Inch Property, Kippenberger Avenue, Rangiora

Preliminary Geotechnical Investigation Report

Westpark Rangiora Limited

Reference: 506685

Revision: 1

2019-07-30

aurecon

Bringing ideas to life

Document control record

Document prepared by:

Aurecon New Zealand Limited
Level 2, Iwikau Building
93 Cambridge Terrace
Christchurch 8013
New Zealand

T +64 3 366 0821
F +64 3 379 6955
E christchurch@aurecongroup.com
W aurecongroup.com

Document control

Report title	Preliminary Geotechnical Investigation Report		
Document code		**Project number**	506685
File path	Https://aurecongroup.sharepoint.com/sites/506685/5 Deliver Design/505 Field Investigations/Geotechnical/Report/506685 - Inch Property Kippenberger Ave - Geotechnical Report.docx		
Client	Westpark Rangiora Limited		
Client contact	Paul McGowan	**Client reference**	

Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
A	2019-07-23	For review	F. Monteith	J. Muirson	J. Kupec	J. Kupec
1	2019-08-01	Issue to Client	F. Monteith	J. Muirson	J. Kupec	J. Kupec
Current revision	**1**					

Approval

Author signature		Approver signature	electr. sign
Name	Fraser Monteith	Name	Dr Jan Kupec
Title	Engineering Geologist	Title	Technical Director

Executive summary

Westpark Rangiora Ltd are investigating the potential of subdividing land on the eastern outskirts of Rangiora township for the purposes of constructing a large residential subdivision. The land proposed for development is approximately 100 hectares in area.

Westpark Rangiora Ltd has engaged Aurecon New Zealand Ltd to undertake a preliminary geotechnical investigation for the proposed subdivision to confirm the underlying ground conditions and to provide preliminary recommendations for the subdivision development..

The proposed subdivision is to be located on a large relatively flat area of farmland immediately east of Rangiora township. Details on the design of the development are not yet known, but we have prepared this report with the understanding that the subdivision will be for residential housing, including one and two storey lightweight buildings, provisions for underground services and surface infrastructure.

Our investigations comprised a review of readily available information, intrusive investigations including geotechnical boreholes and cone penetrometer testing (CPT). The ground conditions at the site can be separated into the northern and the southern blocks. The northern block has a relatively thinner layer of silt and sand overlying gravels, while the southern block has a thicker sequence of soft silts with peat and sand layers ranging between 4m to 6m deep, overlying gravel. The gravels in the southern block have artesian groundwater pressures. When the silts are penetrated through to the gravel, or if there are preferential flow paths through the upper silt layers, groundwater will flow to the surface, as evident from the presence of springs.

Our preliminary geotechnical assessment indicates that liquefaction induced vertical settlement, the potential for consolidation in soft organic soils and peat, and a potentially artesian and shallow groundwater table are geotechnical hazards in the southern block of the site, all of which will affect development of the area. The northern block is primarily characterised by relatively competent soils overlying alluvial gravels from shallower depths and the ground conditions are unlikely to pose any significant geotechnical issues to the proposed development.

At this point, no subdivision development layout or design has been prepared but preliminary recommendations for foundations, infrastructure and pavements have been provided.

An explanatory statement of the work completed is presented in Section 6 and this report shall be read as a whole.

Contents

Appendices

Tables

1 Introduction

Westpark Rangiora Ltd are investigating the potential of subdividing land on the eastern outskirts of Rangiora township for the purposes of constructing a large residential subdivision. The land proposed for development, herein referred to as ‘the site’, is approximately 100 hectares in area.

Westpark Rangiora Ltd has engaged Aurecon New Zealand Ltd (Aurecon) to undertake a preliminary geotechnical investigation for the proposed subdivision to confirm the underlying ground conditions and to provide preliminary recommendations for the subdivision development. This report documents the results of the preliminary geotechnical investigations, identifies the geotechnical hazards that may affect the development and provide preliminary geotechnical engineering recommendations for developing the site, as well as recommendations for further work.

The scope of works included the following:

- A site walkover and reconnaissance of the surroundings to identify site specific hazards from a geotechnical perspective.
- Carry out geotechnical boreholes at four locations across the site to provide information on the ground conditions to depth.
- Install two piezometers to allow monitoring of the groundwater fluctuations.
- Complete 24 Cone Penetration Tests (CPT) tests across the site to further delineate sub-surface conditions.
- Prepare this geotechnical report for the site that details the investigation results and provides preliminary geotechnical engineering recommendations for the site development.

Our work has been carried out under a Short Form Agreement between Westpark Rangiora Ltd and Aurecon as per our proposal dated 19 June 2019. Approval to proceed was given by Westpark Rangiora Ltd on 8 July 2019.

An explanatory statement of the work completed is presented in Section 6 and this report shall be read as a whole.

2 Site Conditions

2.1 Site Description

The main features of the site are:

- The proposed subdivision development is located immediately east and adjacent to Rangiora township in Canterbury, approximately 20km north of Christchurch City. The site is split between two farmland blocks, one to the north of Kippenberger Ave and one to the south (Drawing 1 in Appendix A). The northern block extends to within 200m of Coldