	4.60	1.70	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	2.5	2.6	7.10	4.80	2.30	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	2.9	3	8.20	5.10	3.10	Slight	6.5	6.2	<0.005	<0.005	<0.005	<0.005	-	<1	<10	<0.02	<10	<0.02	-	-	-	-	-
BH1763-02	3	3.45	8.30	3.50	4.80	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	4	4.1	7.70	5.80	1.90	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	80	<100	210	14.0
BH1763-02	4.4	4.5	7.20	5.20	2.00	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	5	5.1	8.70	2.60	6.10	Strong	6.4	5.0	<0.005	0.015	0.015	0.041	-	2	25	0.04	25	0.04	-	-	-	-	-
BH1763-02	6.5	7	9.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	50.00	421	31.2
BH1763-02	7	7.1	8.90	8.40	0.50	Extreme	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH1763-02	9	9.45	7.20	5.10	2.10	Strong	-	-	-	-	-	-	-	-	-	-	-	-	-	40	<100	98	14.1

MATERIALS CONSULTANTS PTY. LTD.

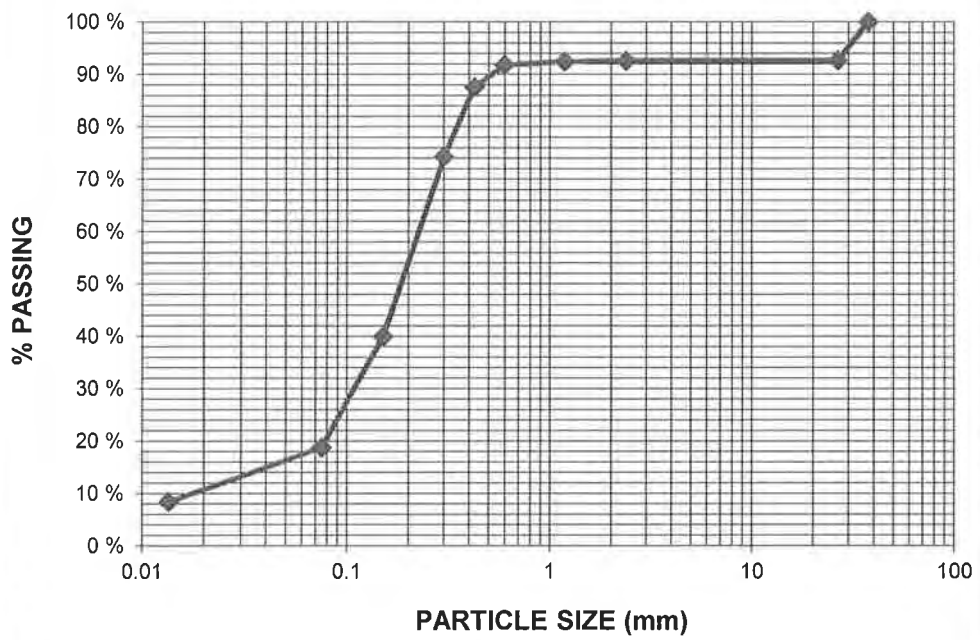
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_244
SAMPLE NO.	943
CLIENT REFERENCE	BH1763-01, 0.95m to 2.0m
DATE TESTED	PSD tested 28.04.2016 & 02.05.2016 Consistency Limit tested 02.05.2016
SAMPLE DESCRIPTION	Silty Sand
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
37.5	100 %
26.50	93 %
2.36	93 %
1.18	92 %
0.600	92 %
0.425	88 %
0.300	74 %
0.150	40 %
0.075	19 %
0.0135	8 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS	
LIQUID LIMIT WA 120.2	21.2
PLASTIC LIMIT WA 121.1	Non Plastic
PLASTICITY INDEX WA 122.1	Non Plastic
LINEAR SHRINKAGE WA 123.1	0.0

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA Accredited for compliance with ISO/IEC 17025 ACCREDITED FOR TECHNICAL COMPETENCE

Approved :
R.Groves, Signatory

Date : 03/05/2016

CERTIFICATE NO. MC 64_244 _2 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

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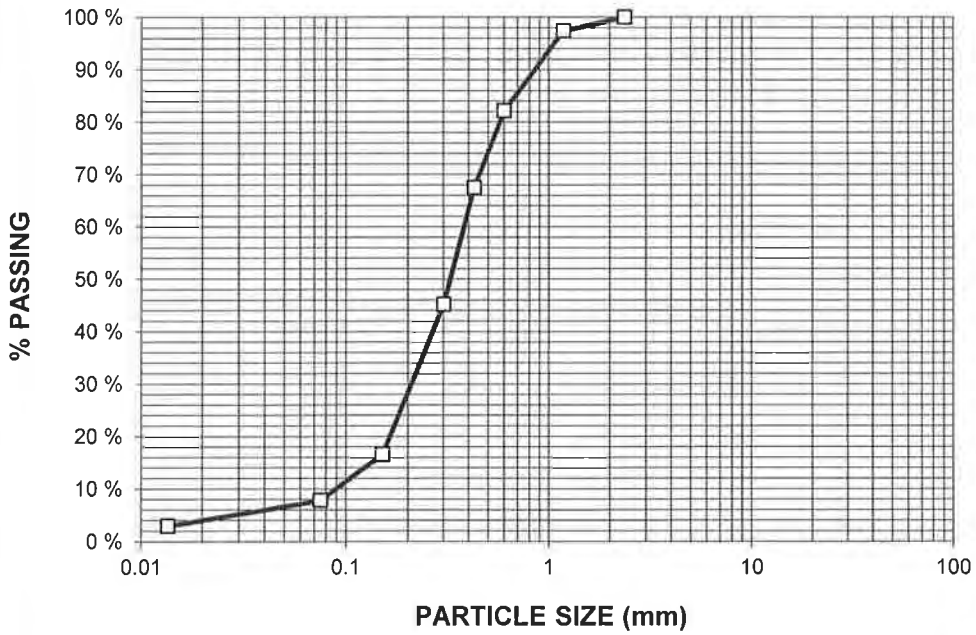
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_245
SAMPLE NO.	944
CLIENT REFERENCE	BH1763-01 - 6.5m to 6.95m
DATE TESTED	28.04.2016 & 29.04.2016
SAMPLE DESCRIPTION	Silty Sand
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100 %
1.18	97 %
0.600	82 %
0.425	67 %
0.300	45 %
0.150	17 %
0.075	8 %
0.0135	3 %

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA Accredited for compliance with ISO/IEC 17025 ACCREDITED FOR TECHNICAL COMPETENCE

Approved

M Snow, Signatory

Date : 29/04/2016

CERTIFICATE NO. MC 64_245 _1 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

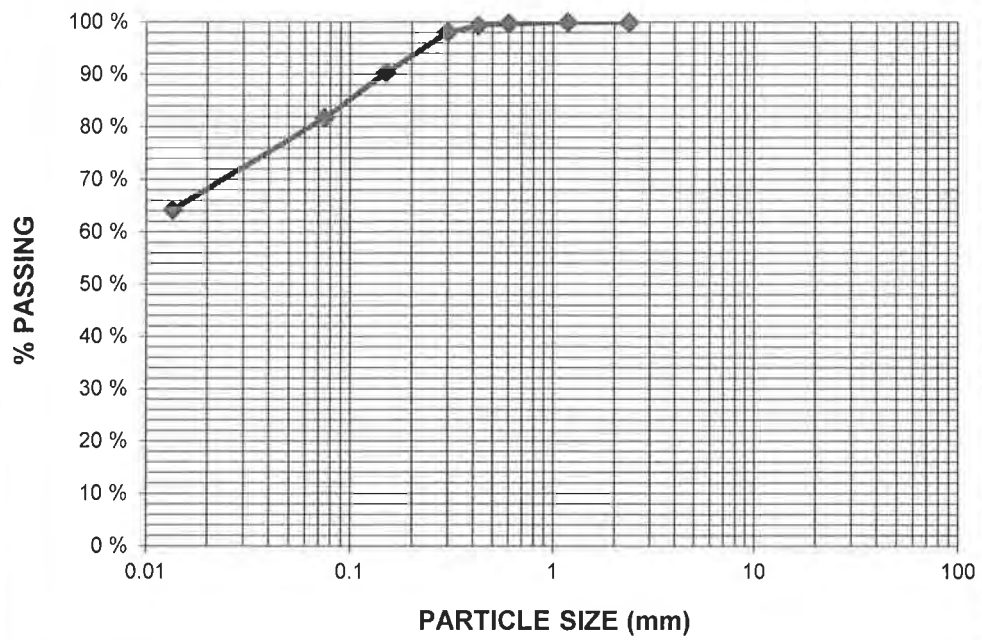
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_246
SAMPLE NO.	945
CLIENT REFERENCE	BH1763-01, 10.65m to 10.82m
DATE TESTED	PSD tested 28.04.2016 & 02 05.2016 Consistency Limit tested 02.05.2016
SAMPLE DESCRIPTION	Clay & Silt
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100 %
1.18	100 %
0.600	100 %
0.425	99 %
0.300	98 %
0.150	90 %
0.075	82 %
0.0135	64 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS	
LIQUID LIMIT WA 120.2	63.6
PLASTIC LIMIT WA 121.1	28.8
PLASTICITY INDEX WA 122.1	34.8
LINEAR SHRINKAGE WA 123.1	12.0

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Curing Present in Linear Shrinkage

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA Accredited for compliance with ISO/IEC 17025 ACCREDITED FOR TECHNICAL COMPETENCE

Approved : R Groves Signatory

Date : 03/05/2016

CERTIFICATE NO. MC 64_246 _1 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

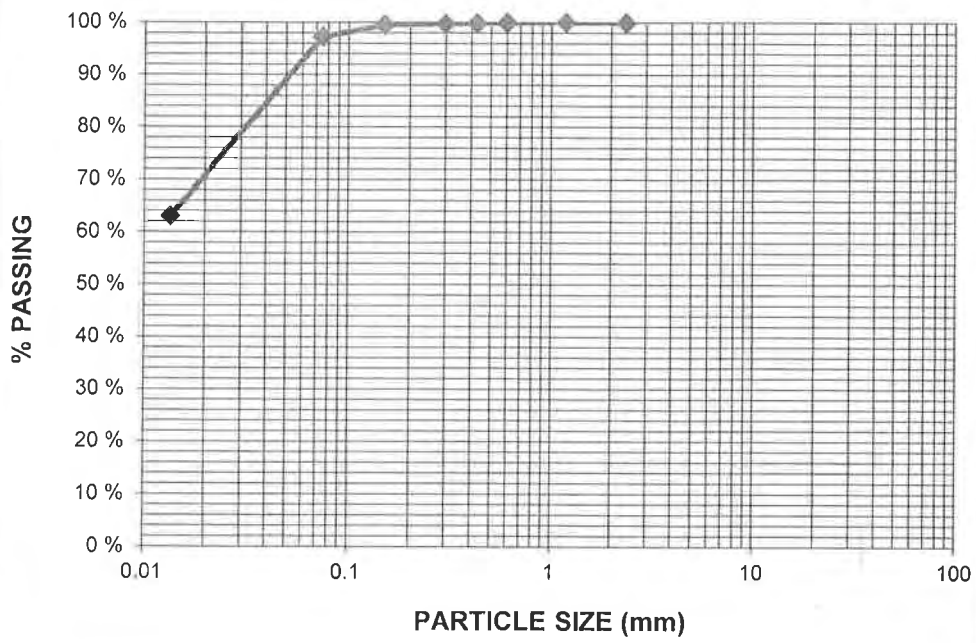
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_247
SAMPLE NO.	946
CLIENT REFERENCE	BH1763-01, 13.5m to 13.65m
DATE TESTED	PSD tested 28.04.2016 & 02.05.2016 Consistency Limit tested 03.05.2016
SAMPLE DESCRIPTION	Clay & Silt
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100 %
1.18	100 %
0.600	100 %
0.425	100 %
0.300	100 %
0.150	99 %
0.075	97 %
0.0135	63 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS	
LIQUID LIMIT WA 120.2	60.9
PLASTIC LIMIT WA 121.1	29.0
PLASTICITY INDEX WA 122.1	31.8
LINEAR SHRINKAGE WA 123.1	9.4

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Curling and Cracking present in Linear Shrinkage.

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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ACCREDITED FOR TECHNICAL COMPETENCE

Approved :
M Snow, Signatory
Date : 04/05/2016

CERTIFICATE NO. MC 64_247 _2 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

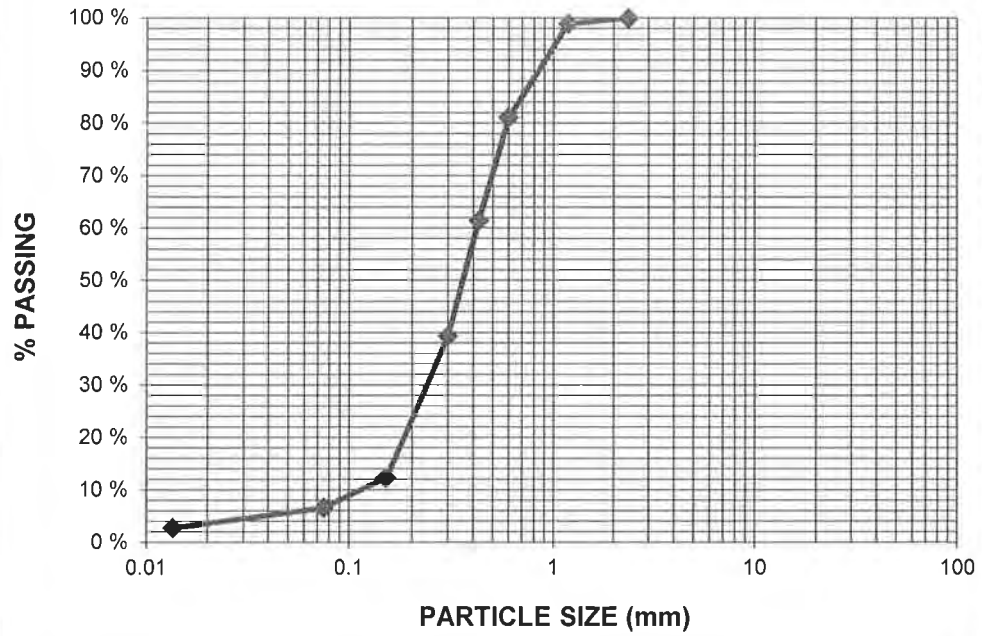
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_248
SAMPLE NO.	947
CLIENT REFERENCE	BH1763-02 - 2.5m to 3.0m
DATE TESTED	PSD tested 28.04.2016, Consistency Limit tested 02.05.2016
SAMPLE DESCRIPTION	Silty Sand
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100 %
1.18	99 %
0.600	81 %
0.425	61 %
0.300	39 %
0.150	12 %
0.075	7 %
0.0135	3 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS	
LIQUID LIMIT WA 120.2	Not Obtainable
PLASTIC LIMIT WA 121.1	Non Plastic
PLASTICITY INDEX WA 122.1	Non Plastic
LINEAR SHRINKAGE WA 123.1	0.0

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

Linear Shrinkage has been conducted at 22.09% Moisture Content in accordance with WA 110.1.

WA 123.1 requires that the Linear Shrinkage be determined at the Liquid Limit of the soil for a standard test.

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Materials Consultants

Approved : _____
R Groves, Signatory

Date : 03/05/2016

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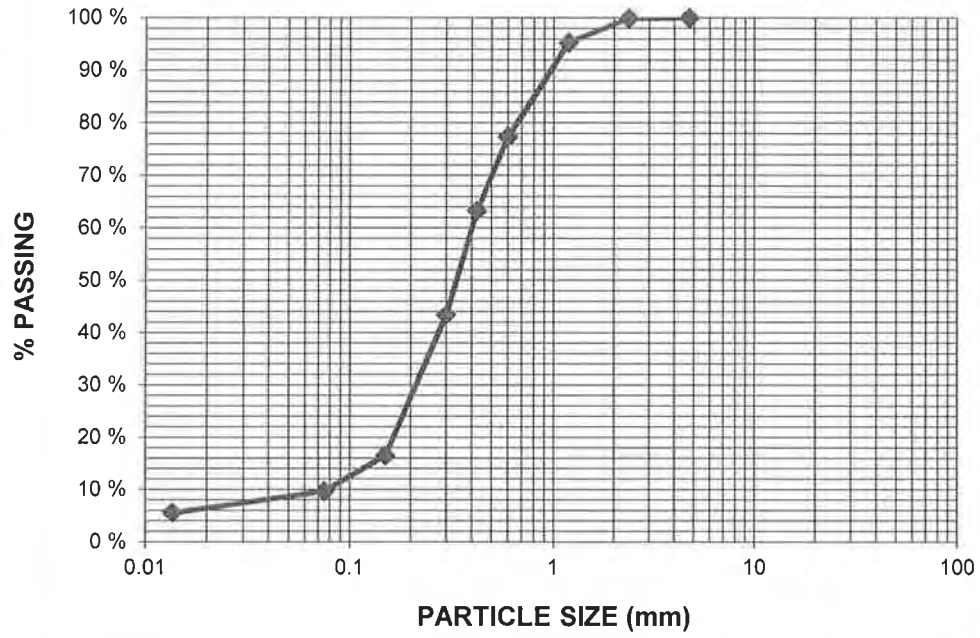
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_249
SAMPLE NO.	948
CLIENT REFERENCE	BH1763-02, 5.0m to 5.5m
DATE TESTED	PSD tested 28.04.2016 & 29.04.2016 Consistency Limit tested 02.05.2016
SAMPLE DESCRIPTION	Silty Sand
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
4.75	100 %
2.36	100 %
1.18	95 %
0.600	77 %
0.425	63 %
0.300	43 %
0.150	17 %
0.075	10 %
0.0135	6 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS	
LIQUID LIMIT WA 120.2	24.9
PLASTIC LIMIT WA 121.1	Non Plastic
PLASTICITY INDEX WA 122.1	Non Plastic
LINEAR SHRINKAGE WA 123.1	0.0

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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Approved : R Groves, Signatory

Date : 03/05/2016

CERTIFICATE NO. MC 64_249 _2 **ISSUE 1**

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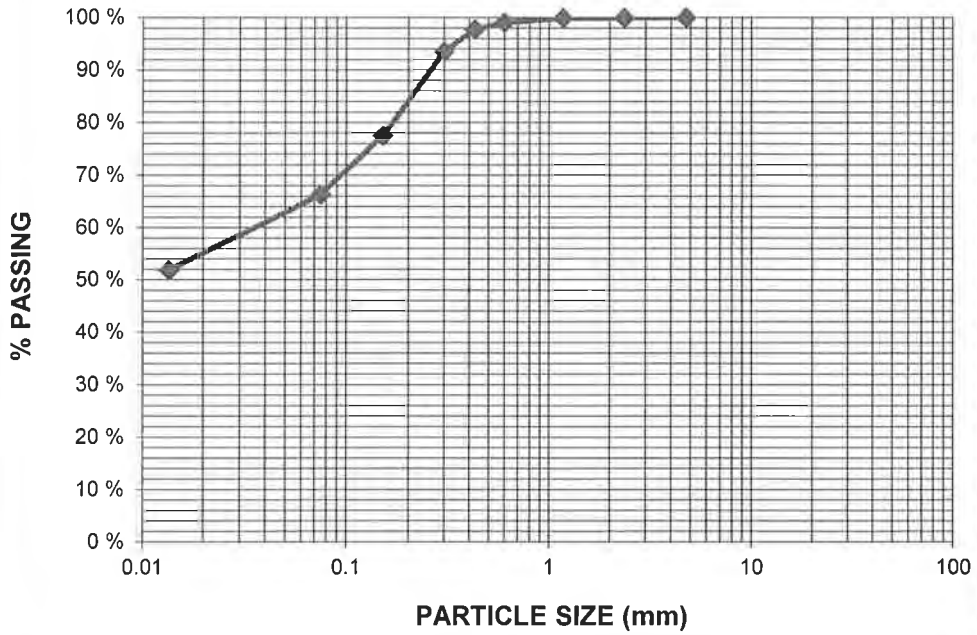
Email : admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION OF A SOIL :
SIEVING AND DECANTATION METHOD : WA 115.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_250
SAMPLE NO.	949
CLIENT REFERENCE	BH1763-02, 6.5m to 7.0m
DATE TESTED	PSD tested 28.04.2016 & 02.05.2016 Consistency Limit tested 02.05.2016
SAMPLE DESCRIPTION	Clay
FEATURE	-
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
4.75	100 %
2.36	100 %
1.18	100 %
0.600	99 %
0.425	98 %
0.300	94 %
0.150	78 %
0.075	66 %
0.0135	52 %

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS		SOIL CLASSIFICATION
LIQUID LIMIT WA 120.2	67.6	GROUP SYMBOL AS1726 TABLE A1
PLASTIC LIMIT WA 121.1	19.5	MH
PLASTICITY INDEX WA 122.1	48.1	
LINEAR SHRINKAGE WA 123.1	11.2	

Sampling procedures: Tested as received.

Remarks: % RETAINED on 37.5 mm SIEVE: 0 %

Curling Present5 in Linear Shrinkage

Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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Approved : R Groves Signatory

Date : 03/05/2016

CERTIFICATE NO. MC 64_250 _1 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

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72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS

TEST METHODS - WA 120.2, WA 121.1, WA 122.1, WA 123.1

CLIENT:	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.:	64_251
SAMPLE NO.:	950
CLIENT REFERENCE:	BH1763-02 - 12.75m to 13.0m
DATE TESTED:	03.05.2016
SAMPLE DESCRIPTION:	Clay
PROJECT:	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

LIQUID LIMIT	**63.4 %**
PLASTIC LIMIT	**27 .6%**
PLASTICITY INDEX	**35.8 %**
LINEAR SHRINKAGE	**9.1 %**

Sampling Procedures:	Tested as received.
Remarks:	Curling present in Linear Shrinkage
	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA

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ACCREDITED FOR **TECHNICAL COMPETENCE**

Approved :

M Snow, Signatory

Date: 04.05.2016

CERTIFICATE NO. MC 64_251 _2 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS

TEST METHODS - WA 120.2, WA 121.1, WA 122.1, WA 123.1

CLIENT:	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.:	64_252
SAMPLE NO.:	951
CLIENT REFERENCE:	BH1763-02, 15.3m to 15.4m
DATE TESTED:	02.05.2016
SAMPLE DESCRIPTION:	Clay
PROJECT:	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

LIQUID LIMIT	**70.0 %**
PLASTIC LIMIT	**26 .6%**
PLASTICITY INDEX	**43.4 %**
LINEAR SHRINKAGE	**12.6 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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Date: 03.05.2016

CERTIFICATE NO. MC 64_252 _2 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - CONE PENETROMETER APPARATUS

TEST METHODS - WA 120.2, WA 121.1, WA 122.1, WA 123.1

CLIENT:	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.:	64_253
SAMPLE NO.:	952
CLIENT REFERENCE:	BH1763-02, 22.5m to 22.95m
DATE TESTED:	02.05.2016
SAMPLE DESCRIPTION:	Silty Clay
PROJECT:	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

LIQUID LIMIT	**57.9 %**
PLASTIC LIMIT	**25 .1%**
PLASTICITY INDEX	**32.8 %**
LINEAR SHRINKAGE	**11.8 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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Date: 03.05.2016

CERTIFICATE NO. MC 64_253 _2 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_244
SAMPLE NO.	943
CLIENT REFERENCE	BH1763-01, 0.95m to 2.0m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Silty Sand
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **21.9 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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APPROVED: _____

R Groves, Signatory

DATE: 28.04.2016

CERTIFICATE NO. MC 64_244 _1 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

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72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_246
SAMPLE NO.	945
CLIENT REFERENCE	BH1763-01, 10.65m to 10.82m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Clay & Silt
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **28.2 %**

Sampling Procedures: Tested as received.

Remarks: Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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R Groves, Signatory

DATE: 28.04.2016

CERTIFICATE NO. MC 64_246 _2 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.

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72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_247
SAMPLE NO.	946
CLIENT REFERENCE	BH1763-01, 13.5m to 13.65m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Clay & Silt
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **28.3 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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DATE: 28.04.2016

CERTIFICATE NO. MC 64_247 _1 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_248
SAMPLE NO.	947
CLIENT REFERENCE	BH1763-02, 2.5m to 3.0m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Silty Sand
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **4.3 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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APPROVED: _____

R Groves, Signatory

DATE: 28.04.2016

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_249
SAMPLE NO.	948
CLIENT REFERENCE	BH1763-02, 5.0m to 5.5m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Silty Sand
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **14.8 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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APPROVED:

M Snow, Signatory

DATE: 29.04.2016

CERTIFICATE NO. MC 64_249 _1 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_250
SAMPLE NO.	949
CLIENT REFERENCE	BH1763-02, 6.5m to 7.0m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Clay
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **36.9 %**

Sampling Procedures: Tested as received.

Remarks: Sample received by Materials Consultants Pty Ltd on the 07.04.2016

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DATE: 28.04.2016

CERTIFICATE NO. MC 64_250 _3 **ISSUE 1**

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_251
SAMPLE NO.	950
CLIENT REFERENCE	BH1763-02, 12.75m to 13.0m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Clay
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **30.2 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA

Accredited for compliance with ISO/IEC 17025

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APPROVED: _____

R Groves, Signatory

DATE: 28.04.2016

CERTIFICATE NO. MC 64_251 _1 **ISSUE 1**

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72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.	64_252
SAMPLE NO.	951
CLIENT REFERENCE	BH1763-02, 15.3m to 15.4m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Clay
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **29.6 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA

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APPROVED: _____

R Groves, Signatory

DATE: 28.04.2016

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Email : admin@matcons.com.au

TEST CERTIFICATE

SOIL & GRANULAR MATERIAL MOISTURE CONTENT :

- CONVECTION OVEN METHOD : WA 110.1

CLIENT	Brierty Contractors Pty Ltd, 72 Melville Parade, South Perth
JOB NO.	64_253
SAMPLE NO.	952
CLIENT REFERENCE	BH1763-02, 22.5m to 22.95m
DATE TESTED	27.04.2016
SAMPLE DESCRIPTION	Silty Clay
PROJECT	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

MOISTURE CONTENT **25.4 %**

Sampling Procedures:	Tested as received.
Remarks:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA

Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR **TECHNICAL COMPETENCE**

APPROVED: _____

R Groves, Signatory

DATE: 28.04.2016

CERTIFICATE NO. MC 64_253 _1 **ISSUE 1**

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72 COLLINGWOOD STREET, OSBORNE PARK WA 6017 TELEPHONE: (08) 9244 3080 FACSIMILE: (08) 9446 6753
Email : admin@matcons.com.au

TEST CERTIFICATE

DETERMINATION OF THE ORGANIC MATTER CONTENT

OF A SOIL - NORMAL METHOD : AS1289.4.1.1

CLIENT:	AECOM Australia Pty Ltd, GPO Box B59, Perth, WA
JOB NO.:	64_250
SAMPLE NO.:	949
CLIENT REFERENCE:	BH1763-02, 6.5m to 7.0m
DATE TESTED:	02.05.2016
SAMPLE DESCRIPTION:	Clay
FEATURE :	-
PROJECT:	Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN

ORGANIC MATTER CONTENT **0.1%**

SAMPLING PROCEDURES:	Tested as received.
REMARKS:	Sample received by Materials Consultants Pty Ltd on the 07.04.2016

NATA

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APPROVED :

M Snow, Signatory

DATE : 02.05.2016

CERTIFICATE NO. MC 64_250 _2 **ISSUE 1**

Soil Particle Density Report

Perth Laboratory
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Perth WA 6017
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www.golder.com
perthlab@golder.com.au

Client:	Material Consultants Pty Ltd (AECOM) 7 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	12/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160439
Sample Identification	Job No. 64_244, Sample No. 943, BH1763-01
	0.95m to 2.0m
Material Description	Silty SAND
Temperature of Test (°C)	20
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.46

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160439_TR-160062_SG_REV0**
	NATA Accreditation No: 1961 Perth
	Accredited for compliance with ISO/IEC 17025
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Darren Corrie – Senior Laboratory Technician

Soil Particle Density Report

Perth Laboratory
84 Guthrie Street Osborne Park
Perth WA 6017
P: +61 8 9441 0700 F: +61 8 9441 0701
www.golder.com
perthlab@golder.com.au

Client:	Material Consultants Pty Ltd (AECOM) 7 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	12/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160440
Sample Identification	Job No. 64_246, Sample No. 945, BH1763-01 10.65m to 10.82m
Material Description	Clayey SILT
Temperature of Test (°C)	20
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.35

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160440_TR-160062_SG_REV0**
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Client:	Material Consultants Pty Ltd (AECOM) 7 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	12/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160441
Sample Identification	Job No. 64_247, Sample No. 946, BH1763-01 13.5m to 13.65m
Material Description	Clayey SILT
Temperature of Test (°C)	21
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.41

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160441_TR-160062_SG_REV0**
NATA Accreditation No: 1961 Perth	
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Client:	Material Consultants Pty Ltd (AECOM) 7 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	12/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160442
Sample Identification	Job No. 64_248, Sample No. 947, BH1763-02 2.5 to 3.0m
Material Description	Silty SAND
Temperature of Test (°C)	20
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.60

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160442_TR-160062_SG_REV0**
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Client:	Material Consultants Pty Ltd (AECOM) 7 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	12/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160443
Sample Identification	Job No. 64_249, Sample No. 948, BH1763-02 5.0 to 5.5m
Material Description	Silty SAND
Temperature of Test (°C)	20
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.65

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160443_TR-160062_SG_REV0**
NATA	**NATA Accreditation No: 1961 Perth**
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Soil Particle Density Report

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perthlab@golder.com.au

Client:	Materials Consultants Pty Ltd (AECOM) 72 Collingwood st osborne Park		
Project:	Bridge 1761-1763 PN 60344161.100-243.01.1761.EN	**Date:**	18/05/16
Location:	Busselton	**Project No.:**	1531362

Test procedure: AS 1289.3.5.1

Laboratory Reference Number	160459
Sample Identification	Job No. 64_250, Sample No. 949, BH1763-02
	6.5m-7.0m
Material Description	CLAY
Temperature of Test (°C)	21
The average apparent Particle Density of the fraction passing 2.36mm (g/cm^3)	2.29

Notes: Tested as received

PLF1-011 RL0 7/12/12

Certificate Reference:	**1531362_160459_TR-160068_SG_REV0**
	NATA Accreditation No: 1961 Perth
	Accredited for compliance with ISO/IEC 17025
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Darren Corrie – Senior Laboratory Technician

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1602823**	Page	: 1 of 8
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Loren Schiavon
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61 2 8784 8503
Project	: 60344161 Bridge 1761-1763 MRWA Bussel Highway Duplication	Date Samples Received	: 01-Apr-2016 16:14
Order number	: 60344161.100	Date Analysis Commenced	: 01-Apr-2016
C-O-C number	: ----	Issue Date	: 05-Apr-2016 12:28
Sampler	: ----		
Site	: Busselton		
Quote number	: ----		
No. of samples received	: 29		
No. of samples analysed	: 27		

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NATA
WORLD RECOGNISED ACCREDITATION

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-01 0.5-0.75	BH1761-01 1.5-1.75	BH1761-01 3.4-3.45	BH1761-01 3.9-4	BH1761-01 4.5-4.6
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602823-001	EP1602823-002	EP1602823-003	EP1602823-004	EP1602823-005
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.4**	**7.1**	**5.6**	**5.6**	**7.0**
pH (Fox)	----	0.1	pH Unit	**3.9**	**4.7**	**4.6**	**4.2**	**7.0**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Extreme**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-01A 5-5.1	BH1761-01A 6-6.1	BH1761-01A 7-7.1	BH1761-01A 8.8-9	BH1761-02 0.5-0.75
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602823-006	EP1602823-007	EP1602823-008	EP1602823-009	EP1602823-010
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.5**	**7.0**	**6.6**	**6.5**	**6.4**
pH (Fox)	----	0.1	pH Unit	**2.7**	**5.3**	**4.7**	**5.7**	**4.4**
Reaction Rate	----	1	-	**Extreme**	**Extreme**	**Moderate**	**Moderate**	**Moderate**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-02 0.75-1	BH1761-02 1-1.25	BH1761-02 1.25-1.5	BH1761-02 1.5-1.95	BH1761-02 2.5-2.9
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602823-011	EP1602823-012	EP1602823-013	EP1602823-014	EP1602823-015
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.5**	**7.1**	**5.9**	**6.3**	**6.7**
pH (Fox)	----	0.1	pH Unit	**6.0**	**4.9**	**3.9**	**4.6**	**5.1**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-02 3-3.1	BH1761-02 3.3-3.4	BH1761-02 4.6-4.7	BH1761-02 5.7-6	BH1761-02 6.8-6.95
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602823-016	EP1602823-017	EP1602823-018	EP1602823-019	EP1602823-020
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**4.5**	**5.2**	**6.2**	**6.0**	**5.6**
pH (Fox)	----	0.1	pH Unit	**3.4**	**3.9**	**3.6**	**2.3**	**4.1**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Strong**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-02 9.5-9.95	BH1763-01 0-0.2	BH1763-01 0.5-0.95	BH1763-01 2-2.45	BH1763-01 5-5.45
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602823-021	EP1602823-022	EP1602823-023	EP1602823-024	EP1602823-026
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**7.1**	**6.4**	**6.7**	**6.7**	**6.4**
pH (Fox)	----	0.1	pH Unit	**3.5**	**4.2**	**3.4**	**3.9**	**2.1**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1763-01 6.5-6.95	BH1763-01 8-8.3	----	----	----
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	----	----	----
Compound	CAS Number	LOR	Unit	EP1602823-027	EP1602823-028	--------	--------	--------
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**7.0**	**6.9**	**----**	**----**	**----**
pH (Fox)	----	0.1	pH Unit	**2.5**	**4.5**	**----**	**----**	**----**
Reaction Rate	----	1	-	**Extreme**	**Strong**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1602903**	Page	: 1 of 2
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Loren Schiavon
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61 2 8784 8503
Project	: 60344161 Bridge 1761-1763 MRWA Bussel Highway Duplication	Date Samples Received	: 01-Apr-2016 16:14
Order number	: 60344161.100	Date Analysis Commenced	: 04-Apr-2016
C-O-C number	: ----	Issue Date	: 05-Apr-2016 13:25
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

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WORLD RECOGNISED ACCREDITATION

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- Analytical Results

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Signatories

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Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

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- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Client sample ID	**BH1761-01A 15-15.45**	**BH1761-02 17.95-18.5**	**----**	**----**	**----**
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1602903-001**	**EP1602903-002**	**--------**	**--------**	**--------**
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.5**	**6.9**	**----**	**----**	**----**
pH (Fox)	----	0.1	pH Unit	**5.7**	**2.5**	**----**	**----**	**----**
Reaction Rate	----	1	-	**Moderate**	**Extreme**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1602905**	Page	: 1 of 6
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Loren Schiavon
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61 2 8784 8503
Project	: Ex EP1602823 60344161 Bridge 1761-1763 MRWA Bussel Highway Duplication	Date Samples Received	: 01-Apr-2016 16:14
Order number	: 60344161.100	Date Analysis Commenced	: 05-Apr-2016
C-O-C number	: ----	Issue Date	: 12-Apr-2016 19:41
Sampler	: ----		
Site	: Busselton		
Quote number	: ----		
No. of samples received	: 8		
No. of samples analysed	: 8		

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WORLD RECOGNISED ACCREDITATION

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA029 (SPOCAS): Excess ANC not required because pH OX less than 6.5.
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-01 4.5-4.6	BH1761-01A 5-5.1	BH1761-01A 6-6.1	BH1761-02 5.7-6	BH1761-02 6.8-6.95
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1602905-001	EP1602905-002	EP1602905-003	EP1602905-004	EP1602905-005
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	5.4	5.4	5.2	----	5.8
pH OX (23B)	----	0.1	pH Unit	4.2	3.9	5.9	----	5.1
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	24	34	15	----	13
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	240	370	13	----	13
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	216	337	<2	----	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	0.039	0.054	0.024	----	0.020
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	0.385	0.594	0.021	----	0.020
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	0.346	0.540	<0.005	----	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.010	0.010	0.006	----	0.010
Peroxide Sulfur (23De)	----	0.005	% S	0.068	0.232	0.012	----	0.017
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.059	0.222	0.006	----	0.007
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	37	138	<5	----	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.017	0.015	0.011	----	<0.005
Peroxide Calcium (23Wh)	----	0.005	% Ca	0.020	0.018	0.015	----	<0.005
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	----	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	----	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	----	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.186	0.106	0.096	----	0.009
Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.185	0.115	0.098	----	0.010
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	0.009	<0.005	----	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	8	<5	----	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	0.012	<0.005	----	<0.005
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	----	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.10	0.28	0.03	----	0.03
Net Acidity (acidity units)	----	10	mole H+ / t	61	172	19	----	17
Liming Rate	----	1	kg CaCO3/t	5	13	1	----	1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	BH1761-01 4.5-4.6	BH1761-01A 5-5.1	BH1761-01A 6-6.1	BH1761-02 5.7-6	BH1761-02 6.8-6.95
				Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit		EP1602905-001	EP1602905-002	EP1602905-003	EP1602905-004	EP1602905-005
					Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting - Continued									
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		0.10	0.28	0.03	----	0.03
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		61	172	19	----	17
Liming Rate excluding ANC	----	1	kg CaCO3/t		5	13	1	----	1
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		----	----	----	5.3	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t		----	----	----	12	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		----	----	----	0.02	----
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.005	% S		----	----	----	0.303	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		----	----	----	189	----
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		----	----	----	1.5	----
Net Acidity (sulfur units)	----	0.02	% S		----	----	----	0.32	----
Net Acidity (acidity units)	----	10	mole H+ / t		----	----	----	201	----
Liming Rate	----	1	kg CaCO3/t		----	----	----	15	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		----	----	----	0.32	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		----	----	----	201	----
Liming Rate excluding ANC	----	1	kg CaCO3/t		----	----	----	15	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1763-01 0.5-0.95	BH1763-01 6.5-6.95	BH1763-01 8-8.3	----	----
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	----	----
Compound	CAS Number	LOR	Unit	EP1602905-006	EP1602905-007	EP1602905-008	--------	--------
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**5.7**	**7.0**	**6.8**	----	----
pH OX (23B)	----	0.1	pH Unit	**4.4**	**3.7**	**5.6**	----	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**9**	<2	<2	----	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	**78**	**20**	<2	----	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	**69**	**20**	<2	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	**0.015**	<0.005	<0.005	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	**0.125**	**0.032**	<0.005	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	**0.110**	**0.032**	<0.005	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	<0.005	<0.005	<0.005	----	----
Peroxide Sulfur (23De)	----	0.005	% S	**0.017**	**0.045**	**0.010**	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	**0.015**	**0.041**	**0.008**	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	**9**	**26**	<5	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.099**	**0.007**	**0.009**	----	----
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.105**	**0.011**	**0.010**	----	----
Acid Reacted Calcium (23X)	----	0.005	% Ca	**0.006**	<0.005	<0.005	----	----
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.025**	**0.006**	**0.006**	----	----
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.026**	**0.006**	**0.006**	----	----
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	----	----
Net Acidity (sulfur units)	----	0.02	% S	**0.03**	**0.03**	<0.02	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	**19**	**22**	<10	----	----
Liming Rate	----	1	kg CaCO3/t	**1**	**2**	<1	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1763-01 0.5-0.95	BH1763-01 6.5-6.95	BH1763-01 8-8.3	----	----
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	----	----
Compound	CAS Number	LOR	Unit	EP1602905-006	EP1602905-007	EP1602905-008	--------	--------
				Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting - Continued								
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.03**	**0.04**	<0.02	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**19**	**26**	<10	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	**2**	<1	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	----	----	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	----	----	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	----	----	----	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	----	----	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	----	----	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	----	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	----	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	----	----	----	----	----
Liming Rate	----	1	kg CaCO3/t	----	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	----	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	----	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	----	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1603049**	Page	: 1 of 10
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Loren Schiavon
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61 2 8784 8503
Project	: Bridge 1761-1763	Date Samples Received	: 05-Apr-2016 04:30
Order number	: 60344161.100-243.01.1761.EN	Date Analysis Commenced	: 07-Apr-2016
C-O-C number	: ----	Issue Date	: 14-Apr-2016 15:47
Sampler	: ----		
Site	: Busselton		
Quote number	: ----		
No. of samples received	: 43		
No. of samples analysed	: 37		

NATA Accredited Laboratory 825
Accredited for compliance with ISO/IEC 17025.

NATA
WORLD RECOGNISED ACCREDITATION

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics, Malaga, WA
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA
Daniel Fisher	Inorganics Analyst	Perth Inorganics, Malaga, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- ASS: EA003 (NATA Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-01 0.5-1	BH1762-01 1-1.5	BH1762-01 2-2.1	BH1762-01 2.5-2.6	BH1762-01 2.9-3
			Client sampling date / time	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-001	EP1603049-002	EP1603049-004	EP1603049-005	EP1603049-006
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	6.4	----	----	4.7
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	5.8	6.4	5.7	6.2	----
pH (Fox)	----	0.1	pH Unit	2.1	2.8	1.8	1.9	----
Reaction Rate	----	1	Reaction Unit	2	2	4	3	----
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	----	47	----	----	351
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	3.4	----	----	17.7
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	----	<100	----	----	300
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	10	----	----	40
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	1.0	1.4	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-01 3.5-3.6	BH1762-01 4-4.1	BH1762-01 4.4-4.5	BH1762-01 5-5.1	BH1762-01 5.6-6
			Client sampling date / time	[03-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-007	EP1603049-008	EP1603049-009	EP1603049-010	EP1603049-011
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	----	----	6.1	----
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	5.6	5.6	5.6	----	6.5
pH (Fox)	----	0.1	pH Unit	2.0	2.2	2.0	----	2.3
Reaction Rate	----	1	Reaction Unit	3	4	4	----	2
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	----	----	----	89	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	----	----	12.8	----
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	----	----	----	<100	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	20	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	BH1762-01 9-9.45	BH1762-01 13.5-13.95	BH1762-01 18-18.45	BH1762-02 0.5-0.75	BH1762-02-0.75-1
				Client sampling date / time	[03-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]
Compound	CAS Number	LOR	Unit		EP1603049-012	EP1603049-013	EP1603049-014	EP1603049-015	EP1603049-016
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.7	5.3	5.3	----	----
EA003 :pH (field/fox)									
pH (F)	----	0.1	pH Unit		5.5	5.8	5.5	6.8	6.8
pH (Fox)	----	0.1	pH Unit		4.2	3.1	3.2	3.6	3.8
Reaction Rate	----	1	Reaction Unit		2	2	2	2	2
EA014 Total Soluble Salts									
Total Soluble Salts	----	5	mg/kg		141	435	222	----	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		18.5	21.2	20.9	----	----
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		<100	<100	<100	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		70	250	120	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-02 1-1.25	BH1762-02 1.25-1.5	BH1762-02 2.5-2.75	BH1762-02 3-3.45	BH1762-02 5-5.1
			Client sampling date / time	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-017	EP1603049-018	EP1603049-020	EP1603049-022	EP1603049-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.7	----	----	----	3.8
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	6.7	6.5	6.3	5.5	5.3
pH (Fox)	----	0.1	pH Unit	3.8	3.7	3.5	1.2	1.3
Reaction Rate	----	1	Reaction Unit	2	1	1	4	4
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	70	----	----	----	1920
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	4.5	----	----	----	14.6
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	----	----	----	1510
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	----	----	----	110
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	----	----	----	6.4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-02 8-8.45	BH1762-02 9.5-9.95	BH1762-02 14-14.45	BH1762-02 19.5-19.95	BH1763-02 1-1.1
			Client sampling date / time	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]	[04-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-027	EP1603049-028	EP1603049-029	EP1603049-030	EP1603049-031
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**----**	**----**	**6.0**	**5.7**	**----**
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	**6.6**	**6.3**	**----**	**5.8**	**7.0**
pH (Fox)	----	0.1	pH Unit	**4.1**	**4.3**	**----**	**1.8**	**4.7**
Reaction Rate	----	1	Reaction Unit	**2**	**2**	**----**	**2**	**1**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**----**	**----**	**372**	**383**	**----**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**----**	**----**	**20.8**	**20.3**	**----**
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	**----**	**----**	<100	<100	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**----**	**----**	**190**	**220**	**----**
EP004: Organic Matter								
Organic Matter	----	0.5	%	**----**	**----**	**----**	**----**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1763-02 1.4-1.5	BH1763-02 1.5-1.95	BH1763-02 2-2.1	BH1763-02 2.5-2.6	BH1763-02 2.9-3
			Client sampling date / time	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-032	EP1603049-033	EP1603049-034	EP1603049-035	EP1603049-036
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**----**	**6.4**	**----**	**----**	**----**
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	**6.7**	**6.2**	**6.3**	**7.1**	**8.2**
pH (Fox)	----	0.1	pH Unit	**4.9**	**4.5**	**4.6**	**4.8**	**5.1**
Reaction Rate	----	1	Reaction Unit	**1**	**1**	**1**	**1**	**1**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**----**	**322**	**----**	**----**	**----**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**----**	**1.1**	**----**	**----**	**----**
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	**----**	<100	**----**	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**----**	**90**	**----**	**----**	**----**
EP004: Organic Matter								
Organic Matter	----	0.5	%	**----**	**----**	**----**	**----**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1763-02 3-3.45	BH1763-02 4-4.1	BH1763-02 4.4-4.5	BH1763-02 7-7.1	BH1763-02 9-9.45
			Client sampling date / time	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603049-037	EP1603049-038	EP1603049-039	EP1603049-040	EP1603049-041
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	7.6	----	----	6.8
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	8.3	7.7	7.2	8.9	7.2
pH (Fox)	----	0.1	pH Unit	3.5	5.8	5.2	8.4	5.1
Reaction Rate	----	1	Reaction Unit	2	2	2	4	3
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	----	210	----	----	98
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	14.0	----	----	14.1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	----	<100	----	----	<100
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	80	----	----	40
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-02 9.0-9.1	BH1763-02 5-5.1	----	----	----
			Client sampling date / time	[04-Apr-2016]	[04-Apr-2016]	----	----	----
Compound	CAS Number	LOR	Unit	EP1603049-042	EP1603049-043	--------	--------	--------
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	----	----	----	----
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	6.6	8.7	----	----	----
pH (Fox)	----	0.1	pH Unit	4.4	2.6	----	----	----
Reaction Rate	----	1	Reaction Unit	2	3	----	----	----
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	----	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	----	----	----	----
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	----	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1603726**	Page	: 1 of 2
Client	: **MATERIAL CONSULTANTS**	Laboratory	: Environmental Division Perth
Contact	: RYAN GROVES	Contact	: Customer Services EP
Address	: 72 Collingwood Street Osborne Park Perth Western Australia 6017	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 9244 3080	Telephone	: +61-8-9209 7655
Project	: Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN	Date Samples Received	: 28-Apr-2016 12:40
Order number	: ----	Date Analysis Commenced	: 02-May-2016
C-O-C number	: ----	Issue Date	: 06-May-2016 06:57
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

NATA Accredited Laboratory 825
Accredited for compliance with ISO/IEC 17025.

NATA WORLD RECOGNISED ACCREDITATION

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Supervisor	Perth Inorganics, Malaga, WA

General Comments

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Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**64_223 922 Clayey Sand BH1761-02(20.5m to 21.1m)**	**64_224 923 Sandy Clay BH1761-02(21.2m to 21.5m)**	**----**	**----**	**----**
			Client sampling date / time	[28-Apr-2016]	[28-Apr-2016]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1603726-001**	**EP1603726-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.5**	**5.6**	**----**	**----**	**----**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**604**	**1400**	**----**	**----**	**----**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**19.7**	**21.3**	**----**	**----**	**----**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**270**	**1020**	**----**	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**160**	**190**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1603725**	Page	: 1 of 2
Client	: **MATERIAL CONSULTANTS**	Laboratory	: Environmental Division Perth
Contact	: RYAN GROVES	Contact	: Customer Services EP
Address	: 72 Collingwood Street Osborne Park Perth Western Australia 6017	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 9244 3080	Telephone	: +61-8-9209 7655
Project	: Bridge 1761-1763, Busselton - Project No. 60344161.100-243.01.1761.EN	Date Samples Received	: 28-Apr-2016 12:48
Order number	: 000719	Date Analysis Commenced	: 02-May-2016
C-O-C number	: ----	Issue Date	: 05-May-2016 18:46
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

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Accredited for compliance with ISO/IEC 17025.

NATA
WORLD RECOGNISED ACCREDITATION

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Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Supervisor	Perth Inorganics, Malaga, WA

General Comments

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Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**64_239 938 Silty Sand, BH1762-02, 6.0m to 6.45m**	**64_250 949 Clay, BH1763-02, 6.5 to 7.0m**	**----**	**----**	**----**
			Client sampling date / time	[28-Apr-2016]	[28-Apr-2016]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1603725-001**	**EP1603725-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.2**	**9.5**	**----**	**----**	**----**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**210**	**421**	**----**	**----**	**----**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**21.6**	**31.2**	**----**	**----**	**----**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**70**	**50**	**----**	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**60**	**50**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1603862**	Page	: 1 of 3
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: ARASH GROBAN	Contact	: Kim Smith
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61-8-9209 7655
Project	: Engineering Technical Services ETS Bridge Design Services - Main Roads WA Panel	Date Samples Received	: 03-May-2016 09:20
Order number	: 60344161 task 100	Date Analysis Commenced	: 04-May-2016
C-O-C number	: ----	Issue Date	: 11-May-2016 07:09
Sampler	: ----		
Site	: 243.01.1761.EN ETS/BDS Panel Main Roads Panel - Bussel Highway Duplication Bridges 1761, 1762 and 1763		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		

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WORLD RECOGNISED ACCREDITATION

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Signatories

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Signatories	*Position*	*Accreditation Category*
Efua Wilson	Metals Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Supervisor	Perth Inorganics, Malaga, WA

General Comments

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- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1603184**	Page	: 1 of 4
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Loren Schiavon
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61 2 8784 8503
Project	: EX EP1602823 & EP1602905 60344161.100 - 143.01.1761.EN Bridge 1761-1763	Date Samples Received	: 01-Apr-2016 16:14
Order number	: 60344161.100-243.01.1761.EN	Date Analysis Commenced	: 13-Apr-2016
C-O-C number	: ----	Issue Date	: 19-Apr-2016 16:09
Sampler	: ----		
Site	: Busselton		
Quote number	: ----		
No. of samples received	: 9		
No. of samples analysed	: 8		

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Accredited for compliance with ISO/IEC 17025.

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WORLD RECOGNISED ACCREDITATION

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Signatories

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Signatories	*Position*	*Accreditation Category*
Indra Astuty	Instrument Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Supervisor	Perth Inorganics, Malaga, WA

General Comments

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Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-01 1.5-1.75	BH1761-01 4.5-4.6	BH1761-01A 6-6.1	BH1761-02 0.75-1	BH1761-02 2.5-2.9
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]
Compound	CAS Number	LOR	Unit	EP1603184-001	EP1603184-002	EP1603184-004	EP1603184-005	EP1603184-006
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.4**	**----**	**7.0**	**6.1**	**6.3**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**152**	**----**	**595**	**90**	**52**
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	**----**	**140**	<100	<100
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**20**	**----**	**160**	<10	<10
EP004: Organic Matter								
Organic Matter	----	0.5	%	**----**	**8.1**	<0.5	**----**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1761-02 5.7-6	BH1763-01 2-2.45	BH1763-01 8-8.3	----	----
			Client sampling date / time	[01-Apr-2016]	[01-Apr-2016]	[01-Apr-2016]	----	----
Compound	CAS Number	LOR	Unit	EP1603184-007	EP1603184-008	EP1603184-009	--------	--------
				Result	Result	Result	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**5.2**	**6.3**	**6.7**	**----**	**----**
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	**923**	**301**	**254**	**----**	**----**
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	**820**	**230**	<100	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**150**	**70**	**60**	**----**	**----**
EP004: Organic Matter								
Organic Matter	----	0.5	%	**----**	**----**	**----**	**----**	**----**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Bridge 1761	Bridge 1762	Bridge 1763	----	----
			Client sampling date / time	03-May-2016 09:00	03-May-2016 09:00	03-May-2016 09:00	----	----
Compound	CAS Number	LOR	Unit	EP1603862-001	EP1603862-002	EP1603862-003	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.74**	**6.74**	**7.39**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2150**	**1410**	**1310**	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**2030**	**898**	**1370**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**133**	**85**	**180**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**133**	**85**	**180**	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**20**	**22**	**16**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**140**	**66**	**53**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**528**	**379**	**282**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**17**	**8**	**39**	----	----
Magnesium	7439-95-4	1	mg/L	**30**	**15**	**27**	----	----
Sodium	7440-23-5	1	mg/L	**400**	**264**	**204**	----	----
Potassium	7440-09-7	1	mg/L	**11**	**10**	**12**	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.01**	<0.01	----	----
Manganese	7439-96-5	0.001	mg/L	**0.123**	**0.057**	**0.132**	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**20.5**	**13.8**	**12.6**	----	----
Total Cations	----	0.01	meq/L	**21.0**	**13.4**	**13.3**	----	----
Ionic Balance	----	0.01	%	**1.26**	**1.46**	**2.65**	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1605227**	Page	: 1 of 6
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR BEN FOLLETT	Contact	: Kim Smith
Address	: LEVEL 6, 3 FORREST PLACE PERTH WA 6849	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 6432 2000	Telephone	: +61-8-9209 7655
Project	: Ex EP1603049 60344161.100-243.01.1761.EN Bridge 1761-1763	Date Samples Received	: 07-Apr-2016 12:38
Order number	: 60344161.100-243.01.1761.EN	Date Analysis Commenced	: 09-Jun-2016
C-O-C number	: ----	Issue Date	: 17-Jun-2016 16:12
Sampler	: ----		
Site	: Busselton		
Quote number	: ----		
No. of samples received	: 9		
No. of samples analysed	: 9		

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NATA
WORLD RECOGNISED ACCREDITATION

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Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

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~ = Indicates an estimated value.

- ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA029 (SPOCAS): Excess ANC not required because pH OX less than 6.5.
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	BH1762-01 2-2.1	BH1762-01 3.5-3.6	BH1762-01 4-4.1	BH1762-02 3-3.45	BH1762-02 5-5.1
				Client sampling date / time	[02-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]
Compound	CAS Number	LOR	Unit		EP1605227-001	EP1605227-002	EP1605227-003	EP1605227-004	EP1605227-005
					Result	Result	Result	Result	Result
EA029-A: pH Measurements									
pH KCl (23A)	----	0.1	pH Unit		----	5.2	5.4	4.7	4.9
pH OX (23B)	----	0.1	pH Unit		----	2.6	2.8	2.1	2.0
EA029-B: Acidity Trail									
Titratable Actual Acidity (23F)	----	2	mole H+ / t		----	8	3	128	73
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t		----	99	55	2460	2640
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t		----	91	52	2330	2570
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S		----	0.013	<0.005	0.205	0.118
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S		----	0.158	0.088	3.94	4.24
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S		----	0.146	0.084	3.74	4.12
EA029-C: Sulfur Trail									
KCl Extractable Sulfur (23Ce)	----	0.005	% S		----	0.018	0.014	0.405	0.165
Peroxide Sulfur (23De)	----	0.005	% S		----	0.181	0.102	4.61	4.75
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S		----	0.163	0.088	4.20	4.58
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t		----	102	55	2620	2860
EA029-D: Calcium Values									
KCl Extractable Calcium (23Vh)	----	0.005	% Ca		----	<0.005	<0.005	0.021	0.015
Peroxide Calcium (23Wh)	----	0.005	% Ca		----	<0.005	<0.005	0.025	0.016
Acid Reacted Calcium (23X)	----	0.005	% Ca		----	<0.005	<0.005	<0.005	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t		----	<5	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S		----	<0.005	<0.005	<0.005	<0.005
EA029-E: Magnesium Values									
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg		----	<0.005	<0.005	0.034	0.015
Peroxide Magnesium (23Tm)	----	0.005	% Mg		----	<0.005	<0.005	0.035	0.016
Acid Reacted Magnesium (23U)	----	0.005	% Mg		----	<0.005	<0.005	<0.005	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t		----	<5	<5	<5	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S		----	<0.005	<0.005	<0.005	<0.005
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		----	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S		----	0.18	0.09	4.41	4.70
Net Acidity (acidity units)	----	10	mole H+ / t		----	110	58	2750	2930
Liming Rate	----	1	kg CaCO3/t		----	8	4	206	220

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	BH1762-01 2-2.1	BH1762-01 3.5-3.6	BH1762-01 4-4.1	BH1762-02 3-3.45	BH1762-02 5-5.1
				Client sampling date / time	[02-Apr-2016]	[03-Apr-2016]	[03-Apr-2016]	[02-Apr-2016]	[02-Apr-2016]
Compound	CAS Number	LOR	Unit		EP1605227-001	EP1605227-002	EP1605227-003	EP1605227-004	EP1605227-005
					Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting - Continued									
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		----	0.18	0.09	4.41	4.70
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		----	110	58	2750	2930
Liming Rate excluding ANC	----	1	kg CaCO3/t		----	8	4	206	220
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		4.9	----	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t		55	----	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		0.09	----	----	----	----
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.005	% S		1.00	----	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		626	----	----	----	----
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		1.5	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S		1.09	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t		681	----	----	----	----
Liming Rate	----	1	kg CaCO3/t		51	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		1.09	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		681	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t		51	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BH1762-02 19.5-19.95	BH1763-02 2.9-3	BH1763-02 5-5.1	BH1763-02 9-9.45	----
			Client sampling date / time	[02-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	----
Compound	CAS Number	LOR	Unit	EP1605227-006	EP1605227-007	EP1605227-008	EP1605227-009	--------
				Result	Result	Result	Result	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**6.0**	**6.5**	**6.4**	----	----
pH OX (23B)	----	0.1	pH Unit	**4.3**	**6.2**	**5.0**	----	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	----	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	**22**	<2	**9**	----	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	**21**	<2	**9**	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	**0.036**	<0.005	**0.015**	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	**0.034**	<0.005	**0.015**	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	<0.005	<0.005	<0.005	----	----
Peroxide Sulfur (23De)	----	0.005	% S	**0.060**	<0.005	**0.044**	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	**0.055**	<0.005	**0.041**	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	**34**	<5	**25**	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.011**	<0.005	**0.050**	----	----
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.013**	<0.005	**0.052**	----	----
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	----	----
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.020**	<0.005	**0.021**	----	----
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.025**	<0.005	**0.023**	----	----
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	**0.006**	<0.005	<0.005	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	----	----
Net Acidity (sulfur units)	----	0.02	% S	**0.06**	<0.02	**0.04**	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	**36**	<10	**25**	----	----
Liming Rate	----	1	kg CaCO3/t	**3**	<1	**2**	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	BH1762-02 19.5-19.95	BH1763-02 2.9-3	BH1763-02 5-5.1	BH1763-02 9-9.45	----
				Client sampling date / time	[02-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	[04-Apr-2016]	----
Compound	CAS Number	LOR	Unit		EP1605227-006	EP1605227-007	EP1605227-008	EP1605227-009	--------
					Result	Result	Result	Result	----
EA029-H: Acid Base Accounting - Continued									
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		**0.06**	<0.02	**0.04**	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		**36**	<10	**25**	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t		**3**	<1	**2**	----	----
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		----	----	----	**5.9**	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t		----	----	----	<2	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		----	----	----	<0.02	----
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.005	% S		----	----	----	<0.005	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		----	----	----	<10	----
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		----	----	----	**1.5**	----
Net Acidity (sulfur units)	----	0.02	% S		----	----	----	<0.02	----
Net Acidity (acidity units)	----	10	mole H+ / t		----	----	----	<10	----
Liming Rate	----	1	kg CaCO3/t		----	----	----	<1	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		----	----	----	<0.02	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		----	----	----	<10	----
Liming Rate excluding ANC	----	1	kg CaCO3/t		----	----	----	<1	----

Appendix E

Pile Capacity Estimates

PROJECT : Bridge 1763 - Bussell Highway over Sabina River

VERTICAL BEARING CAPACITY CALCULATION

AECOM

Type of pile : Steel tube piles with RC
Size of pile : 610 mm
Reference borehole : BH1763-01, BH1763-02
Reference structure : Abutments 1 & 2
f_g = 0.75

Case i : (unplugged) $R_{d,ug}$ = $(1.50 \times Sf_s \times A_s) + (F_b \times A_{anulus})$
Case ii : (compressible plug) $R_{d,ug}$ = $(Sf_s \times A_s) + 0.77*(F_b \times A_b)$
Case iii : (plugged, concrete backfilled) $R_{d,ug}$ = $(Sf_s \times A_s) + (F_b \times A_b)$

Ed = 1200 kN Compression
0 kN Tension

fs lim 95
fb lim 8000

Depth (m) From	-	To	Elevation (RL) From	-	To	Material Type	Consistency/ density	N value (Blow/ft)	f_s (kN/m^2)	f_s, lim (kN/m^2)	$f_s \times A_s$ (kN)	$Sf_s \times A_s$ (kN)	K	f_b (kN/m^2)	f_b, lim (kN/m^2)	End Bearing i $f_b \times A_b$ (kN)	End Bearing ii $f_b \times A_b$ (kN)	End Bearing iii $f_b \times A_b$ (kN)	Ultimate geotechnical strength of pile i $R_{d,ug}$ (kN)	Ultimate geotechnical strength of pile ii $R_{d,ug}$ (kN)	Ultimate geotechnical strength of pile iii $R_{d,ug}$ (kN)	Compression Design geotechnical strength of i $f_g R_{d,ug}$ (kN)	Compression Design geotechnical strength of ii $f_g R_{d,ug}$ (kN)	Compression Design geotechnical strength of iii $f_g R_{d,ug}$ (kN)	Tension $f_g R_{d,ug}$ (kN)
0.0	-	1.0	11.70	-	10.70	silty sand	L	Soil within this depth is neglected for the vertical bearing capacity calculation																	
1.0	-	2.0	10.70	-	9.70	silty sand	L																		
2.0	-	3.0	9.70	-	8.70	silty sand	L	7	17.6	17.6	33.7	33.7	300	2100	2100	77.8	472.6	613.7	128.4	506.3	647.4	96	380	486	25
3.0	-	4.0	8.70	-	7.70	silty sand	L	7	17.6	17.6	33.7	67.5	300	2100	2100	77.8	472.6	613.7	179.0	540.0	681.2	134	405	511	51
4.0	-	5.0	7.70	-	6.70	silty sand	L	7	17.6	17.6	33.7	101.2	300	2100	2100	77.8	472.6	613.7	229.6	573.7	714.9	172	430	536	76
5.0	-	6.0	6.70	-	5.70	silty sand	L	7	17.6	17.6	33.7	134.9	300	2100	2100	77.8	472.6	613.7	280.2	607.5	748.6	210	456	561	101
6.0	-	7.0	5.70	-	4.70	silty sand	L	7	17.6	17.6	33.7	168.6	300	2100	2100	77.8	472.6	613.7	330.8	641.2	782.4	248	481	587	126
7.0	-	8.0	4.70	-	3.70	silty sand	L	7	17.6	17.6	33.7	202.4	300	2100	2100	77.8	472.6	613.7	381.4	674.9	816.1	286	506	612	152
8.0	-	9.0	3.70	-	2.70	clay and silt	VSt	23	46.4	46.4	88.9	291.3	300	6900	6900	255.8	1552.7	2016.5	692.7	1844.0	2307.8	520	1383	1731	218
9.0	-	10.0	2.70	-	1.70	clay and silt	VSt	23	46.4	46.4	88.9	380.2	300	6900	6900	255.8	1552.7	2016.5	826.1	1932.9	2396.7	620	1450	1798	285
10.0	-	10.5	1.70	-	1.20	clay and silt	VSt	23	46.4	46.4	44.5	424.7	300	6900	6900	255.8	1552.7	2016.5	892.8	1977.4	2441.2	670	1483	1831	319
10.5	-	11.0	1.20	-	0.70	clay and silt	VSt	23	46.4	46.4	44.5	469.1	300	6900	6900	255.8	1552.7	2016.5	959.5	2021.8	2485.6	720	1516	1864	352
11.0	-	11.5	0.70	-	0.20	clay and silt	VSt	23	46.4	46.4	44.5	513.6	300	6900	6900	255.8	1552.7	2016.5	1026.2	2066.3	2530.1	770	1550	1898	385
11.5	-	12.0	0.20	-	-0.30	clay and silt	VSt	23	46.4	46.4	44.5	558.0	300	6900	6900	255.8	1552.7	2016.5	1092.9	2110.8	2574.5	820	1583	1931	419
12.0	-	12.5	-0.30	-	-0.80	clay and silt	VSt	23	46.4	46.4	44.5	602.5	300	6900	6900	255.8	1552.7	2016.5	1159.5	2155.2	2619.0	870	1616	1964	452
12.5	-	13.0	-0.80	-	-1.30	clay and silt	VSt	23	46.4	46.4	44.5	647.0	300	6900	6900	255.8	1552.7	2016.5	1226.2	2199.7	2663.5	920	1650	1998	485
13.0	-	13.5	-1.30	-	-1.80	clay and silt	VSt	23	46.4	46.4	44.5	691.4	300	6900	6900	255.8	1552.7	2016.5	1292.9	2244.1	2707.9	970	1683	2031	519
13.5	-	14.0	-1.80	-	-2.30	clay and silt	VSt	23	46.4	46.4	44.5	735.9	300	6900	6900	255.8	1552.7	2016.5	1359.6	2288.6	2752.4	1020	1716	2064	552
14.0	-	14.5	-2.30	-	-2.80	clay and silt	VSt	23	46.4	46.4	44.5	780.3	300	6900	6900	255.8	1552.7	2016.5	1426.3	2333.1	2796.8	1070	1750	2098	585
14.5	-	15.0	-2.80	-	-3.30	clay and silt	VSt	23	46.4	46.4	44.5	824.8	300	6900	6900	255.8	1552.7	2016.5	1493.0	2377.5	2841.3	1120	1783	2131	619
15.0	-	15.5	-3.30	-	-3.80	clay and silt	VSt	23	46.4	46.4	44.5	869.3	300	6900	6900	255.8	1552.7	2016.5	1559.7	2422.0	2885.8	1170	1816	2164	652
15.5	-	16.0	-3.80	-	-4.30	clay and silt	VSt	23	46.4	46.4	44.5	913.7	300	6900	6900	255.8	1552.7	2016.5	1626.4	2466.4	2930.2	1220	1850	2198	685
16.0	-	16.5	-4.30	-	-4.80	sand/silt/clay	D	40	77.0	77.0	73.8	987.5	300	12000	8000	296.6	1800.2	2338.0	1777.8	2787.7	3325.5	1333	2091	2494	741
16.5	-	17.0	-4.80	-	-5.30	sand/silt/clay	D	40	77.0	77.0	73.8	1061.3	300	12000	8000	296.6	1800.2	2338.0	1888.5	2861.5	3399.3	1416	2146	2549	796
17.0	-	17.5	-5.30	-	-5.80	sand/silt/clay	D	40	77.0	77.0	73.8	1135.1	300	12000	8000	296.6	1800.2	2338.0	1999.2	2935.3	3473.0	1499	2201	2605	851
17.5	-	18	-5.80	-	-6.30	sand/silt/clay	D	40	77.0	77.0	73.8	1208.8	300	12000	8000	296.6	1800.2	2338.0	2109.8	3009.1	3546.8	1582	2257	2660	907
18.0	-	18.5	-6.30	-	-6.80	sand/silt/clay	D	40	77.0	77.0	73.8	1282.6	300	12000	8000	296.6	1800.2	2338.0	2220.5	3082.9	3620.6	1665	2312	2715	962
18.5	-	19	-6.80	-	-7.30	sand/silt/clay	D	40	77.0	77.0	73.8	1356.4	300	12000	8000	296.6	1800.2	2338.0	2331.2	3156.6	3694.4	1748	2367	2771	1017
19.0	-	19.5	-7.30	-	-7.80	sand/silt/clay	D	40	77.0	77.0	73.8	1430.2	300	12000	8000	296.6	1800.2	2338.0	2441.8	3230.4	3768.2	1831	2423	2826	1073
19.5	-	20	-7.80	-	-8.30	sand/silt/clay	D	40	77.0	77.0	73.8	1504.0	300	12000	8000	296.6	1800.2	2338.0	2552.5	3304.2	3841.9	1914	2478	2881	1128

GeoLogismiki
Geotechnical Engineers
Merarhias 56
http://www.geologismiki.gr

CPT: CPT-01
Total depth: 17.90 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

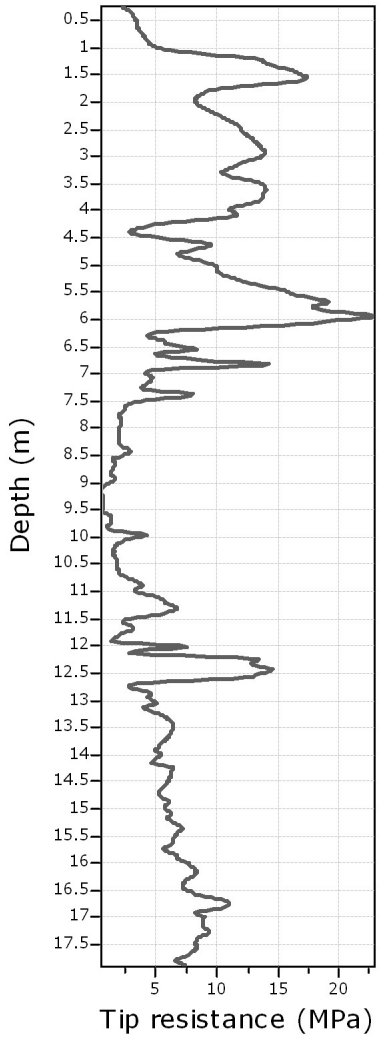
Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²

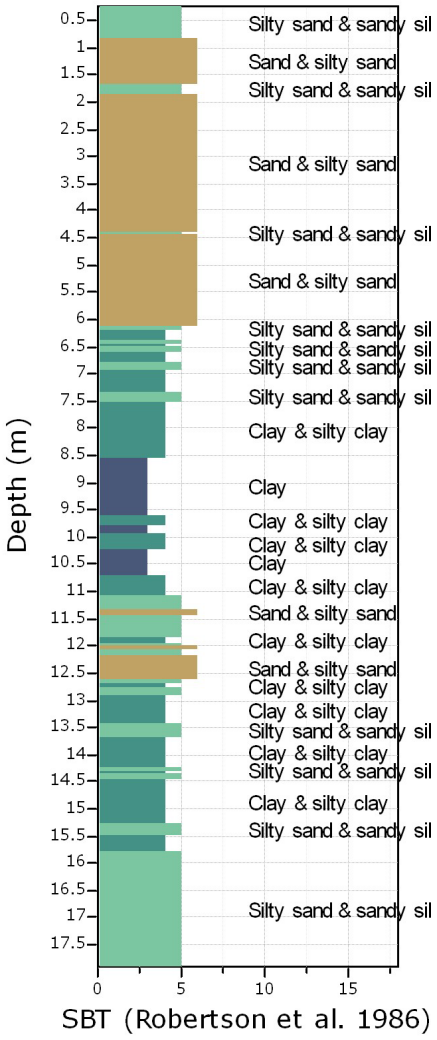
Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II

Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00

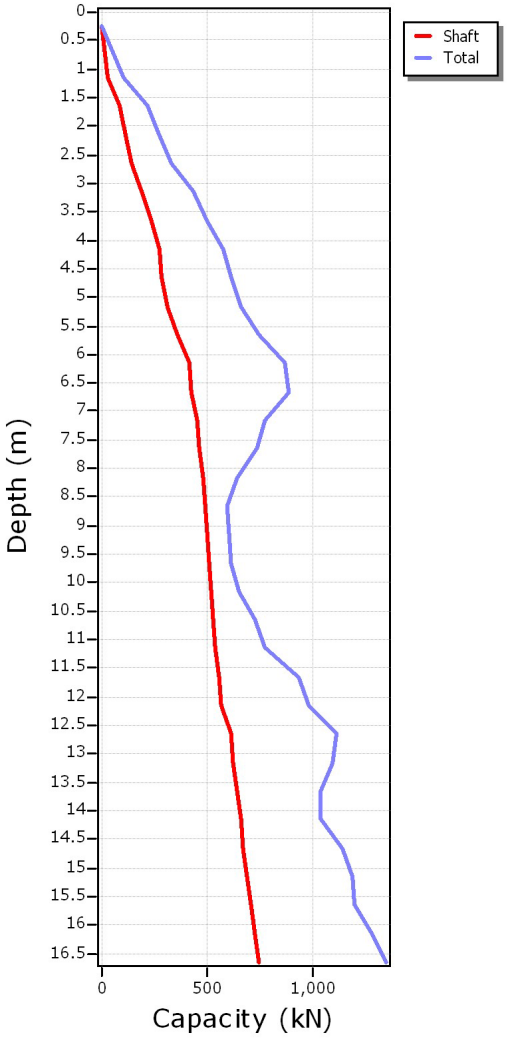
Cone resistance



Soil Behaviour Type



Allowable pile capacity



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s, outter}$ (kN)	$Q_{s, inner}$ (kN)	$Q_{b, steel}$ (kN)	$Q_{, total inner}$ (kN)	$Q_{b, total out}$ (kN)	$Q_{total, unplugged}$ (kN)	$Q_{total, plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	8.49	8.22	0.50	4.11	64.12	62.02	77.44	139.46	1200.61	203.58	1264.73	203.58	101.79
2	1.66	10.53	11.03	0.40	4.41	175.54	169.79	83.15	252.94	1289.19	428.48	1464.73	428.48	214.24
3	2.16	12.34	12.37	0.50	6.19	223.48	216.16	116.59	332.75	1807.66	556.23	2031.15	556.23	278.12
4	2.66	11.42	11.42	0.40	4.57	287.92	278.48	86.12	364.61	1335.25	652.53	1623.17	652.53	326.27
5	3.16	12.42	12.42	0.50	6.21	386.43	373.76	117.09	490.86	1815.45	877.29	2201.88	877.29	438.65
6	3.66	10.86	10.86	0.40	4.34	465.74	450.47	81.88	532.34	1269.42	998.08	1735.16	998.08	499.04
7	4.16	9.68	9.68	0.50	4.84	542.38	524.59	91.21	615.80	1414.10	1158.18	1956.48	1158.18	579.09
8	4.66	9.82	9.95	0.50	4.97	575.23	556.37	93.78	650.14	1453.92	1225.37	2029.15	1225.37	612.68
9	5.16	12.01	11.75	0.50	5.87	616.94	596.72	110.72	707.44	1716.64	1324.38	2333.59	1324.38	662.19
10	5.66	12.36	11.67	0.40	4.67	713.58	690.18	88.02	778.20	1364.66	1491.78	2078.24	1491.78	745.89
11	6.16	11.92	11.92	0.50	5.96	824.82	797.78	112.31	910.08	1741.21	1734.90	2566.03	1734.90	867.45
12	6.66	9.06	9.20	0.55	5.06	857.83	829.71	95.33	925.03	1477.97	1782.87	2335.81	1782.87	891.43
13	7.16	5.01	4.95	0.45	2.23	904.44	874.79	42.01	916.80	651.35	1821.25	1555.80	1555.80	777.90
14	7.66	4.02	4.03	0.45	1.82	934.10	903.47	34.22	937.70	530.63	1871.80	1464.73	1464.73	732.36
15	8.16	2.53	2.53	0.45	1.14	956.29	924.94	21.46	946.40	332.79	1902.70	1289.09	1289.09	644.54
16	8.66	1.56	1.56	0.45	0.70	981.74	949.55	13.27	962.81	205.66	1944.55	1187.40	1187.40	593.70
17	9.16	1.56	1.46	0.50	0.73	998.49	965.75	13.80	979.56	213.97	1978.05	1212.46	1212.46	606.23
18	9.66	1.47	1.42	0.50	0.71	1012.41	979.21	13.39	992.60	207.55	2005.01	1219.96	1219.96	609.98
19	10.16	2.01	1.98	0.45	0.89	1034.83	1000.90	16.78	1017.68	260.16	2052.52	1295.00	1295.00	647.50
20	10.66	3.13	2.97	0.45	1.34	1055.83	1021.21	25.22	1046.43	391.01	2102.26	1446.84	1446.84	723.42
21	11.16	3.44	3.24	0.50	1.62	1084.87	1049.30	30.52	1079.83	473.21	2164.70	1558.09	1558.09	779.04
22	11.66	6.02	5.15	0.50	2.58	1111.56	1075.11	48.58	1123.69	753.15	2235.25	1864.71	1864.71	932.36

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s,\ outter}$ (kN)	$Q_{s,\ inner}$ (kN)	$Q_{b,\ steel}$ (kN)	$Q_{,\ total\ inner}$ (kN)	$Q_{b,\ total\ out}$ (kN)	$Q_{total,\ unplugged}$ (kN)	$Q_{total,\ plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
23	12.16	6.22	5.63	0.50	2.81	1134.86	1097.66	53.05	1150.71	822.57	2285.57	1957.44	1957.44	978.72
24	12.66	6.58	6.95	0.50	3.47	1221.23	1181.19	65.47	1246.66	1015.03	2467.89	2236.26	2236.26	1118.13
25	13.16	6.91	7.09	0.45	3.19	1252.86	1211.78	60.17	1271.96	932.95	2524.82	2185.81	2185.81	1092.90
26	13.66	5.39	5.42	0.50	2.71	1282.31	1240.27	51.09	1291.36	792.08	2573.67	2074.39	2074.39	1037.20
27	14.16	5.76	5.76	0.45	2.59	1314.69	1271.59	48.88	1320.47	757.81	2635.16	2072.50	2072.50	1036.25
28	14.66	5.89	5.89	0.55	3.24	1345.71	1301.59	61.07	1362.66	946.79	2708.37	2292.50	2292.50	1146.25
29	15.16	6.27	6.27	0.55	3.45	1379.25	1334.03	65.05	1399.08	1008.48	2778.33	2387.74	2387.74	1193.87
30	15.66	6.78	6.78	0.50	3.39	1411.27	1365.00	63.95	1428.95	991.42	2840.22	2402.69	2402.69	1201.34
31	16.16	7.77	7.70	0.50	3.85	1445.66	1398.26	72.60	1470.86	1125.59	2916.52	2571.25	2571.25	1285.63
32	16.66	8.34	8.34	0.50	4.17	1484.10	1435.44	78.57	1514.02	1218.18	2998.12	2702.28	2702.28	1351.14

Abbreviations

Tip depth: Depth from free surface where tip capacity will be calculated
q'_{ca}: Mean q_t value between -a and +a (above and below pile tip depth respectively)
q_{ca}: Mean value between -a and +a according to LCPC method
k_c: Bearing capacity factor
q_p: Pile unit end bearing capacity
$Q_{s,\ outter}$: Shaft capacity outside
$Q_{s,\ inner}$: Shaft capacity inside
$Q_{b,\ steel}$: Base capacity of steel annulus
$Q_{,\ total\ inner}$: Total capacity inside
$Q_{b,\ total\ out}$: Base capacity of pile tip
$Q_{total,\ unplugged}$: Total capacity of unplugged pile
$Q_{total,\ plugged}$: Total capacity of plugged pile
$Q_{ultimate}$: Ultimate pile capacity
$Q_{allowable}$: Allowable pile capacity

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CPT: CPT-02
Total depth: 9.20 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

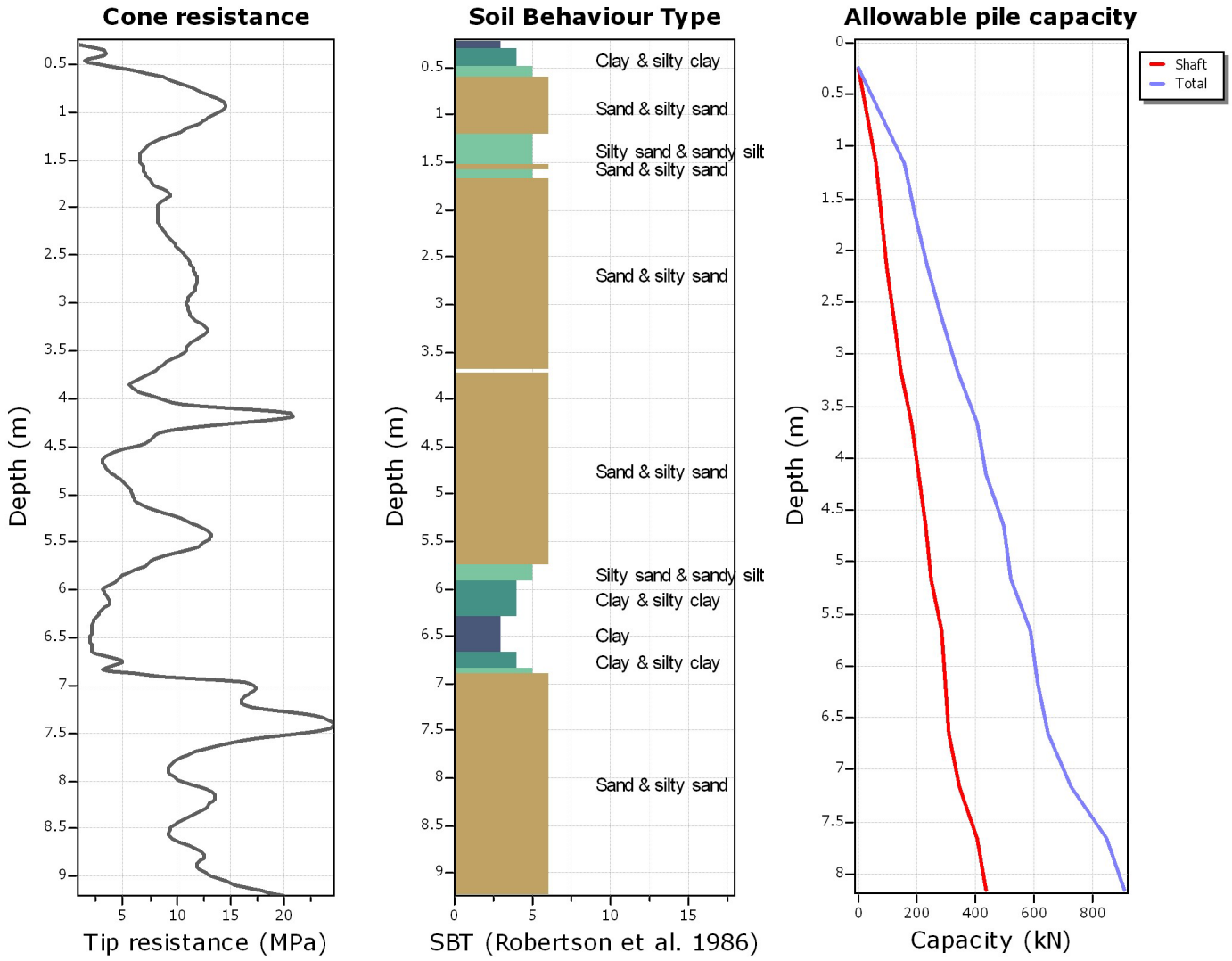
Project:
Location:

Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²

Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II

Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s, outter}$ (kN)	$Q_{s, inner}$ (kN)	$Q_{b, steel}$ (kN)	$Q_{, total inner}$ (kN)	$Q_{b, total out}$ (kN)	$Q_{total, unplugged}$ (kN)	$Q_{total, plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	8.27	8.87	0.50	4.43	117.43	113.58	83.56	197.14	1295.50	314.57	1412.93	314.57	157.29
2	1.66	9.62	9.63	0.50	4.81	154.02	148.97	90.72	239.69	1406.49	393.70	1560.51	393.70	196.85
3	2.16	9.27	9.27	0.50	4.64	194.19	187.82	87.37	275.20	1354.64	469.39	1548.84	469.39	234.69
4	2.66	10.43	10.43	0.50	5.21	242.53	234.58	98.29	332.87	1523.86	575.40	1766.39	575.40	287.70
5	3.16	10.25	10.25	0.50	5.12	297.34	287.60	96.59	384.18	1497.49	681.53	1794.83	681.53	340.76
6	3.66	10.47	10.04	0.50	5.02	364.01	352.07	94.67	446.74	1467.71	810.75	1831.72	810.75	405.37
7	4.16	8.64	8.26	0.40	3.30	414.40	400.81	62.28	463.09	965.60	877.49	1380.00	877.49	438.74
8	4.66	8.69	8.71	0.50	4.36	467.53	452.20	82.11	534.32	1273.08	1001.85	1740.61	1001.85	500.93
9	5.16	7.37	7.11	0.50	3.56	497.44	481.13	67.01	548.14	1038.94	1045.58	1536.38	1045.58	522.79
10	5.66	6.18	6.20	0.50	3.10	567.53	548.92	58.39	607.31	905.30	1174.84	1472.83	1174.84	587.42
11	6.16	6.82	6.29	0.45	2.83	598.69	579.06	53.35	632.41	827.15	1231.10	1425.84	1231.10	615.55
12	6.66	9.23	8.25	0.45	3.71	626.15	605.62	69.97	675.60	1084.87	1301.75	1711.03	1301.75	650.88
13	7.16	11.03	11.28	0.40	4.51	699.34	676.41	85.03	761.45	1318.38	1460.79	2017.72	1460.79	730.40
14	7.66	13.48	13.93	0.40	5.57	813.11	786.45	105.04	891.49	1628.54	1704.60	2441.65	1704.60	852.30
15	8.16	13.52	13.53	0.40	5.41	875.82	847.10	102.03	949.13	1581.87	1824.95	2457.69	1824.95	912.47

Abbreviations

Tip depth:	Depth from free surface where tip capacity will be calculated	$Q_{b, steel}$:	Base capacity of steel annulus
q'_{ca}:	Mean q_t value between -a and +a (above and below pile tip depth respectively)	$Q_{, total inner}$:	Total capacity inside
q_{ca}:	Mean value between -a and +a according to LCPC method	$Q_{b, total out}$:	Base capacity of pile tip
k_c:	Bearing capacity factor	$Q_{total, unplugged}$:	Total capacity of unplugged pile
q_p:	Pile unit end bearing capacity	$Q_{total, plugged}$:	Total capacity of plugged pile
$Q_{s, outter}$:	Shaft capacity outside	$Q_{ultimate}$:	Ultimate pile capacity
$Q_{s, inner}$:	Shaft capacity inside	$Q_{allowable}$:	Allowable pile capacity

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CPT: CPT-03
Total depth: 8.02 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

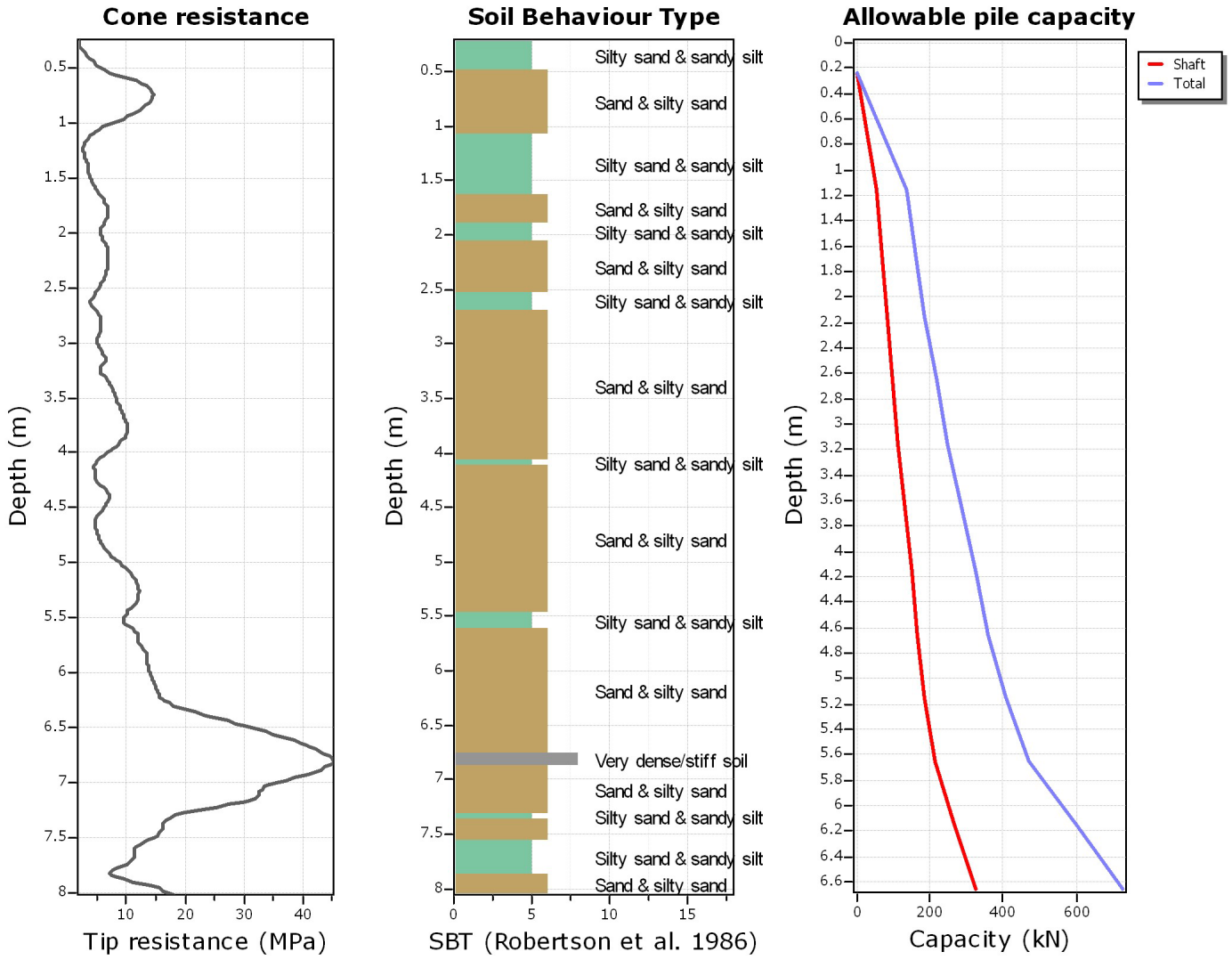
Project:
Location:

Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²

Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II

Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s, outter}$ (kN)	$Q_{s, inner}$ (kN)	$Q_{b, steel}$ (kN)	$Q_{, total inner}$ (kN)	$Q_{b, total out}$ (kN)	$Q_{total, unplugged}$ (kN)	$Q_{total, plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	6.45	6.68	0.50	3.34	104.92	101.48	63.00	164.47	976.69	269.39	1081.61	269.39	134.70
2	1.66	6.32	6.57	0.50	3.28	132.21	127.88	61.89	189.77	959.59	321.98	1091.80	321.98	160.99
3	2.16	5.40	5.47	0.50	2.74	162.73	157.40	51.57	208.96	799.47	371.69	962.21	371.69	185.85
4	2.66	6.18	6.16	0.50	3.08	193.86	187.51	58.08	245.58	900.41	439.44	1094.27	439.44	219.72
5	3.16	6.77	6.66	0.50	3.33	221.37	214.11	62.72	276.83	972.47	498.20	1193.84	498.20	249.10
6	3.66	6.82	6.69	0.50	3.35	257.28	248.85	63.07	311.91	977.84	569.20	1235.12	569.20	284.60
7	4.16	7.08	7.06	0.50	3.53	297.55	287.79	66.55	354.35	1031.87	651.89	1329.42	651.89	325.95
8	4.66	7.91	7.81	0.50	3.90	328.83	318.05	73.59	391.64	1140.98	720.47	1469.81	720.47	360.24
9	5.16	9.46	9.55	0.50	4.77	366.47	354.45	89.99	444.44	1395.25	810.91	1761.72	810.91	405.45
10	5.66	13.97	13.01	0.40	5.20	428.14	414.11	98.07	512.18	1520.54	940.32	1948.69	940.32	470.16
11	6.16	22.46	20.95	0.40	8.38	532.46	515.01	157.99	673.00	2449.55	1205.46	2982.01	1205.46	602.73
12	6.66	24.87	24.00	0.40	9.60	647.45	626.22	180.95	807.17	2805.52	1454.62	3452.97	1454.62	727.31

Abbreviations

Tip depth:	Depth from free surface where tip capacity will be calculated	$Q_{b, steel}$:	Base capacity of steel annulus
q'_{ca}:	Mean q_t value between -a and +a (above and below pile tip depth respectively)	$Q_{, total inner}$:	Total capacity inside
q_{ca}:	Mean value between -a and +a according to LCPC method	$Q_{b, total out}$:	Base capacity of pile tip
k_c:	Bearing capacity factor	$Q_{total, unplugged}$:	Total capacity of unplugged pile
q_p:	Pile unit end bearing capacity	$Q_{total, plugged}$:	Total capacity of plugged pile
$Q_{s, outter}$:	Shaft capacity outside	$Q_{ultimate}$:	Ultimate pile capacity
$Q_{s, inner}$:	Shaft capacity inside	$Q_{allowable}$:	Allowable pile capacity

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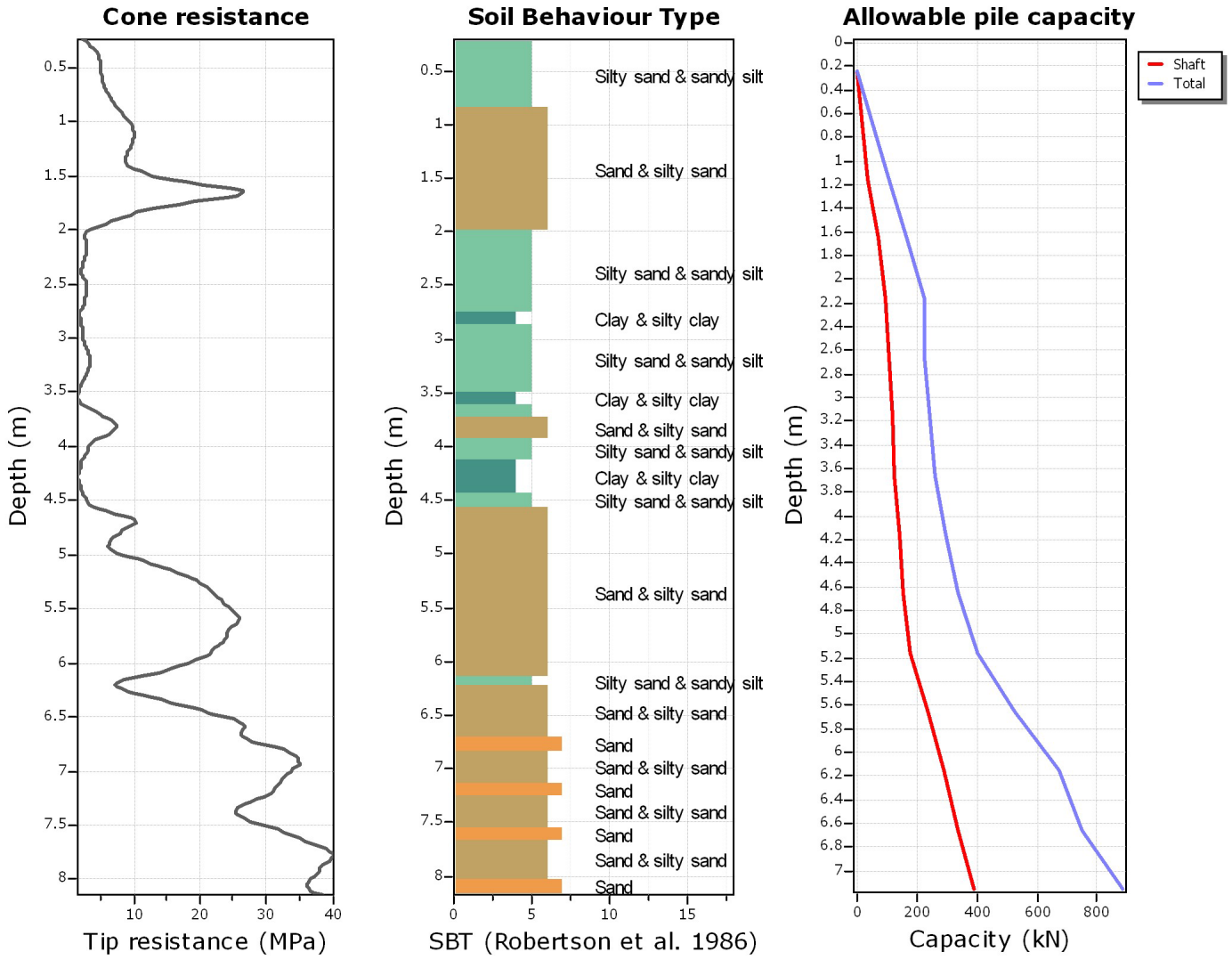
CPT: CPT-04
Total depth: 8.14 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s, outter}$ (kN)	$Q_{s, inner}$ (kN)	$Q_{b, steel}$ (kN)	$Q_{, total inner}$ (kN)	$Q_{b, total out}$ (kN)	$Q_{total, unplugged}$ (kN)	$Q_{total, plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	9.14	8.27	0.50	4.13	70.92	68.59	77.91	146.50	1207.86	217.41	1278.77	217.41	108.71
2	1.66	8.57	7.96	0.40	3.18	140.37	135.77	60.01	195.78	930.47	336.15	1070.84	336.15	168.08
3	2.16	6.88	7.09	0.50	3.54	193.94	187.58	66.79	254.38	1035.54	448.32	1229.49	448.32	224.16
4	2.66	3.52	3.55	0.50	1.77	213.92	206.91	33.45	240.36	518.64	454.28	732.56	454.28	227.14
5	3.16	2.99	2.70	0.50	1.35	232.27	224.65	25.45	250.10	394.56	482.37	626.83	482.37	241.18
6	3.66	2.94	2.67	0.50	1.34	251.89	243.63	25.17	268.80	390.17	520.69	642.07	520.69	260.35
7	4.16	4.51	4.13	0.50	2.06	279.32	270.16	38.89	309.05	602.94	588.37	882.26	588.37	294.18
8	4.66	9.46	8.62	0.50	4.31	301.31	291.43	81.23	372.66	1259.48	673.97	1560.78	673.97	336.98
9	5.16	14.16	14.25	0.40	5.70	354.12	342.51	107.42	449.93	1665.46	804.06	2019.58	804.06	402.03
10	5.66	17.24	17.72	0.40	7.09	469.11	453.73	133.57	587.30	2070.96	1056.41	2540.06	1056.41	528.20
11	6.16	22.87	22.46	0.50	11.23	574.91	556.06	211.72	767.78	3282.54	1342.68	3857.45	1342.68	671.34
12	6.66	24.36	25.07	0.40	10.03	668.45	646.53	189.02	835.55	2930.52	1504.00	3598.97	1504.00	752.00
13	7.16	29.83	30.58	0.40	12.23	783.43	757.74	230.57	988.32	3574.84	1771.75	4358.27	1771.75	885.87

Abbreviations

Tip depth:	Depth from free surface where tip capacity will be calculated	$Q_{b, steel}$:	Base capacity of steel annulus
q'_{ca}:	Mean q_t value between -a and +a (above and below pile tip depth respectively)	$Q_{, total inner}$:	Total capacity inside
q_{ca}:	Mean value between -a and +a according to LCPC method	$Q_{b, total out}$:	Base capacity of pile tip
k_c:	Bearing capacity factor	$Q_{total, unplugged}$:	Total capacity of unplugged pile
q_p:	Pile unit end bearing capacity	$Q_{total, plugged}$:	Total capacity of plugged pile
$Q_{s, outter}$:	Shaft capacity outside	$Q_{ultimate}$:	Ultimate pile capacity
$Q_{s, inner}$:	Shaft capacity inside	$Q_{allowable}$:	Allowable pile capacity

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CPT: CPT-05B
Total depth: 12.18 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

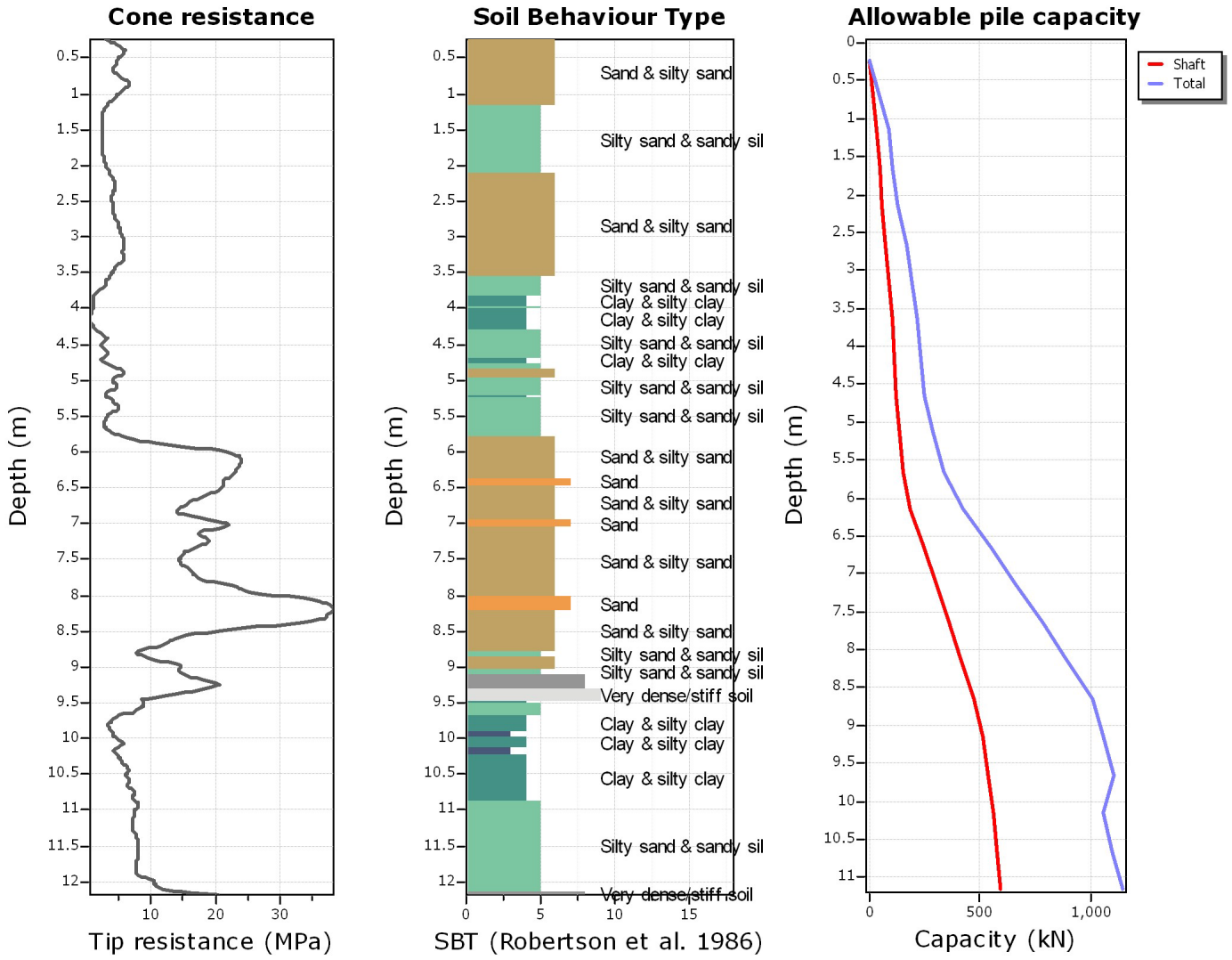
Project:
Location:

Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²

Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II

Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s,\ outter}$ (kN)	$Q_{s,\ inner}$ (kN)	$Q_{b,\ steel}$ (kN)	$Q_{,\ total\ inner}$ (kN)	$Q_{b,\ total\ out}$ (kN)	$Q_{total,\ unplugged}$ (kN)	$Q_{total,\ plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	3.99	3.99	0.50	1.99	68.05	65.81	37.59	103.41	582.87	171.45	650.91	171.45	85.73
2	1.66	3.83	3.83	0.50	1.92	89.79	86.85	36.14	122.99	560.27	212.78	650.07	212.78	106.39
3	2.16	3.85	3.77	0.50	1.89	114.85	111.08	35.55	146.63	551.14	261.48	665.99	261.48	130.74
4	2.66	4.51	4.54	0.50	2.27	148.26	143.39	42.83	186.22	664.00	334.48	812.25	334.48	167.24
5	3.16	4.12	4.07	0.50	2.03	176.79	171.00	38.33	209.32	594.23	386.11	771.02	386.11	193.06
6	3.66	3.49	3.49	0.50	1.74	205.75	199.01	32.86	231.86	509.42	437.62	715.17	437.62	218.81
7	4.16	3.14	3.21	0.50	1.60	219.40	212.21	30.22	242.42	468.48	461.82	687.87	461.82	230.91
8	4.66	3.05	3.06	0.50	1.53	239.73	231.87	28.83	260.71	447.03	500.44	686.77	500.44	250.22
9	5.16	5.72	4.70	0.50	2.35	269.17	260.35	44.28	304.62	686.48	573.79	955.65	573.79	286.90
10	5.66	10.96	9.97	0.50	4.98	297.07	287.33	93.95	381.28	1456.58	678.36	1753.65	678.36	339.18
11	6.16	14.45	15.53	0.40	6.21	375.80	363.48	117.13	480.61	1815.98	856.42	2191.78	856.42	428.21
12	6.66	17.87	18.32	0.40	7.33	490.79	474.70	138.16	612.86	2142.07	1103.64	2632.85	1103.64	551.82
13	7.16	19.35	18.91	0.40	7.56	604.75	584.93	142.58	727.50	2210.54	1332.26	2815.29	1332.26	666.13
14	7.66	22.17	20.79	0.40	8.31	719.00	695.42	156.73	852.15	2429.98	1571.15	3148.98	1571.15	785.57
15	8.16	20.56	19.32	0.40	7.73	833.98	806.63	145.66	952.30	2258.38	1786.27	3092.36	1786.27	893.14
16	8.66	20.10	20.13	0.40	8.05	946.66	915.62	151.78	1067.41	2353.26	2014.07	3299.92	2014.07	1007.03
17	9.16	13.78	13.74	0.40	5.49	1025.65	992.02	103.57	1095.59	1605.78	2121.25	2631.43	2121.25	1060.62
18	9.66	8.92	8.92	0.50	4.46	1080.61	1045.18	84.09	1129.27	1303.73	2209.88	2384.34	2209.88	1104.94
19	10.16	7.40	7.60	0.45	3.42	1113.80	1077.28	64.47	1141.76	999.61	2255.56	2113.41	2113.41	1056.71
20	10.66	6.47	6.55	0.55	3.60	1147.34	1109.72	67.90	1177.62	1052.72	2324.96	2200.05	2200.05	1100.03
21	11.16	7.63	7.58	0.50	3.79	1183.00	1144.22	71.41	1215.63	1107.20	2398.63	2290.20	2290.20	1145.10

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s,\ outter}$ (kN)	$Q_{s,\ inner}$ (kN)	$Q_{b,\ steel}$ (kN)	$Q_{,\ total\ inner}$ (kN)	$Q_{b,\ total\ out}$ (kN)	$Q_{total,\ unplugged}$ (kN)	$Q_{total,\ plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)

Abbreviations

Tip depth: Depth from free surface where tip capacity will be calculated
q'_{ca}: Mean q_t value between -a and +a (above and below pile tip depth respectively)
q_{ca}: Mean value between -a and +a according to LCPC method
k_c: Bearing capacity factor
q_p: Pile unit end bearing capacity
$Q_{s,\ outter}$: Shaft capacity outside
$Q_{s,\ inner}$: Shaft capacity inside
$Q_{b,\ steel}$: Base capacity of steel annulus
$Q_{,\ total\ inner}$: Total capacity inside
$Q_{b,\ total\ out}$: Base capacity of pile tip
$Q_{total,\ unplugged}$: Total capacity of unplugged pile
$Q_{total,\ plugged}$: Total capacity of plugged pile
$Q_{ultimate}$: Ultimate pile capacity
$Q_{allowable}$: Allowable pile capacity

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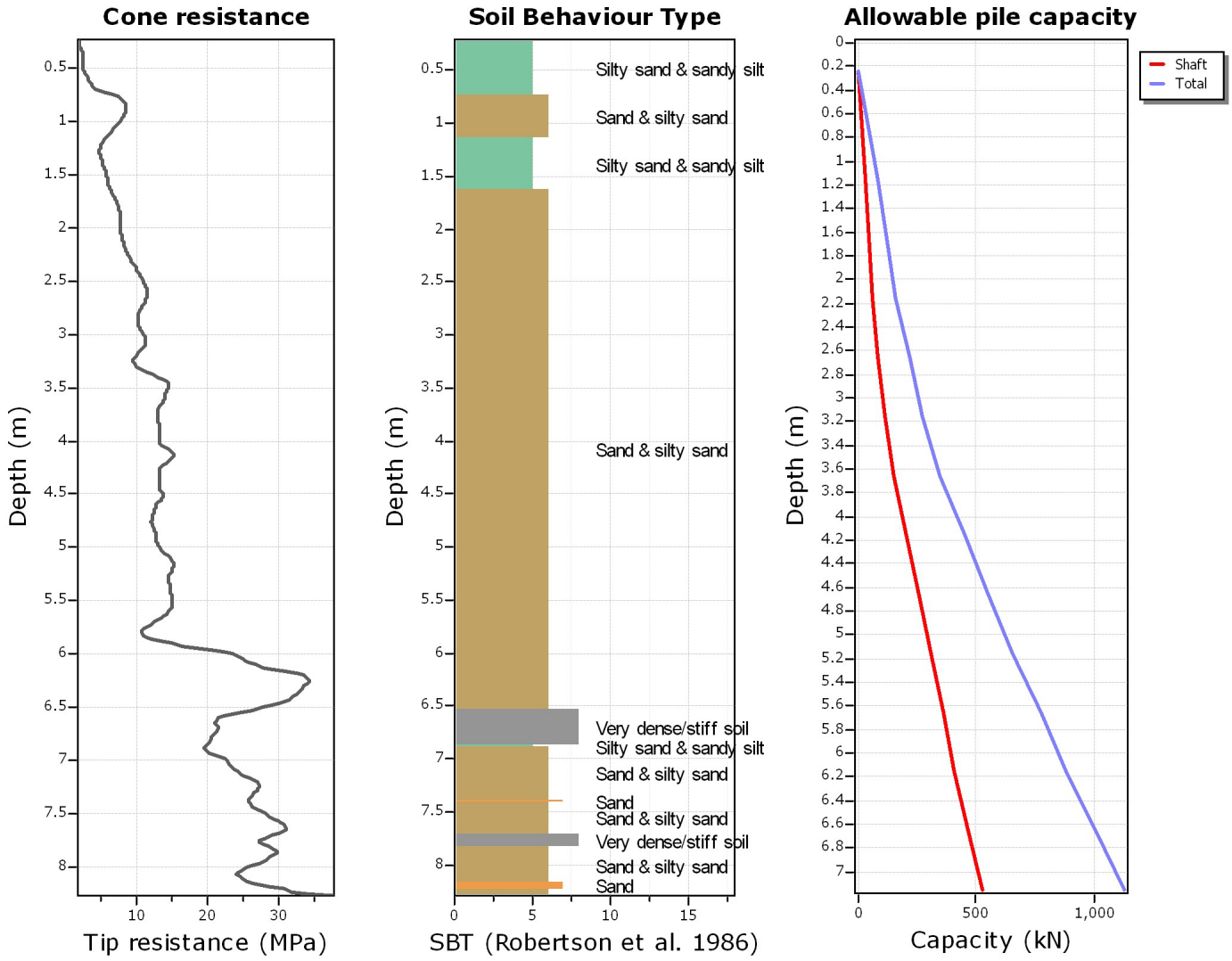
CPT: CPT-06
Total depth: 8.26 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m^2	Pile tip Group:	Group IIB
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m^2	Pile shaft FOS:	2.00
Internal diameter:	0.59 m^2	Inner unti friction area:	1.854 m^2	Pile tip FOS:	2.00
Solid pile tip area:	0.292 m^2	Pile shaft Group:	Group II		

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s, outter}$ (kN)	$Q_{s, inner}$ (kN)	$Q_{b, steel}$ (kN)	$Q_{, total inner}$ (kN)	$Q_{b, total out}$ (kN)	$Q_{total, unplugged}$ (kN)	$Q_{total, plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	5.59	5.87	0.50	2.94	58.04	56.14	55.33	111.47	857.80	169.51	915.85	169.51	84.75
2	1.66	7.44	7.35	0.50	3.67	86.41	83.58	69.24	152.82	1073.53	239.23	1159.94	239.23	119.62
3	2.16	8.44	8.51	0.50	4.26	122.51	118.50	80.24	198.73	1244.00	321.24	1366.52	321.24	160.62
4	2.66	10.14	10.04	0.50	5.02	170.90	165.30	94.64	259.94	1467.28	430.84	1638.18	430.84	215.42
5	3.16	11.64	11.64	0.50	5.82	222.19	214.91	109.70	324.61	1700.82	546.80	1923.01	546.80	273.40
6	3.66	12.53	12.53	0.40	5.01	305.31	295.30	94.47	389.77	1464.64	695.07	1769.95	695.07	347.54
7	4.16	13.12	13.12	0.40	5.25	409.10	395.69	98.94	494.63	1534.01	903.73	1943.11	903.73	451.86
8	4.66	13.69	13.69	0.40	5.48	511.19	494.43	103.24	597.67	1600.61	1108.85	2111.80	1108.85	554.43
9	5.16	14.33	13.93	0.40	5.57	611.88	591.82	105.07	696.89	1628.95	1308.77	2240.83	1308.77	654.38
10	5.66	19.02	17.51	0.40	7.00	724.34	700.60	132.01	832.61	2046.70	1556.95	2771.04	1556.95	778.47
11	6.16	21.13	20.64	0.40	8.26	819.33	792.47	155.66	948.12	2413.31	1767.46	3232.64	1767.46	883.73
12	6.66	24.52	25.04	0.40	10.02	934.31	903.68	188.81	1092.50	2927.42	2026.81	3861.73	2026.81	1013.41
13	7.16	26.44	26.44	0.40	10.58	1049.30	1014.89	199.36	1214.25	3090.88	2263.55	4140.18	2263.55	1131.77

Abbreviations

Tip depth:	Depth from free surface where tip capacity will be calculated	$Q_{b, steel}$:	Base capacity of steel annulus
q'_{ca}:	Mean q_t value between -a and +a (above and below pile tip depth respectively)	$Q_{, total inner}$:	Total capacity inside
q_{ca}:	Mean value between -a and +a according to LCPC method	$Q_{b, total out}$:	Base capacity of pile tip
k_c:	Bearing capacity factor	$Q_{total, unplugged}$:	Total capacity of unplugged pile
q_p:	Pile unit end bearing capacity	$Q_{total, plugged}$:	Total capacity of plugged pile
$Q_{s, outter}$:	Shaft capacity outside	$Q_{ultimate}$:	Ultimate pile capacity
$Q_{s, inner}$:	Shaft capacity inside	$Q_{allowable}$:	Allowable pile capacity

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CPT: CPT-07
Total depth: 15.38 m
Surface Elevation: 0.00 m
Coords: X:0, Y:0
Cone Type: Uknown
Cone Operator: Uknown

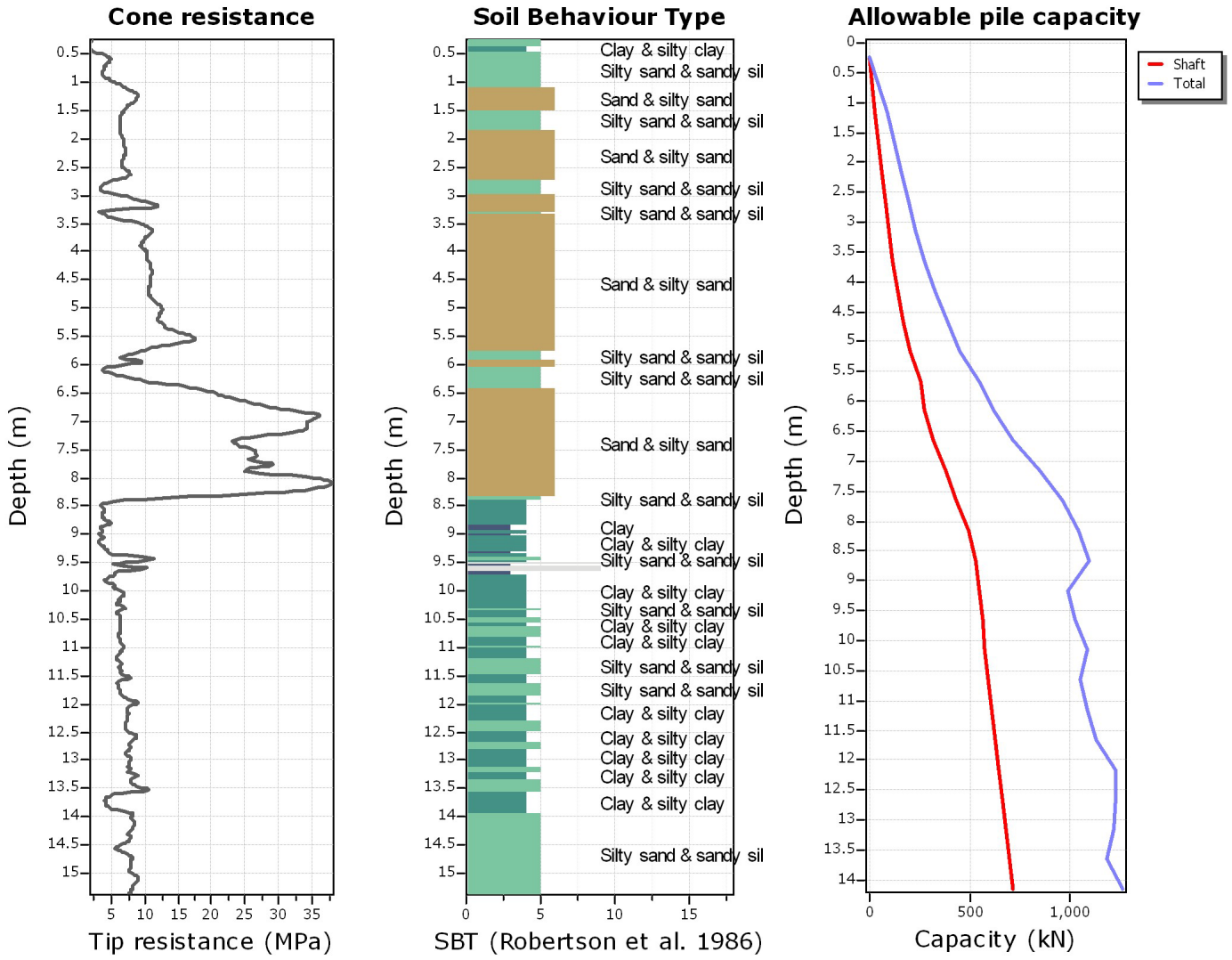
Project:
Location:

Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²

Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II

Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00



Pile group for bearing capacity factor k_c

- Group I: plain bored piles; mud bored piles; micro piles (grouted under low pressure); cased bored piles; hollow bored piles; piers; barrettes
- Group II: cast screwed piles; driven precast piles; prestressed tubular piles; driven cast piles; jacked metal piles; micropiles (small diameter piles grouted under high pressure with diameter < 250 mm); driven grouted piles (low pressure grouting); driven metal piles; driven rammed piles; jacket concrete piles; high pressure grouted piles of large diameter

Pile group for friction coefficient alpha

- Group IA: plain bored piles; mud bored piles; hollow auger bored piles; micro piles (grouted under low pressure); cast screwed piles; piers; barrettes
- Group IB: cased bored piles; driven cast piles
- Group IIA: driven precast piles; prestresses tubular piles; jacket concrete piles
- Group IIB: driven metal piles; jacked metal piles

Pile properties

Outter diameter: 0.61 m
Wall thickness: 0.010 m
Internal diameter: 0.59 m²
Solid pile tip area: 0.292 m²
Sectional area of steel tip: 0.019 m²
Outter unit friction area: 1.916 m²
Inner unti friction area: 1.854 m²
Pile shaft Group: Group II
Pile tip Group: Group IIB
Pile shaft FOS: 2.00
Pile tip FOS: 2.00

:: Pile bearing capacity calculations (f_p restrictions applied) ::

No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s,\ outter}$ (kN)	$Q_{s,\ inner}$ (kN)	$Q_{b,\ steel}$ (kN)	$Q_{,\ total\ inner}$ (kN)	$Q_{b,\ total\ out}$ (kN)	$Q_{total,\ unplugged}$ (kN)	$Q_{total,\ plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
1	1.16	5.63	5.75	0.50	2.87	59.76	57.80	54.16	111.95	839.65	171.71	899.41	171.71	85.86
2	1.66	6.63	6.71	0.50	3.36	96.36	93.20	63.28	156.49	981.18	252.85	1077.54	252.85	126.42
3	2.16	6.64	6.64	0.50	3.32	128.07	123.87	62.54	186.41	969.62	314.49	1097.69	314.49	157.24
4	2.66	6.79	6.56	0.50	3.28	161.76	156.46	61.81	218.27	958.28	380.03	1120.04	380.03	190.02
5	3.16	7.73	7.78	0.50	3.89	196.31	189.87	73.33	263.20	1136.84	459.50	1333.15	459.50	229.75
6	3.66	8.77	9.24	0.50	4.62	237.80	230.01	87.09	317.10	1350.25	554.90	1588.05	554.90	277.45
7	4.16	10.02	10.29	0.50	5.14	286.19	276.81	96.97	373.78	1503.40	659.97	1789.59	659.97	329.99
8	4.66	11.69	11.56	0.50	5.78	338.27	327.18	108.91	436.09	1688.57	774.37	2026.85	774.37	387.18
9	5.16	11.36	11.17	0.40	4.47	411.18	397.70	84.24	481.94	1306.10	893.12	1717.27	893.12	446.56
10	5.66	12.00	11.53	0.40	4.61	514.35	497.49	86.95	584.43	1348.02	1098.78	1862.37	1098.78	549.39
11	6.16	17.26	16.14	0.50	8.07	552.17	534.06	152.14	686.20	2358.75	1238.36	2910.91	1238.36	619.18
12	6.66	20.77	21.35	0.40	8.54	643.12	622.03	160.97	783.00	2495.66	1426.12	3138.78	1426.12	713.06
13	7.16	26.84	27.39	0.40	10.96	758.10	733.24	206.54	939.78	3202.18	1697.88	3960.28	1697.88	848.94
14	7.66	26.82	26.59	0.40	10.64	873.08	844.46	200.49	1044.95	3108.41	1918.03	3981.49	1918.03	959.01
15	8.16	18.85	18.35	0.40	7.34	988.06	955.67	138.34	1094.01	2144.84	2082.07	3132.90	2082.07	1041.04
16	8.66	13.58	14.40	0.45	6.48	1053.93	1019.38	122.14	1141.52	1893.72	2195.45	2947.66	2195.45	1097.73
17	9.16	6.54	6.74	0.45	3.03	1087.47	1051.81	57.18	1108.99	886.51	2196.46	1973.98	1973.98	986.99
18	9.66	5.64	5.72	0.55	3.15	1123.22	1086.39	59.32	1145.71	919.76	2268.93	2042.98	2042.98	1021.49
19	10.16	6.34	6.36	0.55	3.50	1156.75	1118.83	65.94	1184.77	1022.41	2341.52	2179.17	2179.17	1089.58
20	10.66	6.21	6.22	0.50	3.11	1188.26	1149.30	58.64	1207.94	909.19	2396.20	2097.45	2097.45	1048.73
21	11.16	6.56	6.55	0.50	3.27	1219.24	1179.26	61.72	1240.98	956.91	2460.22	2176.15	2176.15	1088.07
22	11.66	6.88	6.88	0.50	3.44	1250.34	1209.35	64.84	1274.19	1005.32	2524.53	2255.66	2255.66	1127.83

:: Pile bearing capacity calculations (f_p restrictions applied) ::

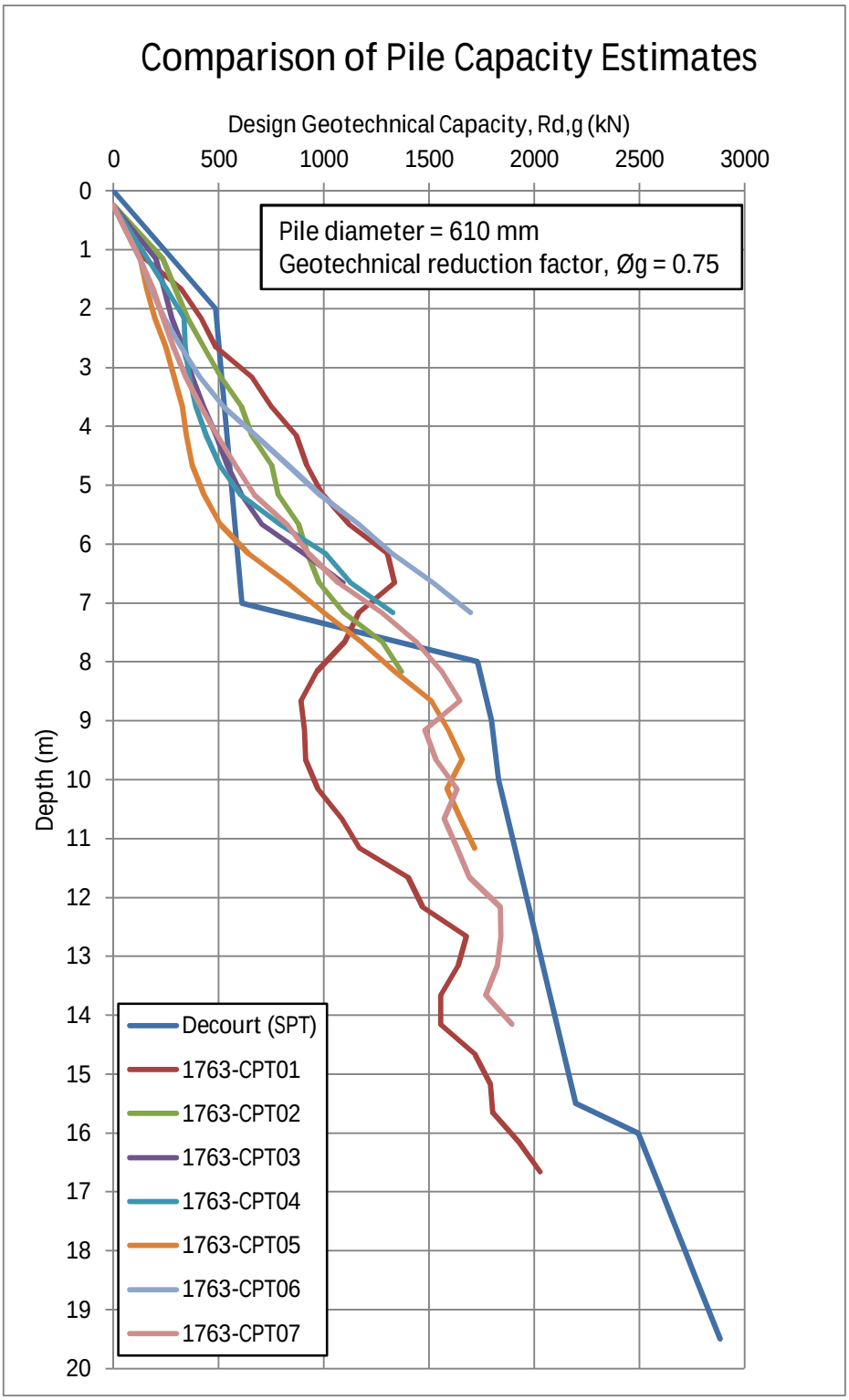
No	Tip depth (m)	q'_{ca} (MPa)	q_{ca} (MPa)	k_c	q_p (MPa)	$Q_{s,\ outter}$ (kN)	$Q_{s,\ inner}$ (kN)	$Q_{b,\ steel}$ (kN)	$Q_{,\ total\ inner}$ (kN)	$Q_{b,\ total\ out}$ (kN)	$Q_{total,\ unplugged}$ (kN)	$Q_{total,\ plugged}$ (kN)	$Q_{ultimate}$ (kN)	$Q_{allowable}$ (kN)
23	12.16	7.27	7.27	0.55	4.00	1283.40	1241.32	75.42	1316.74	1169.31	2600.14	2452.71	2452.71	1226.35
24	12.66	7.78	7.77	0.50	3.89	1318.59	1275.36	73.24	1348.59	1135.45	2667.18	2454.04	2454.04	1227.02
25	13.16	7.40	7.37	0.50	3.69	1354.11	1309.71	69.50	1379.21	1077.58	2733.32	2431.68	2431.68	1215.84
26	13.66	7.33	7.35	0.45	3.31	1391.78	1346.14	62.33	1408.47	966.38	2800.25	2358.16	2358.16	1179.08
27	14.16	7.41	7.51	0.50	3.76	1428.22	1381.39	70.80	1452.19	1097.67	2880.41	2525.89	2525.89	1262.94

Abbreviations

Tip depth: Depth from free surface where tip capacity will be calculated
q'_{ca}: Mean q_t value between -a and +a (above and below pile tip depth respectively)
q_{ca}: Mean value between -a and +a according to LCPC method
k_c: Bearing capacity factor
q_p: Pile unit end bearing capacity
$Q_{s,\ outter}$: Shaft capacity outside
$Q_{s,\ inner}$: Shaft capacity inside
$Q_{b,\ steel}$: Base capacity of steel annulus
$Q_{,\ total\ inner}$: Total capacity inside
$Q_{b,\ total\ out}$: Base capacity of pile tip
$Q_{total,\ unplugged}$: Total capacity of unplugged pile
$Q_{total,\ plugged}$: Total capacity of plugged pile
$Q_{ultimate}$: Ultimate pile capacity
$Q_{allowable}$: Allowable pile capacity

PROJECT: Bridge 1763 - Bussell Highway over Sabina River
CLIENT: Main Roads Western Australia
Project No.: 60344161

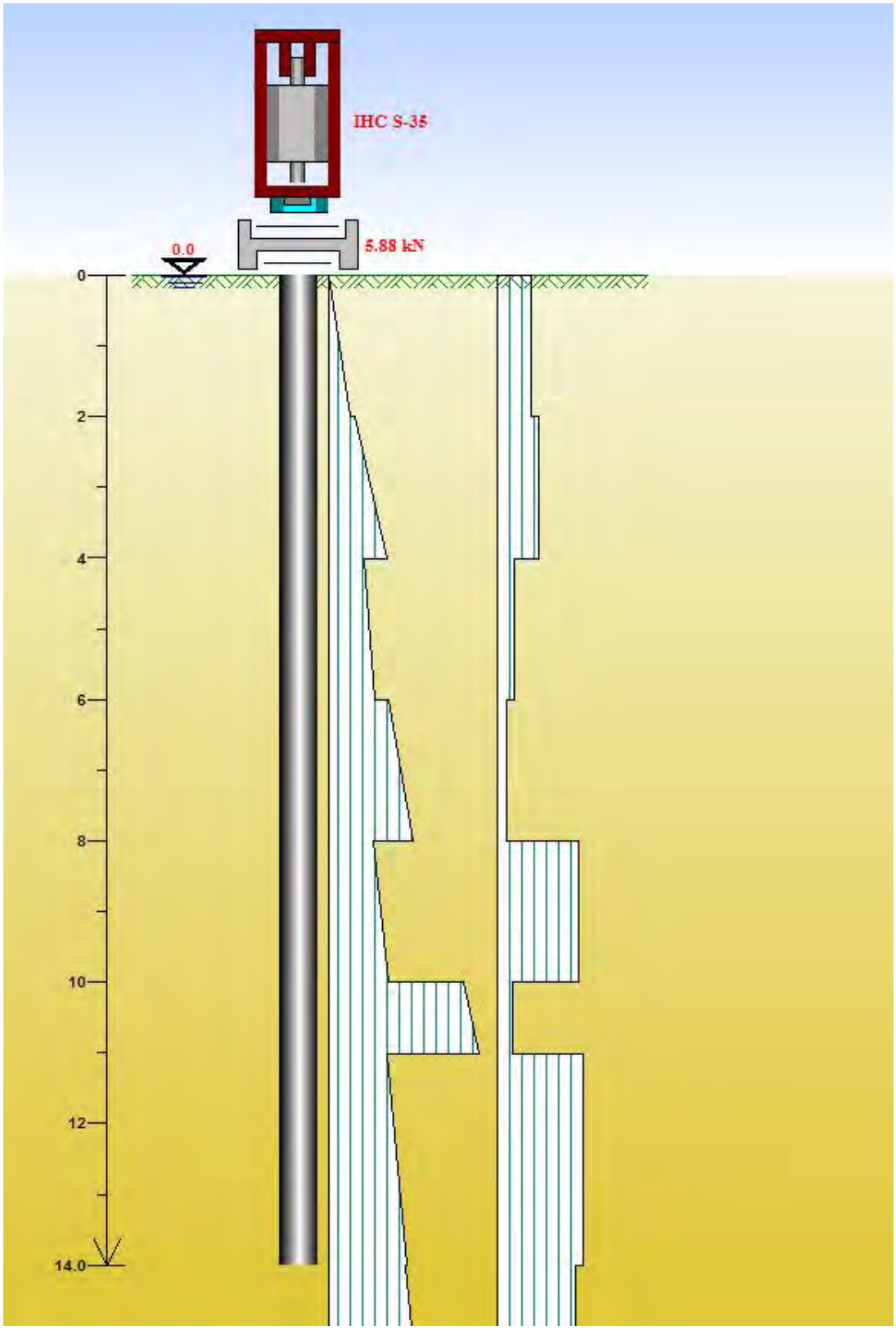
LOCATION: Western Australia
SUBJECT: Comparison of pile capacity estimates from SPT and CPT data



Appendix F

Preliminary Pile Driveability Analyses

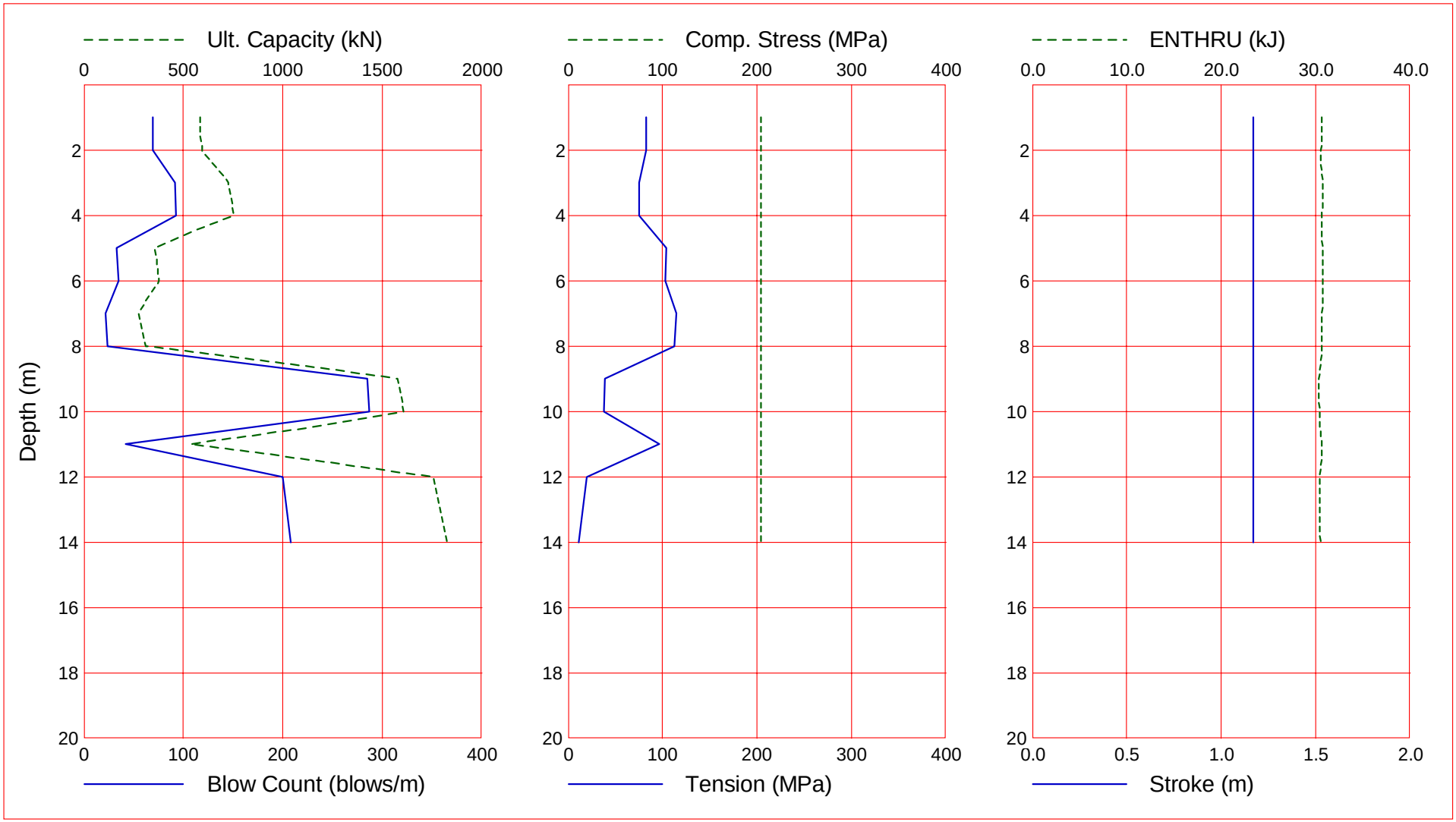
Bridge 1763 – Borehole BH-02 – 610mm CHS casing



AECOM Australia Pty Ltd
Bridge 1763 - BH02 - 610mm CHS casing

2016 Aug 02
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.833 / 1.000



Gain/Loss 1 at Shaft and Toe 0.833 / 1.000

Depth m	Ultimate Capacity kN	Friction kN	End Bearing kN	Blow Count blows/m	Comp. Stress MPa	Tension Stress MPa	Stroke m	ENTHRU kJ
1.0	587.0	2.5	584.5	69.1	204.070	-82.466	1.17	30.7
2.0	594.5	10.0	584.5	69.6	204.069	-82.471	1.17	30.6
3.0	727.4	26.0	701.4	92.0	204.069	-75.464	1.17	30.8
4.0	750.8	49.4	701.4	93.0	204.069	-74.987	1.17	30.7
5.0	359.1	66.9	292.2	33.2	204.069	-103.679	1.17	30.8
6.0	379.2	87.0	292.2	34.5	204.070	-103.205	1.17	30.8
7.0	275.6	117.8	157.8	21.4	204.070	-114.584	1.17	30.7
8.0	312.0	154.2	157.8	23.4	204.070	-112.304	1.17	30.7
9.0	1579.3	176.5	1402.8	285.0	204.070	-38.649	1.17	30.3
10.0	1605.2	202.4	1402.8	287.4	204.070	-37.716	1.17	30.4
11.0	536.7	268.4	268.3	42.2	204.070	-96.069	1.17	30.7
12.0	1758.3	297.1	1461.2	200.5	204.075	-19.892	1.17	30.5
14.0	1825.1	363.9	1461.2	208.3	204.121	-11.167	1.17	30.6

Total Number of Blows: 1559

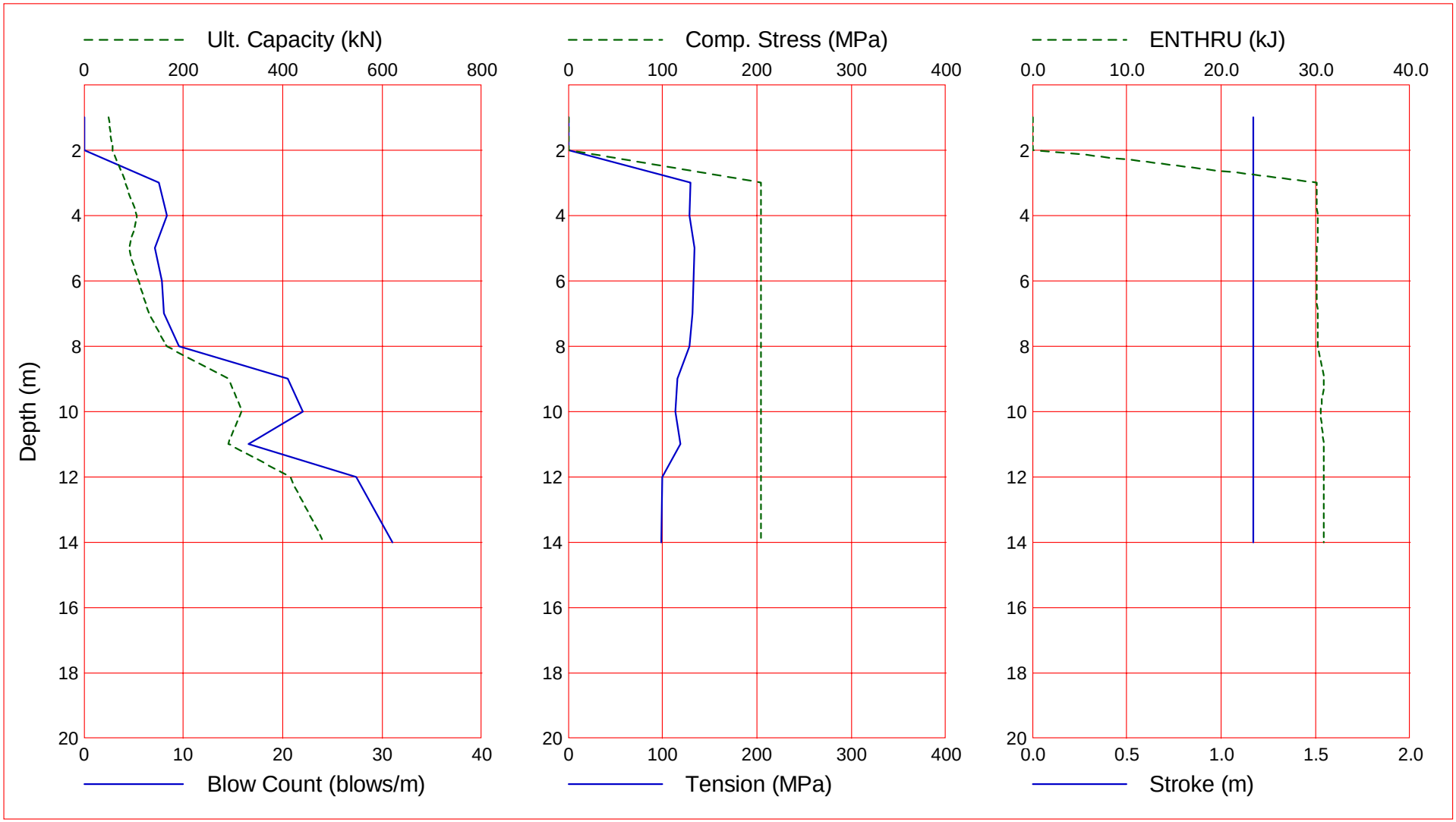
Driving Time (min):	51	38	31	25	22	19	17	15	14	12
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

AECOM Australia Pty Ltd
Bridge 1763 - BH02 - 610mm CHS casing

2016 Aug 02
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.833 / 1.000



Gain/Loss 1 at Shaft and Toe 0.833 / 1.000

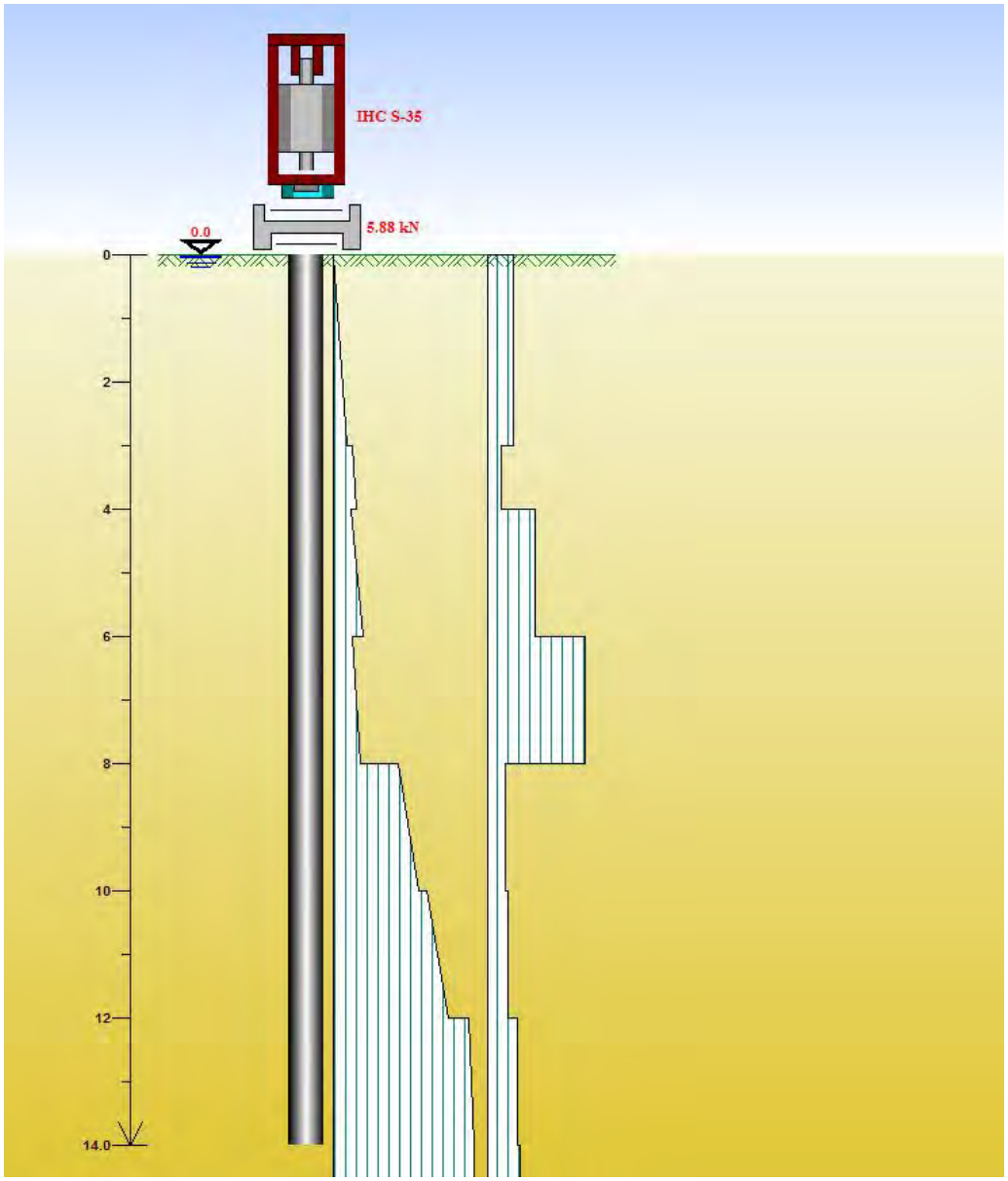
Depth m	Ultimate Capacity kN	Friction kN	End Bearing kN	Blow Count blows/m	Comp. Stress MPa	Tension Stress MPa	Stroke m	ENTHRU kJ
1.0	50.2	2.5	47.7	0.0	0.000	0.000	1.17	0.0
2.0	57.7	10.0	47.7	0.0	0.000	0.000	1.17	0.0
3.0	83.2	26.0	57.2	7.5	204.070	-129.069	1.17	30.1
4.0	106.6	49.4	57.2	8.4	204.070	-128.334	1.17	30.2
5.0	90.7	66.9	23.8	7.1	204.070	-133.893	1.17	30.1
6.0	110.8	87.0	23.8	7.8	204.070	-133.069	1.17	30.1
7.0	130.7	117.8	12.9	8.1	204.070	-132.066	1.17	30.2
8.0	167.1	154.2	12.9	9.6	204.070	-128.946	1.17	30.2
9.0	290.9	176.5	114.4	20.5	204.070	-115.658	1.17	30.9
10.0	316.8	202.4	114.4	22.0	204.070	-113.946	1.17	30.6
11.0	290.3	268.4	21.9	16.6	204.070	-118.994	1.17	30.9
12.0	416.3	297.1	119.2	27.4	204.076	-100.192	1.17	30.9
14.0	483.1	363.9	119.2	31.0	204.122	-98.829	1.17	30.9

Total Number of Blows: 179

Driving Time (min):	5	4	3	2	2	2	1	1	1	1
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

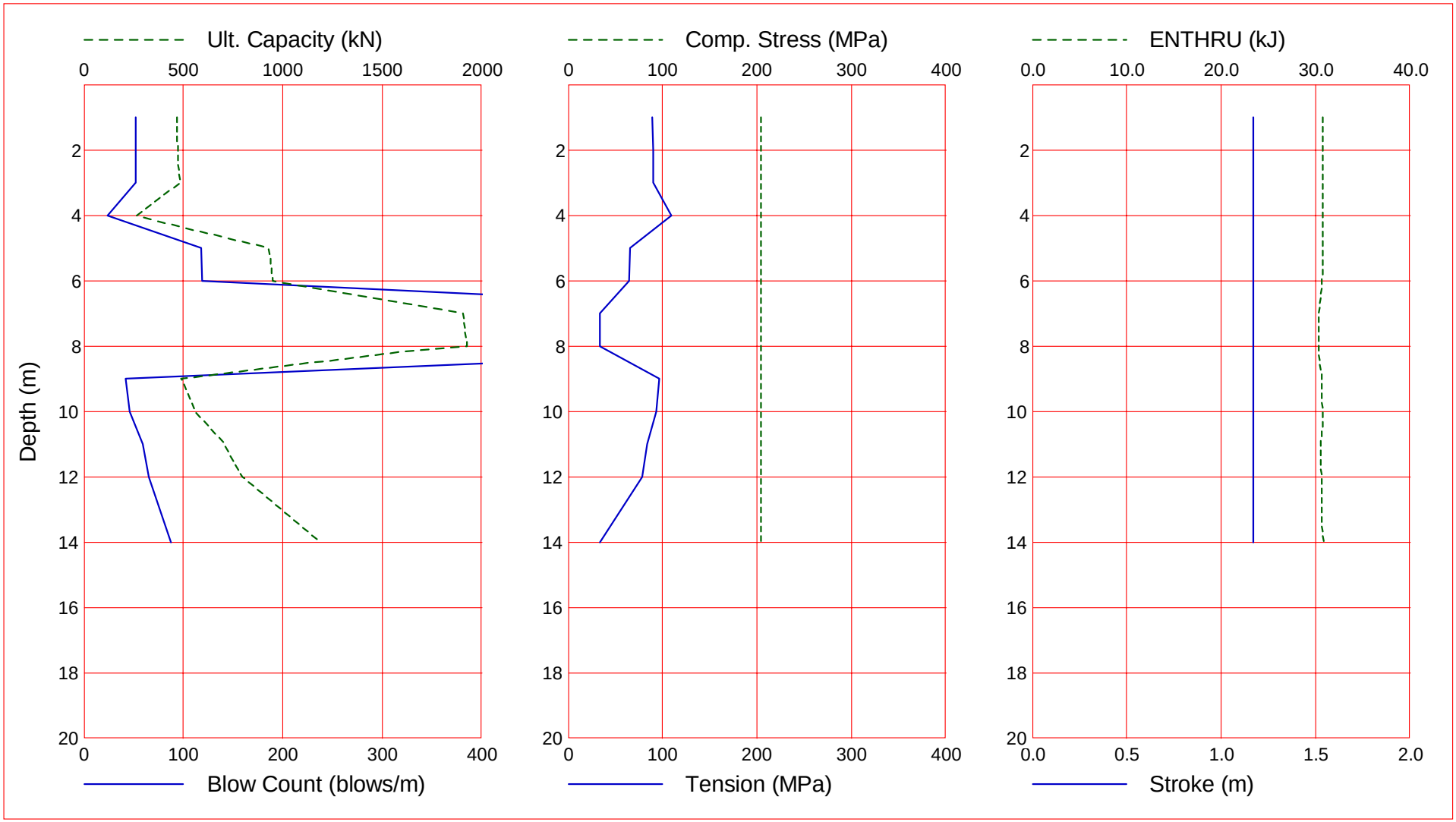
Bridge 1763 – Borehole BH-01 – 610mm CHS casing



AECOM Australia Pty Ltd
Bridge 1763 - BH01 - 610mm CHS casing

2016 Aug 02
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.833 / 1.000



Gain/Loss 1 at Shaft and Toe 0.833 / 1.000

Depth m	Ultimate Capacity kN	Friction kN	End Bearing kN	Blow Count blows/m	Comp. Stress MPa	Tension Stress MPa	Stroke m	ENTHRU kJ
1.0	469.5	1.9	467.6	51.7	204.069	-89.498	1.17	30.8
2.0	475.1	7.5	467.6	52.1	204.069	-89.621	1.17	30.8
3.0	484.4	16.8	467.6	52.6	204.069	-89.766	1.17	30.8
4.0	268.2	34.4	233.8	24.3	204.070	-109.154	1.17	30.8
5.0	928.6	51.8	876.7	118.4	204.070	-65.218	1.17	30.8
6.0	951.3	74.5	876.7	118.9	204.070	-64.615	1.17	30.7
7.0	1904.0	92.0	1811.9	800.1	204.070	-33.546	1.17	30.3
8.0	1925.3	113.4	1811.9	808.4	204.070	-33.147	1.17	30.3
9.0	488.7	173.1	315.6	42.2	204.070	-96.819	1.17	30.7
10.0	557.0	241.4	315.6	46.0	204.070	-92.914	1.17	30.8
11.0	703.8	325.0	378.8	59.2	204.070	-83.377	1.17	30.6
12.0	796.8	418.0	378.8	65.7	204.074	-78.627	1.17	30.7
14.0	1189.9	653.3	536.6	87.7	204.104	-33.669	1.17	30.9

Total Number of Blows: 2358

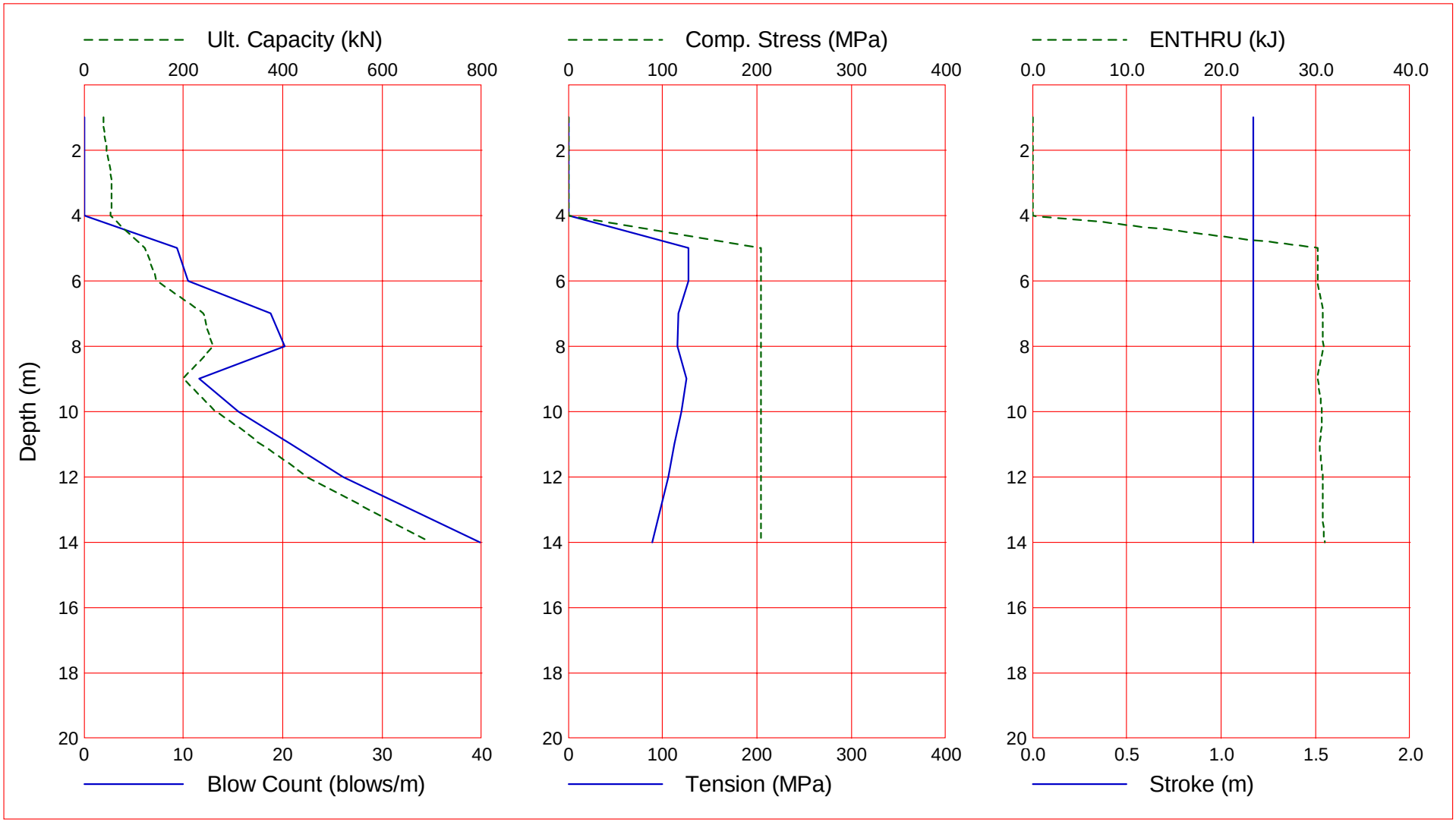
Driving Time (min):	78	58	47	39	33	29	26	23	21	19
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

AECOM Australia Pty Ltd
Bridge 1763 - BH01 - 610mm CHS casing

2016 Aug 02
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.833 / 1.000



Gain/Loss 1 at Shaft and Toe 0.833 / 1.000

Depth m	Ultimate Capacity kN	Friction kN	End Bearing kN	Blow Count blows/m	Comp. Stress MPa	Tension Stress MPa	Stroke m	ENTHRU kJ
1.0	40.0	1.9	38.1	0.0	0.000	0.000	1.17	0.0
2.0	45.6	7.5	38.1	0.0	0.000	0.000	1.17	0.0
3.0	54.9	16.8	38.1	0.0	0.000	0.000	1.17	0.0
4.0	53.4	34.4	19.1	0.0	0.000	0.000	1.17	0.0
5.0	123.3	51.8	71.5	9.4	204.069	-127.109	1.17	30.2
6.0	146.0	74.5	71.5	10.5	204.070	-127.039	1.17	30.2
7.0	239.8	92.0	147.8	18.8	204.070	-117.131	1.17	30.8
8.0	261.1	113.4	147.8	20.2	204.070	-116.039	1.17	30.9
9.0	198.8	173.1	25.7	11.6	204.070	-125.376	1.17	30.2
10.0	267.1	241.4	25.7	15.5	204.070	-119.801	1.17	30.7
11.0	355.9	325.0	30.9	20.8	204.070	-113.004	1.17	30.5
12.0	448.9	418.0	30.9	26.1	204.074	-106.658	1.17	30.8
14.0	697.0	653.3	43.8	39.8	204.104	-88.631	1.17	31.0

Total Number of Blows: 186

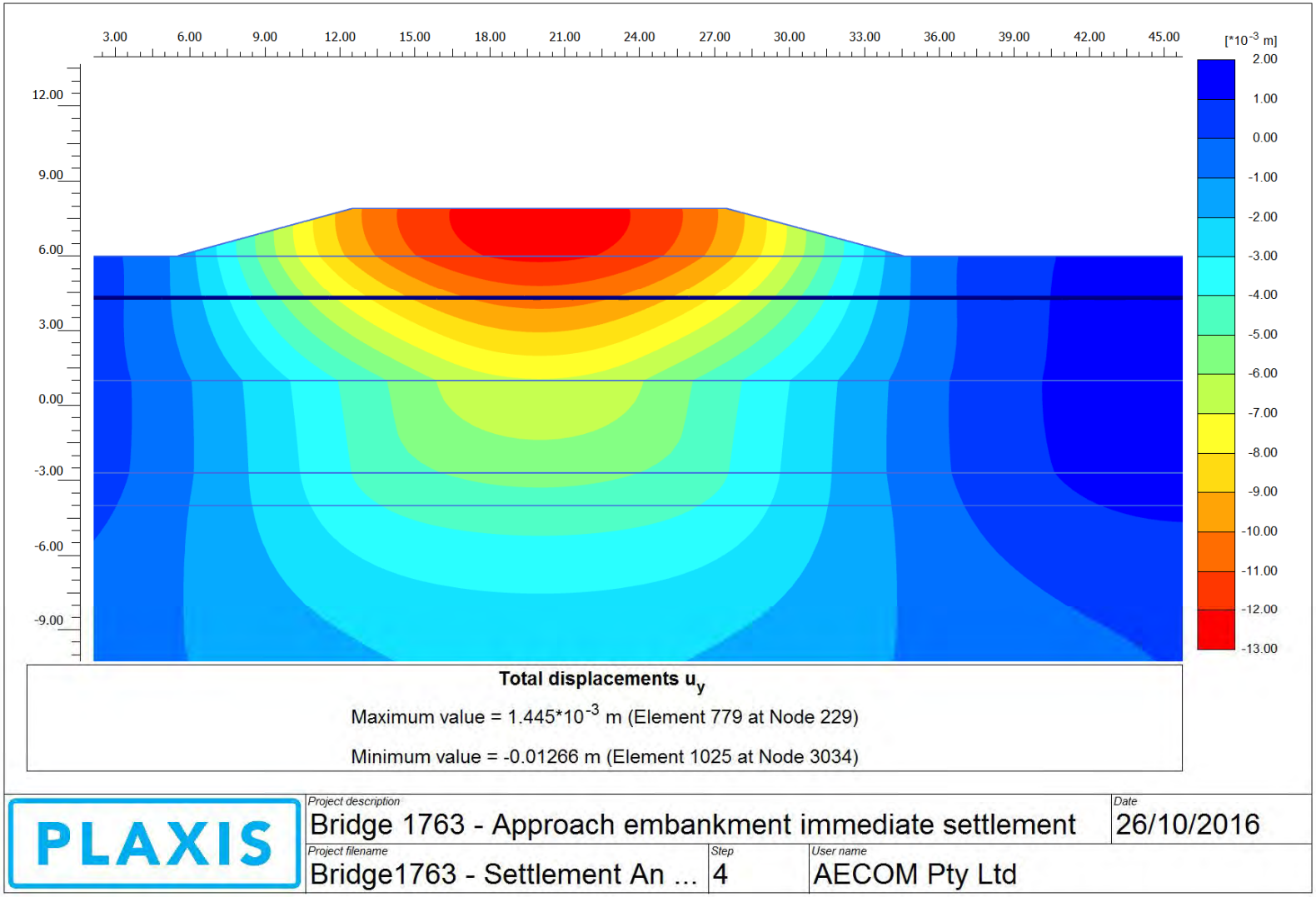
Driving Time (min):	6	4	3	3	2	2	2	1	1	1
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

Appendix G

Settlement Estimates for Approach Embankment

Output Version 2012.2.14975.10081



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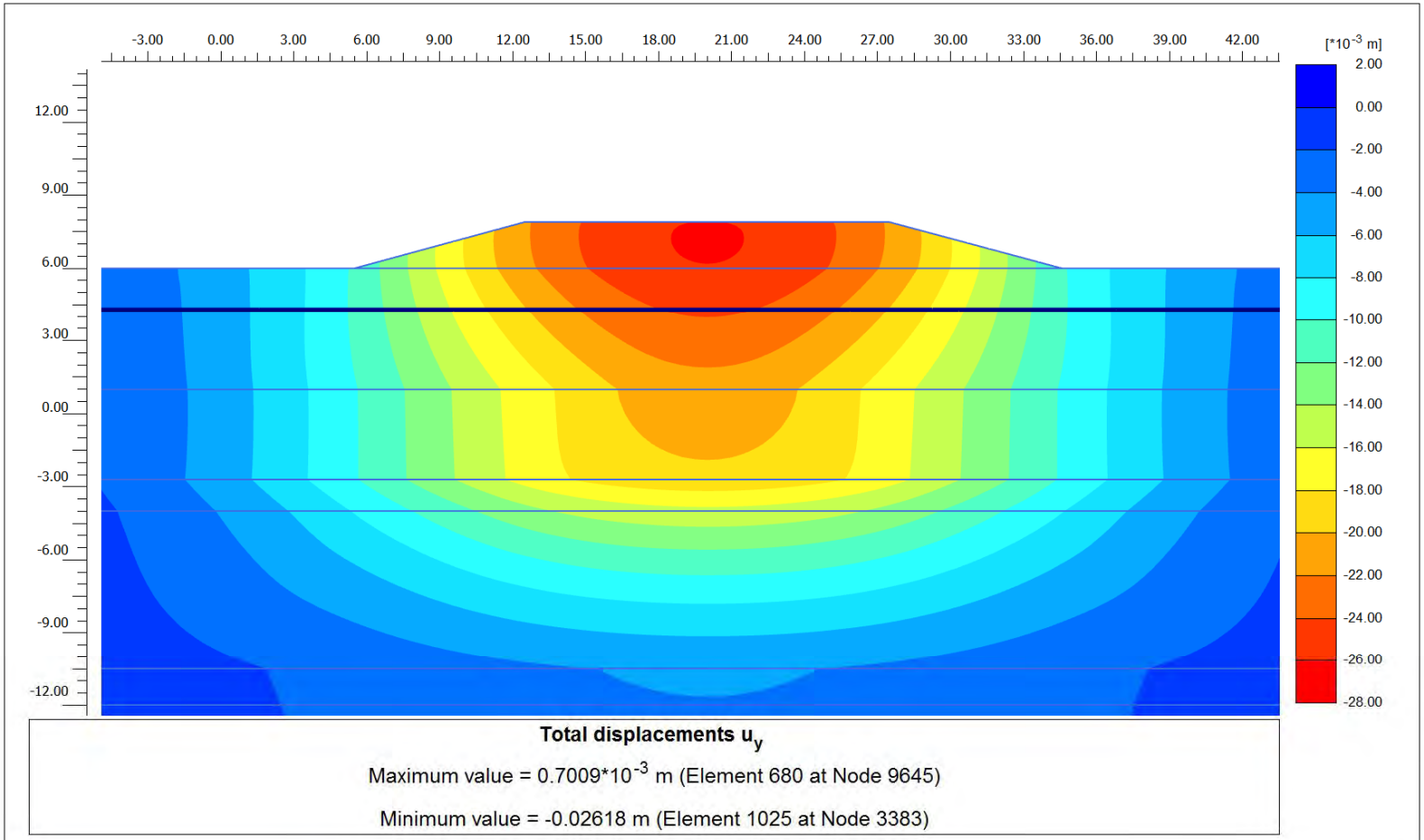

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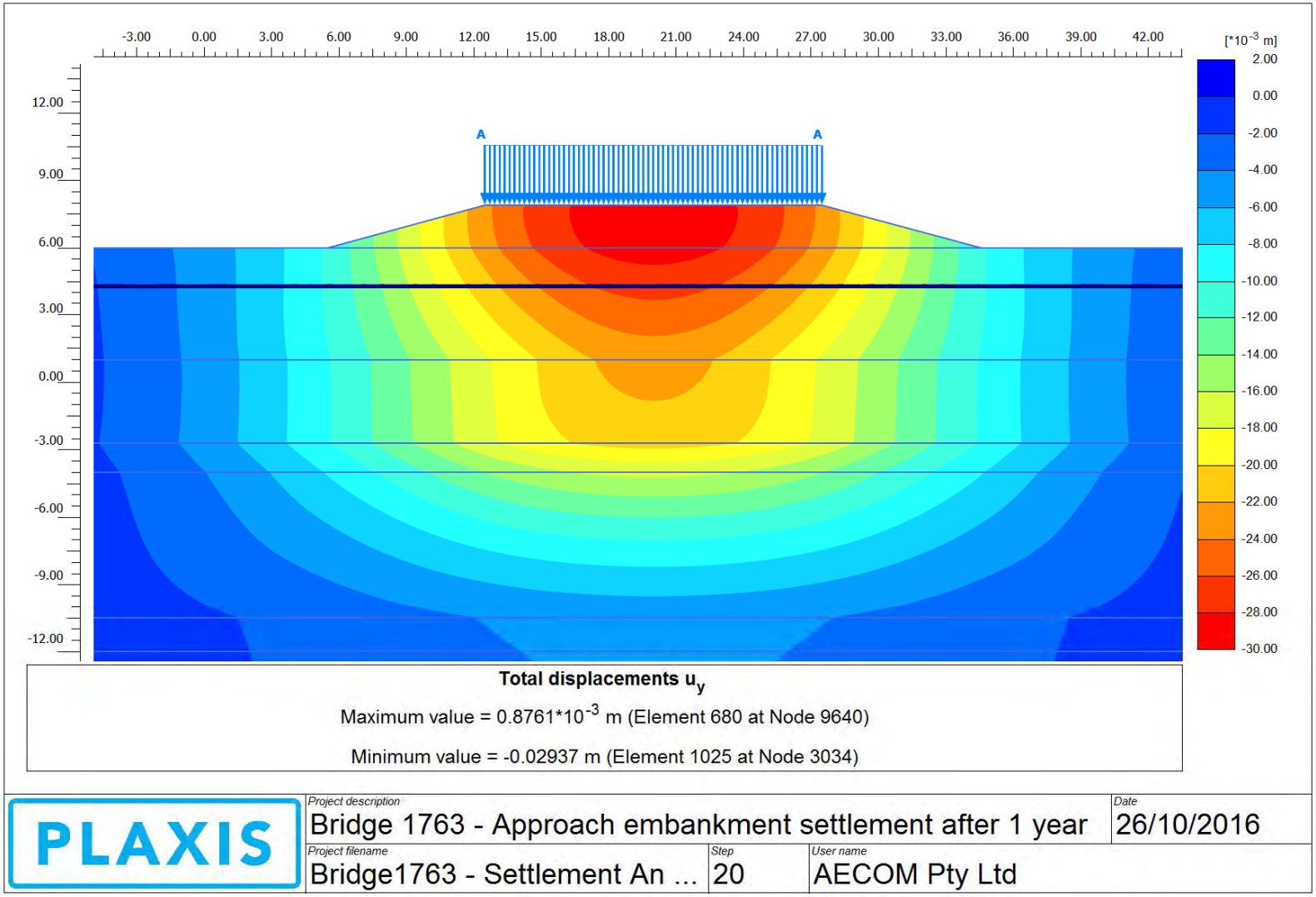

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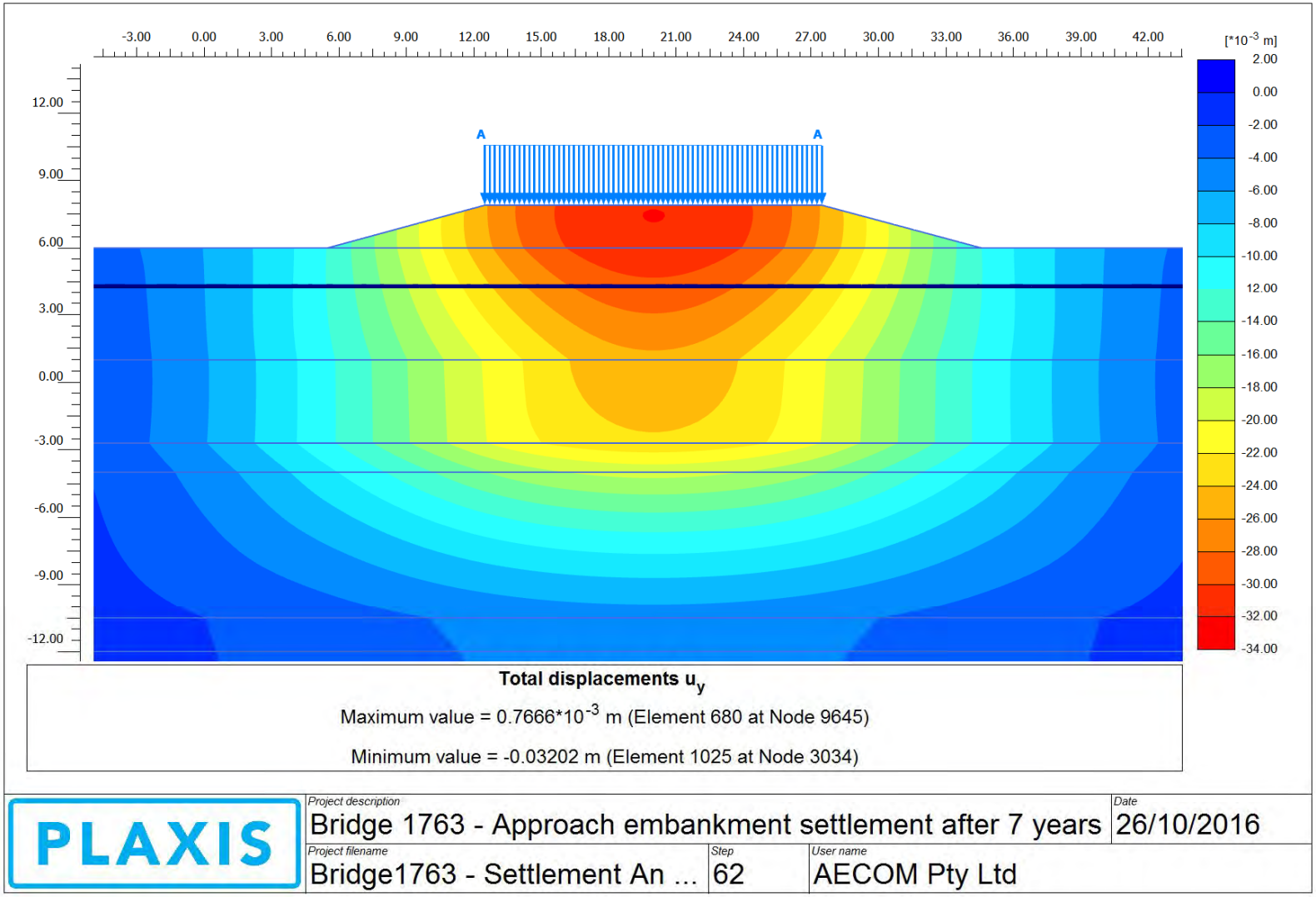
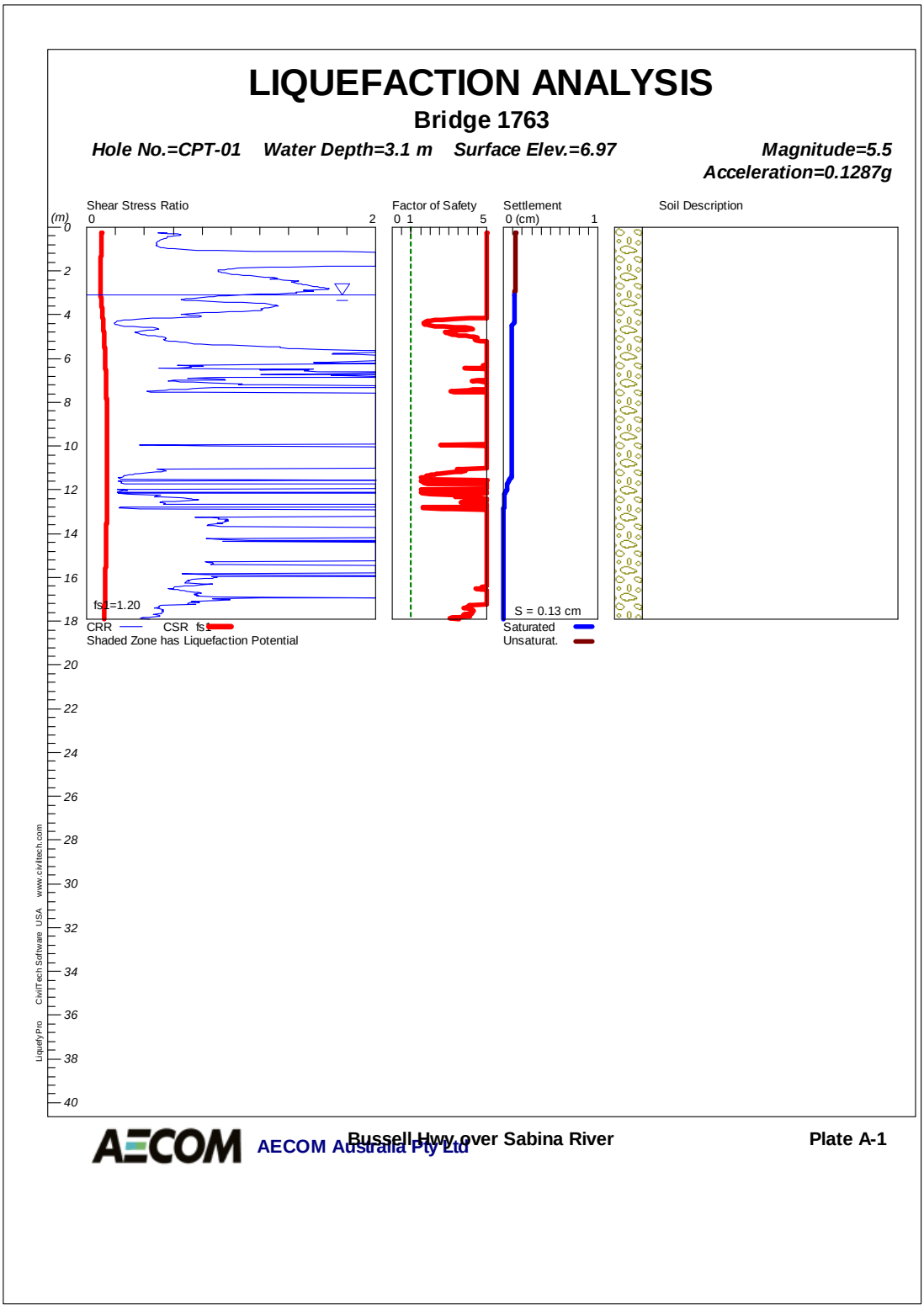


Appendix H

Preliminary Liquefaction Assessment

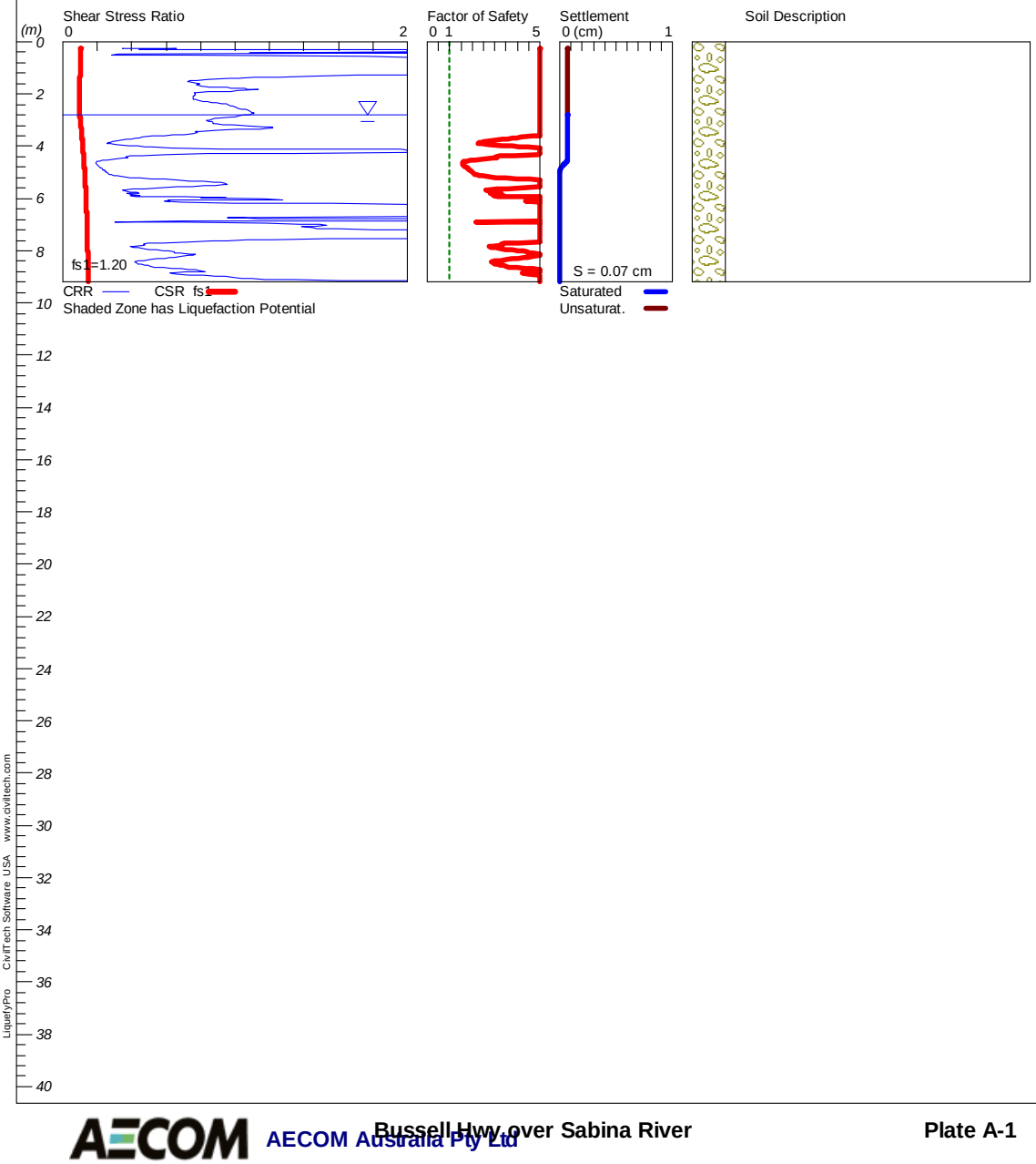
Appendix H – Preliminary Liquefaction Assessment



LIQUEFACTION ANALYSIS

Bridge 1763

Hole No.=CPT-02 Water Depth=2.8 m Surface Elev.=6.54 Magnitude=5.5 Acceleration=0.1287g



AECOM Australia Pty Ltd

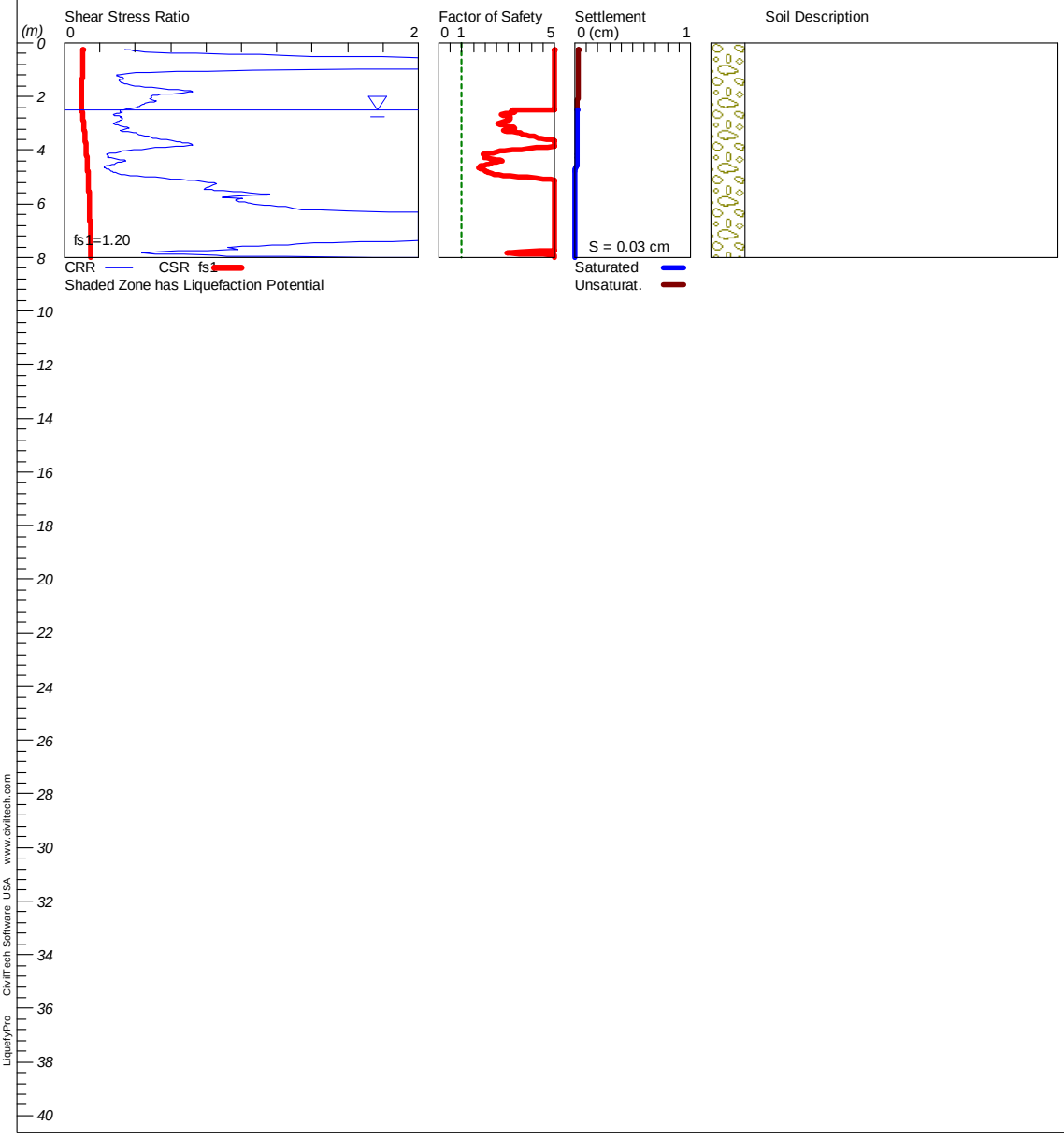
Bussell Hwy over Sabina River

Plate A-1

LIQUEFACTION ANALYSIS

Bridge 1763

Hole No.=CPT-03 Water Depth=2.5 m Surface Elev.=6.07 Magnitude=5.5 Acceleration=0.1287g



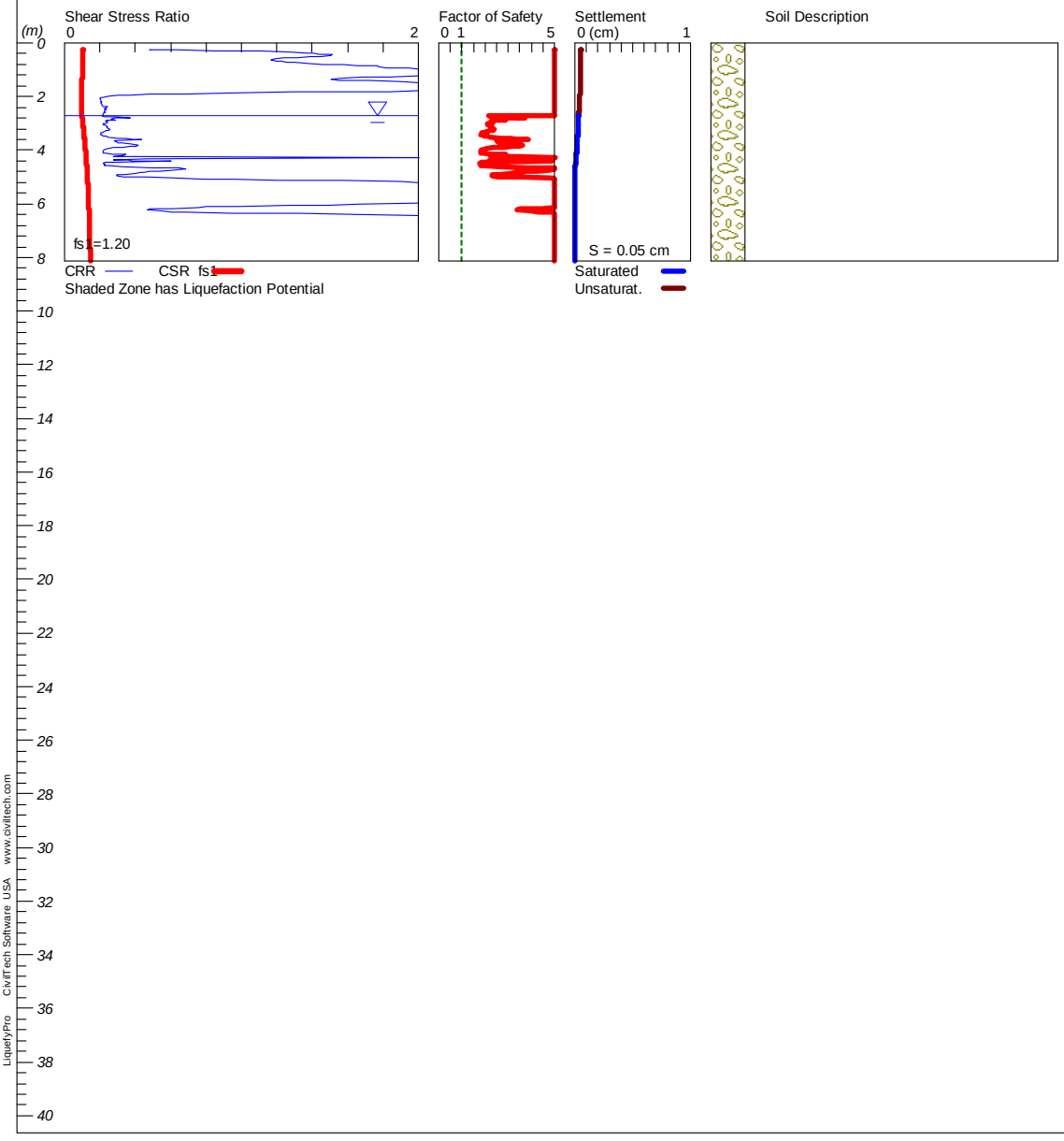
AECOM Australia Pty Ltd

Bussell Hwy over Sabina River **Plate A-1**

LIQUEFACTION ANALYSIS

Bridge 1763

Hole No.=CPT-04 Water Depth=2.7 m Surface Elev.=5.91 Magnitude=5.5 Acceleration=0.1287g



AECOM Australia Pty Ltd

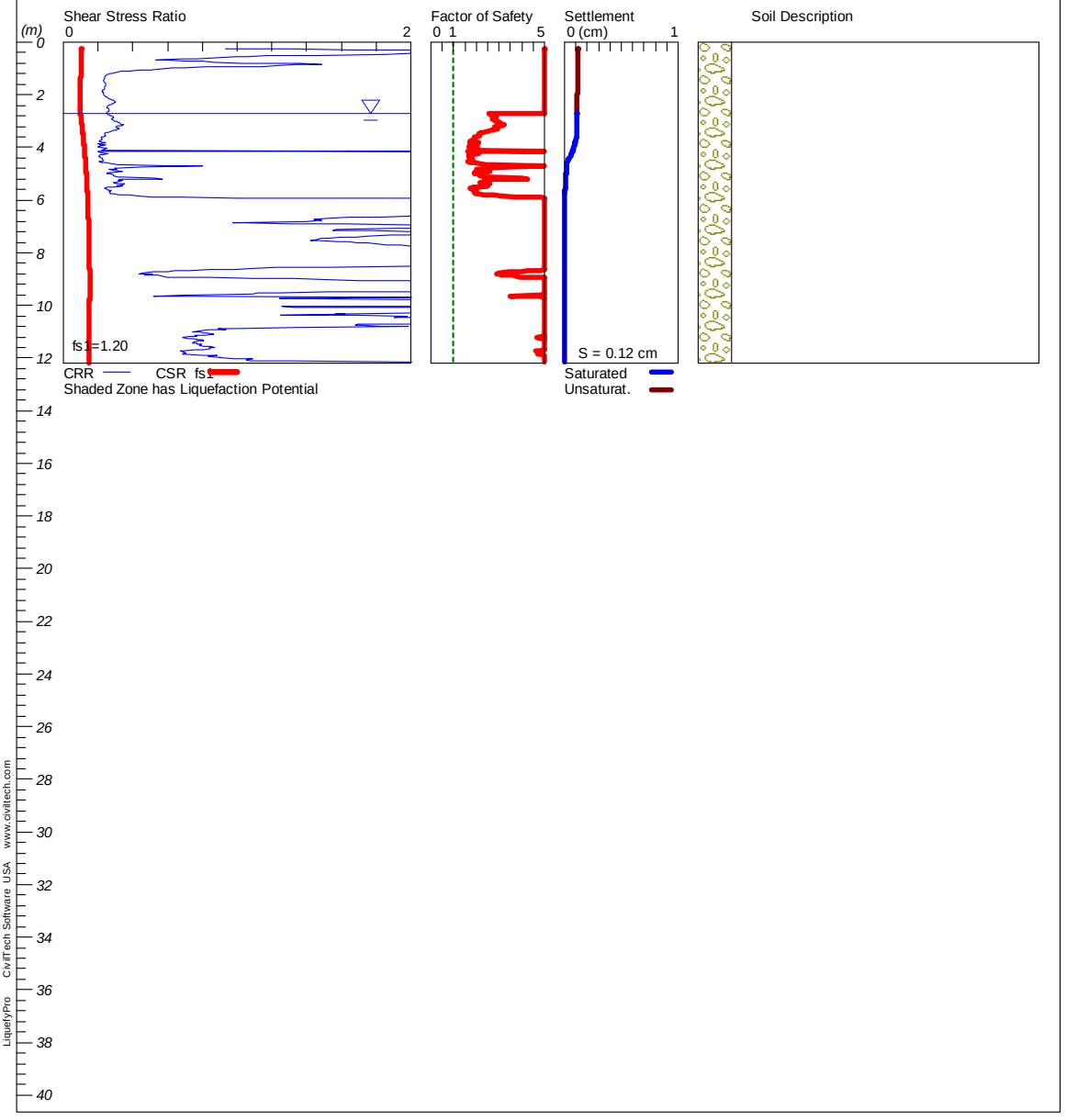
Bussell Hwy over Sabina River

Plate A-1

LIQUEFACTION ANALYSIS

Bridge 1763

Hole No.=CPT-05B Water Depth=2.7 m Surface Elev.=6.10 Magnitude=5.5
Acceleration=0.1287g

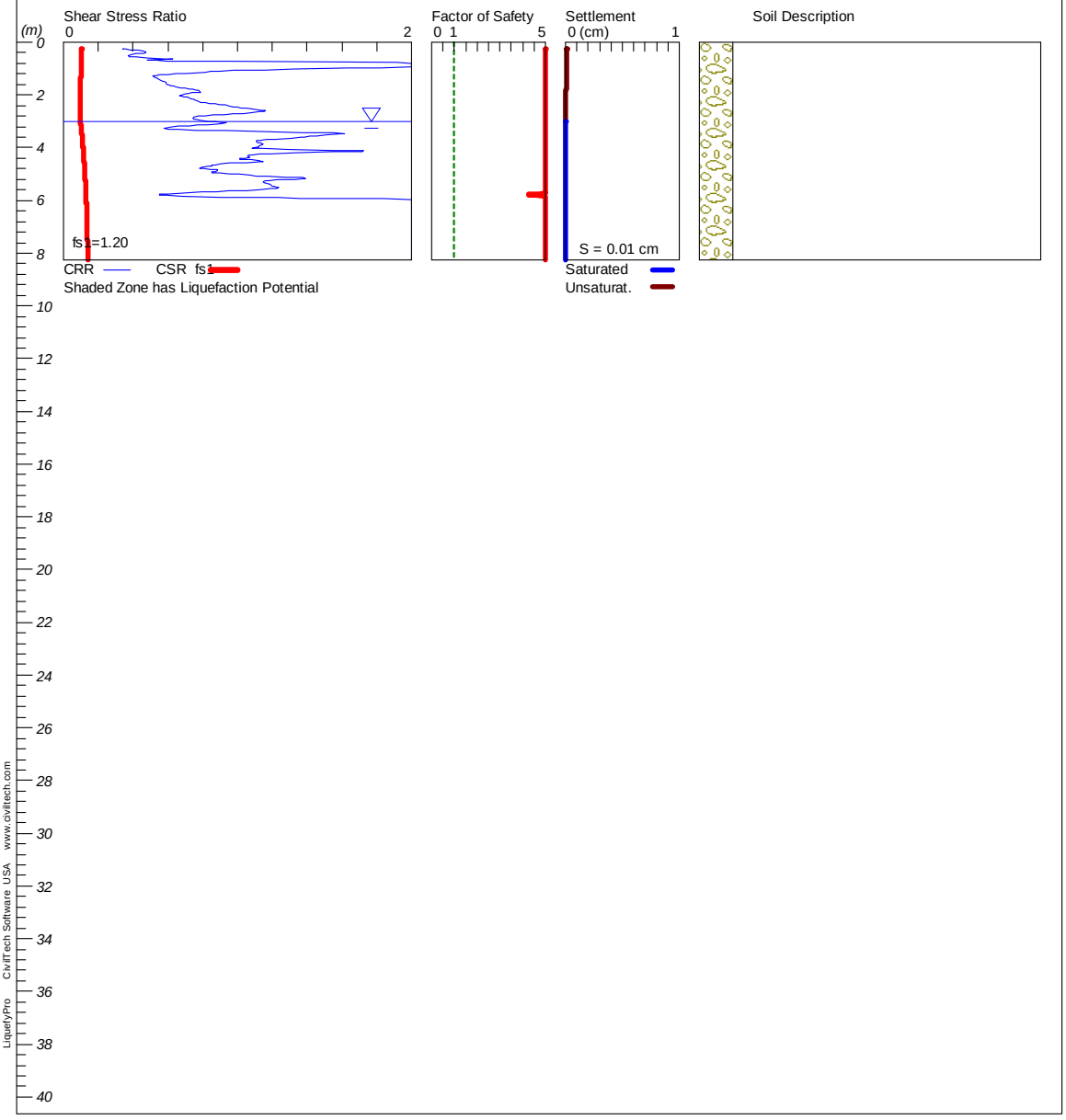


AECOM Australia Pty Ltd Bussell Hwy over Sabina River Plate A-1

LIQUEFACTION ANALYSIS

Bridge 1763

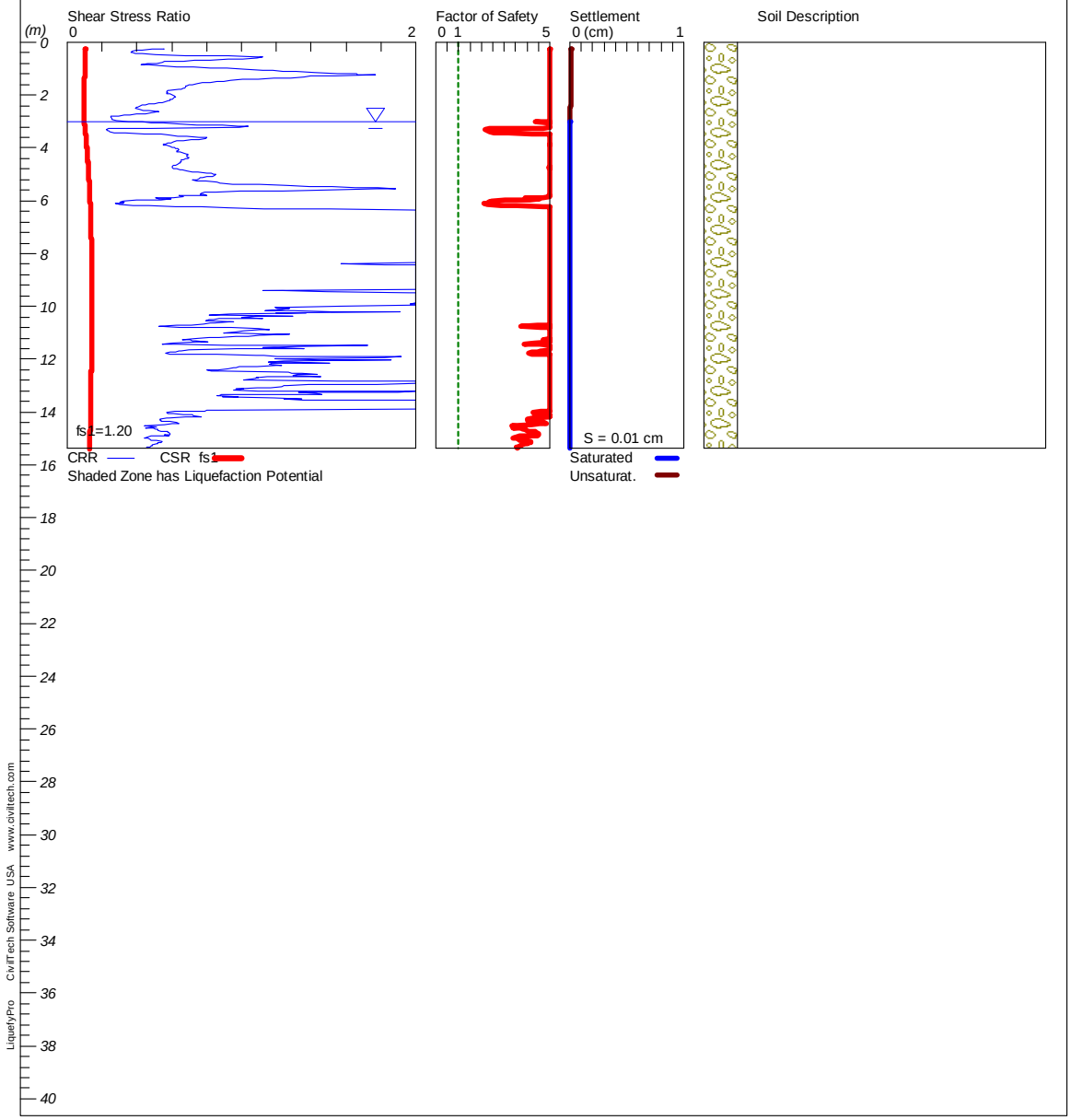
Hole No.=CPT-06 Water Depth=3 m Surface Elev.=6.25 Magnitude=5.5 Acceleration=0.1287g



AECOM Australia Pty Ltd

Bussell Hwy over Sabina River

Plate A-1



AECOM Australia Pty Ltd

Bussell Hwy over Sabina River

Plate A-1

Client Comments Response

Appendix I

Design:	Bridge 1763 – Bussell Highway Over Sabina River
Review Stage:	Geotechnical Factual, Interpretive and Design Report

No.	Document reference	Review comment	Designer's response	Close-out comment
Comments from Material Engineering Branch (received 2 Sep 2016)				
1.	Clause 6.6.3	The report indicates that the piles are constructed to the design toe levels to resist the design action effects presented in Tables 4 and 5. The laboratory testing on collected soil samples are presented in Table 4. Please check Table 4 and amend accordingly.	Noted. References have been corrected.	
2.	Clause 6.6.3	The report indicates that the pile settlements under axial design serviceability loads are expected to be in the order of 5 mm to 15 mm. No geotechnical design parameters for the proposed bridge regarding settlements (e.g. unit weight, effective angle of internal friction, drained Young's modulus and Poisson's ratio).	The service loads of the pile are estimated from CPT traces using CPTe-IT program. For that methodology no additional geotechnical parameters are required. Please refer attached CPTe-IT results for the load settlement based on the CPTU3, CPTU4, CPTU5 and CPTU75 traces, which are nearest to the proposed pile location. The pile settlement analysis conservatively assumed pile embedment of 13.5 m and preliminary service load of 1200 kN.	

			A relatively small movement between the soil and pile is required to fully mobilized skin friction. It was found that pile movement in the range of 3 to 5 mm is sufficient to fully mobilized the skin friction (see FHWA Geo 8 , Poulos & Davis (1980) and Budhu (2000)). Generally, the movement needed to mobilize the skin friction is approximately equal to 1/10 of pile displacement needed to mobilize the base. (see FHWA (2007) and Johnson et. al. (2001)) In the CPTe-IT program, the movements of 5 mm and 50 mm have been assumed to fully mobilized the skin friction and end bearing, respectively. The attached settlement analysis results indicated that the pile settlement is approximately 5 mm. References:FHWA (2007), Geotechnical Engineering Circular No. 8: Design and Construction of Continuous Flight Auger Piles, Document No. FHWA-HIF-07-039. Johnson, K., Karunasena, W., Sivakugan, N. & Guazzo, A. (2001), Modelling Pile-Soil Interaction Using Contact Surfaces, In: Computational Soil Mechanics – New Frontiers for New Millennium, Valliappan S and Khalili N eds. Elsevier: Amsterdam, pp 1155-1165. Budhu, M. (2000), Soil Mechanics and Foundations. John Wiley and Sons Inc.	

			Poulos, H. G. & Davis, E.H. (1980), Pile foundation analysis and design. Toronto: John Wiley & Sons, Inc.	
3.	Table 4	The number of tests regarding moisture content and Atterberg limits test given in Attachment B (laboratory test results) do not match with the number of tests as shown in the Table 4. Please check Table 4 and amend accordingly.	Noted. There are results for nine Moisture Content and nine Atterberg limit tests. Table 4 has been revised to separate the Atterberg Limit and Linear Shrinkage.	
4.	Clause 6.4.2	The units are missing for skin friction and ultimate end bearing (LCPC method).	Noted. The values correspond to kPa. This has been addressed in the report.	
5.	General	The additional axial forces induced in a pile by negative friction shall be considered in the structural design of the abutment piles.	Noted. Based on the ground information, long term settlements or effects of negative friction are not expected	
6.	Clause 6.1 and 6.6	The report indicates that the 610 mm diameter reinforced concrete pile with drive steel casing is preferred. The report indicates that the weight of pile is relatively negligible when considering the design action effects and therefore has not been considered in the estimates of mobilised resistance. The bridge works will involve installation of steel casing followed infill reinforced concrete pile. Please clarify.	Anticipated construction sequence for the bored pile are as follows: - Drive the steel casing to the required to toe levels - Excavate the soil from the centre of the casing. - In fill the reinforced concrete pile - Allow the reinforced concrete pile to set.	

Comments from Peter Newhouse (received 28 Sep 2016)				
7.		General – the report should use the normal bridge terminology for describing the position on the bridge. Use Abutment 1 and 2, LHS and RHS. Abutment 1 = east abutment. SLKs increase from Abutment 1 to Abutment 2. LHS and RHS are as viewed from Abutment 1 end facing Abutment 2. The current descriptions used in the report are confusing.	Noted. The report has been amended accordingly.	
8.		Page i, Executive Summary, 2nd paragraph – check the proposed spacing between the carriageways. Refer to the road design drawings.	Noted. The report has been amended accordingly.	
9.		Page i, Sub-soil Class and Liquefaction – it should be noted that the risk of liquefactions has been assessed as low.	Noted. The report has been amended accordingly.	
10.		Page 2, Section 1.1, 2nd paragraph – check the proposed spacing between the carriageways. Refer to the road design drawings.	Noted. The report has been amended accordingly.	
11.		Page 2, Section 1.2 – reference should be made to the Geotechnical Brief (Doc 60240577-RPGT-0020). Have the requirements outlined in the Brief been fully addressed in this report?	Noted. The Geotechnical Brief is referenced in the report; the requirements have been addressed.	
12.		Page 10, Section 5.1, 1st paragraph – change to " … City of Busselton …"	Noted. The report has been amended accordingly.	

13.		Page 10, Section 5.1, 1st paragraph – check the proposed spacing between the carriageways. Refer to the road design drawings.	Noted. The report has been amended accordingly.	
14.		Page 10, Section 5.2, 5th paragraph – change to " … presented in Figure 3 in Appendix A …"	Noted. The report has been amended accordingly.	
15.		Page 11, Section 5.3.1, 3rd paragraph – analysis is required as to whether the milling backfill presents settlement and durability issues for the bridge.	It is understood that the mining is unlikely to affect either bridge abutment or pier locations but the presence of mining backfill beneath the approach structure cannot be ruled out. Therefore, settlement analysis was carried out at the approach embankments.	
16.		Page 19, Section 7.1 – proposed road levels are available so some analysis should be undertaken on the need for pre-consolidation of the bridge approaches.	Noted. The settlement analysis is included in the revised report.	
17.		Page 19, Section 7.1 – mention should be made of the proposed approach slabs.	Noted. The approach slab requirements are included in the revised report.	
18.		Page 22, Section 8.2 – in relation to Tables 9 and 10, it should be noted that the non-aggressive soil and groundwater exposure classification for steel means that the proposed steel sleeves to be used for the piling will not require any additional corrosion protection treatment.	The steel sleeves provide environmental protection for the cast-insitu bored piles and also provide temporary support during excavation of the bored piles due to the potential collapse of cohesionless soils.	
19.		Page 24, Section 9.2.2 – change heading to "DER action criteria".	Noted. The report has been amended accordingly.	

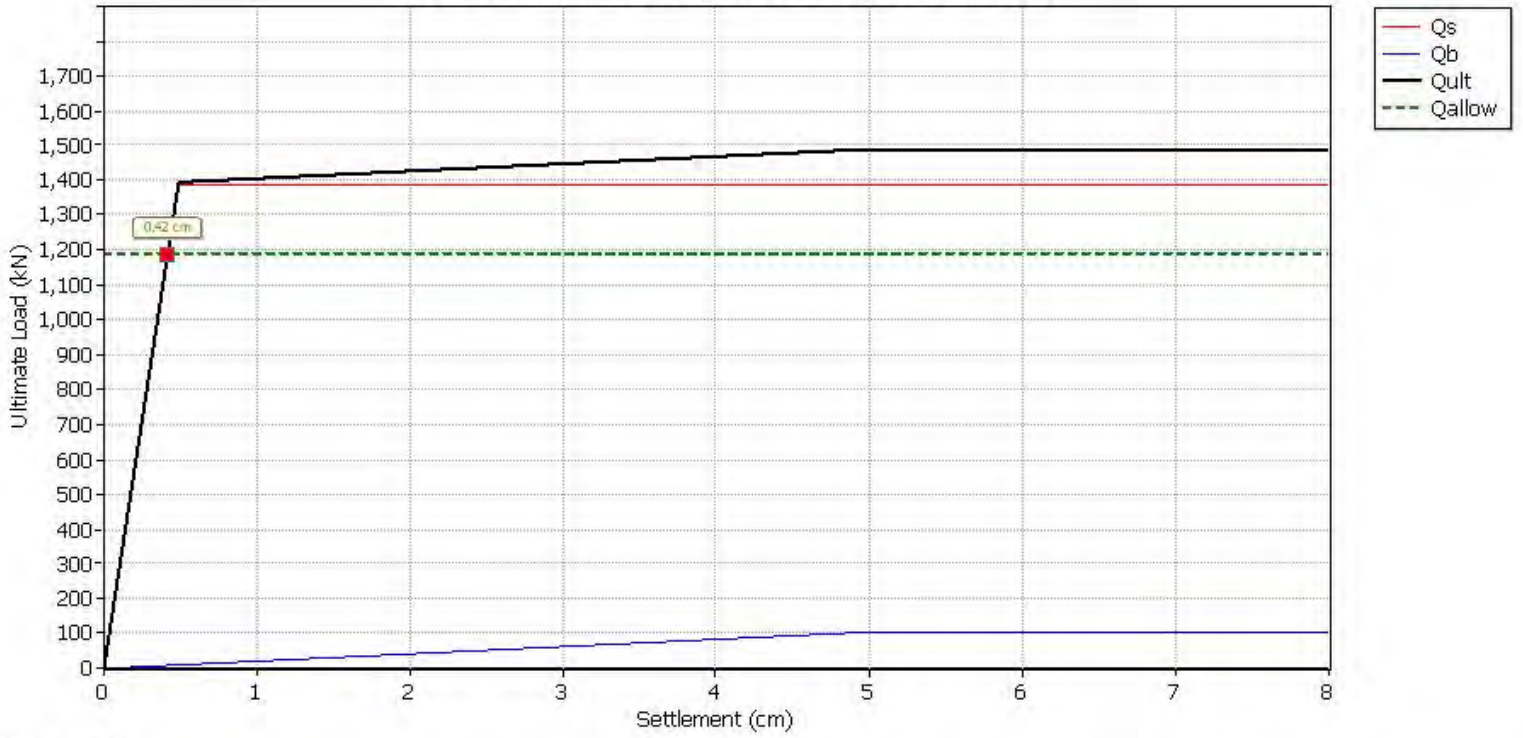
Comments from Jonathan Haylock				
20.		With reference to the following with regard to earthworks and the approach analysis: · Executive Summary - section - Settlement at Approach Embankment; · Section 7.0 – Approach Embankment · Section 8.3 - Earthworks o The geotechnical investigations and reporting for the bridges, have been carried out with the assumption that the road geometry is as provided. It is confusing why a different assumption was made for the approaches to the bridges. A change in the road alignment will change both the approaches & bridges analyses. However, this is almost certainly unlikely to happen. o We were not notified that this part of the scope would be put on hold. o The total cost estimate for the work and reporting (RFS Value) included approach embankment analysis. AECOM have recently claimed for the full estimated amount less about $8K. It is assumed the remaining amount is allowed for to complete the full scope of work, with regard to all approach analyses. o In addition, any preloading requirement will form part of the critical path in pre-construction enabling works required prior to construction delivery. This information is required as soon as possible. o Please complete this section of the report as	Noted. The settlement analysis for approach embankment and earthworks section have been included in the revised report. Noted. Noted. Preloading is not required for this bridge. Noted. Section 7 and Section 8.3 are now completed. Please refer to the revised report.	

		soon as possible and update those respective sections.		
21.		Other comments: · Section 1.1 – Paragraph 2 – the new highway will lie approximately 31m between edge lines (or 38m between centre lines) south east of the existing highway. This should be consistent across all AECOM reports. · Section 1.1 – Paragraph 5 – last sentence - Whereas the road design is considered to be at 15% design stage – that encompasses the intersection designs which are at a very early stage. The highway alignment design is up to 85% complete. · Section 5.0 – was there any mining activity/backfill. There is mention in 5.1 about the historic meandering of the river, but why has the course of the river changed? Are there any concern we should have about historic mining deposits? · Section 6.5 – First paragraph – Is this paragraph required? There is reference to other design actions at the end of the next paragraph. · Other – I also like to see a summary table of all actions through the report that need to be carried forward to a later stage. There should also be reference to who and at what stage those actions should be managed/resolved.	Noted. The relevant section has been amended. Noted. This section has been removed to avoid confusion. We are in the opinion that the historic meandering river do not have implication to the design of the proposed bridge. If there are any issues, the proposed investigation works would have picked up the very loose sand and very soft clay layers. Noted. The first paragraph has been removed to avoid confusion. Noted. A summary table will be provided to include the list of actions to be carried out at a later stage.	

Comments from DS Cheema (received dd/mm/yyyy) Not really sure if these ones apply to both 1762 and 1763?				
22.		For the proposed two span bridge pile foundation has been assessed adequate both for abutments & pier due to the presence of compressible soft soils.		
23.		The subsurface layers comprises of alluvial deposits, Guildford formation of varying relative density & and a competent Leederville formation 12m below river bed level depth approximately.	Noted.	
24.		Driven steel cased pile considered are of 610mm diameter comprising of six piles for each abutment & pier footing. Subsequent design stages will need to confirm that a group of six piles will be adequate for the ultimate loading condition in the event of any differential settlement.	Noted.	
25.		Also need a confirmation for abutment piles any lateral pressure due to movement of soft soils will be within the lateral capacity of the piles.	Noted. This will be included in a summary table on the actions list.	
26.		The chemical test reports indicates the mild environment for concrete and non-aggressive for steel, however in combination with the presence of ASS & PASS, assessed, exposure class for concrete and steel may need to be reconfirmed in the subsequent design stages for their severity level from durability aspect.	Noted. This consideration shall be included in the subsequent design stages.	
27.		Risk associated with the liquefaction resulting from post-earthquake deformation has been perceived as minimum due to the confinement of liquefiable soil zones to be at a significant depth. This may require confirmation in the subsequent design stages.	Noted. This will be included in the actions list in the subsequent design stages.	

28.		Phi(g) has been adopted as 0.75 on account of proposed inclusion of 15% dynamic load of the pile. This also may need revisiting during the subsequent design stages.	Noted. This will be included in the actions list in the subsequent design stages.	
29.		For pile driveability hammer with ram wt over 50kN is not considered viable from overstressing consideration of the pile. Subsequent design stages will need to confirm that required embedment will be achieved without exceeding this hammer driving wt limit.	Noted. This will be included in the actions list in the subsequent design stages.	

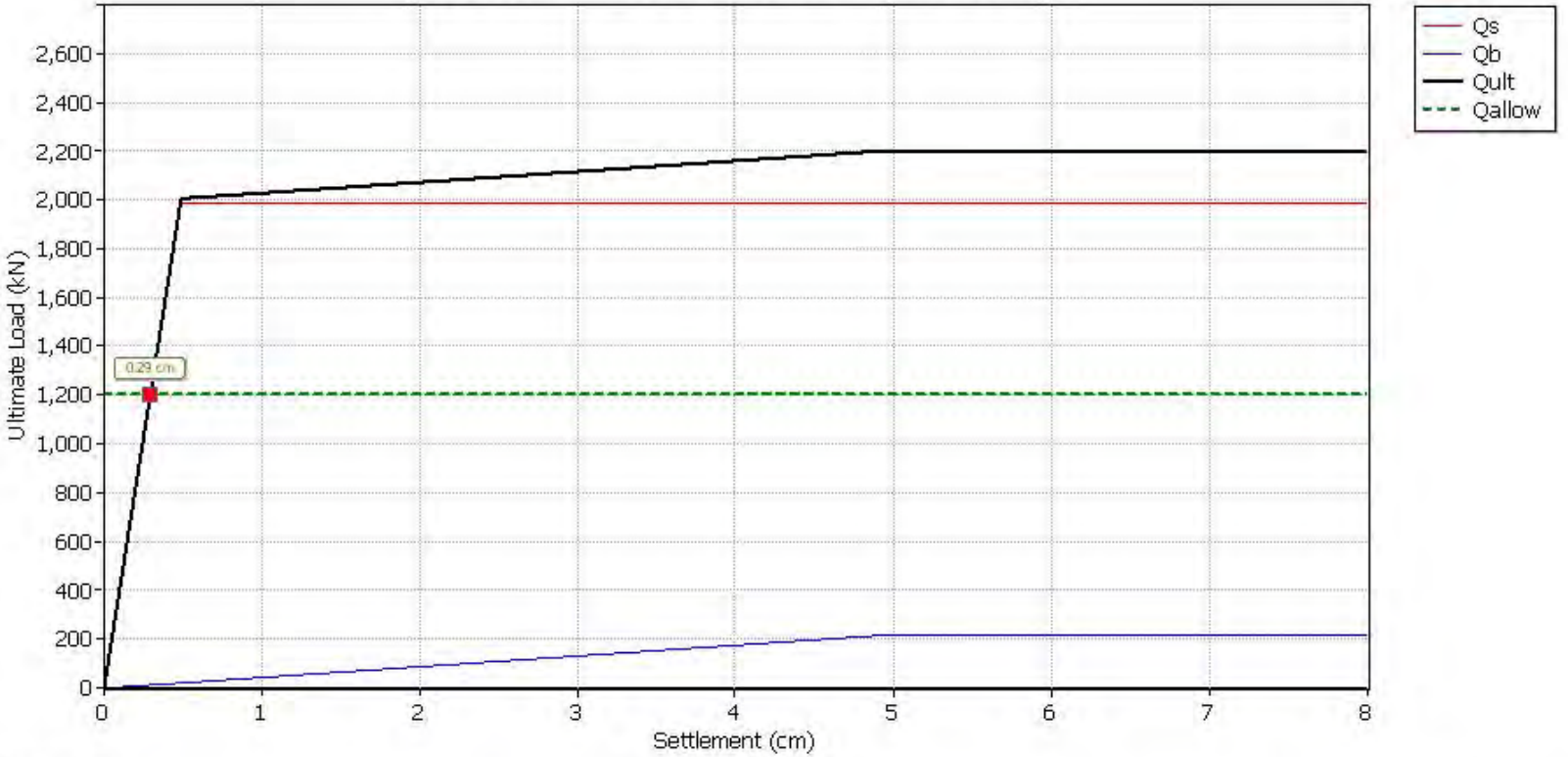
Load vs Settlement - Pipe pile calculation at depth 13.50 (m)



Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m²	Pile tip Group:	Group I	Shaft displacement: 0.008 x Ds (where Ds = shaft diameter)
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m²	Pile shaft FOS:	1.25	Tip displacement: 0.080 x Db (where Db = base/tip diameter)
Internal diameter:	0.59 m²	Inner unti friction area:	1.854 m²	Pile tip FOS:	1.25	
Solid pile tip area:	0.292 m²	Pile shaft Group:	Group IIB			

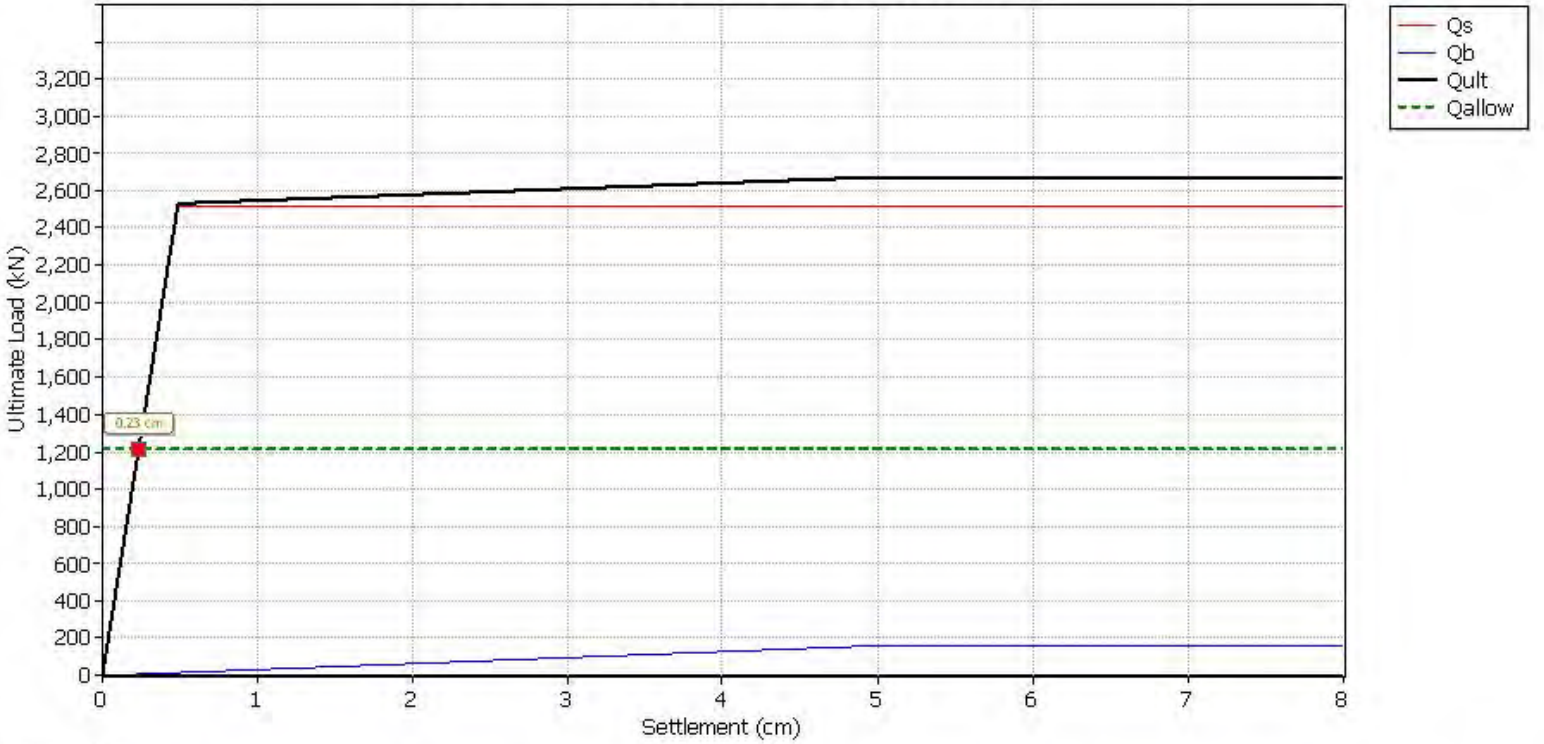
Load vs Settlement - Pipe pile calculation at depth 13.50 (m)



Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m²	Pile tip Group:	Group I	Shaft displacement: 0.008 x Ds (where Ds = shaft diameter)
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m²	Pile shaft FOS:	1.83	Tip displacement: 0.080 x Db (where Db = base/tip diameter)
Internal diameter:	0.59 m²	Inner unti friction area:	1.854 m²	Pile tip FOS:	1.83	
Solid pile tip area:	0.292 m²	Pile shaft Group:	Group IIB			

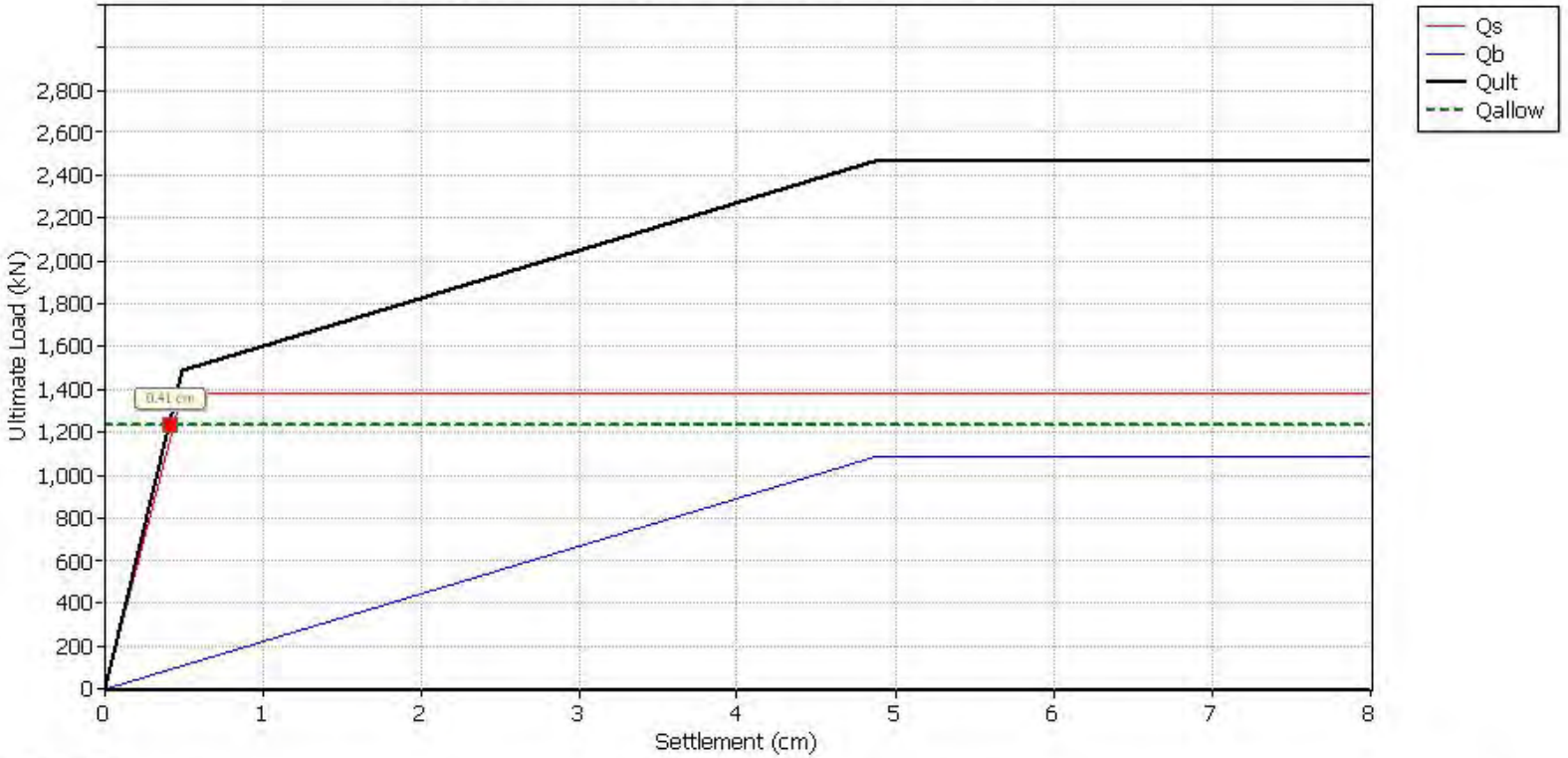
Load vs Settlement - Pipe pile calculation at depth 13.50 (m)



Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m²	Pile tip Group:	Group II	Shaft displacement: 0.008 x Ds (where Ds = shaft diameter)
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m²	Pile shaft FOS:	2.20	Tip displacement: 0.080 x Db (where Db = base/tip diameter)
Internal diameter:	0.59 m²	Inner unti friction area:	1.854 m²	Pile tip FOS:	2.20	
Solid pile tip area:	0.292 m²	Pile shaft Group:	Group IIB			

Load vs Settlement - Pipe pile calculation at depth 13.50 (m)



Pile properties

Outter diameter:	0.61 m	Sectional area of steel tip:	0.019 m²	Pile tip Group:	Group II	Shaft displacement: 0.008 x Ds (where Ds = shaft diameter)	
Wall thickness:	0.010 m	Outter unit friction area:	1.916 m²	Pile shaft FOS:	2.00	Tip displacement: 0.080 x Db (where Db = base/tip diameter)	
Internal diameter:	0.59 m²	Inner unti friction area:	1.854 m²	Pile tip FOS:	2.00		
Solid pile tip area:	0.292 m²	Pile shaft Group:	Group IIB				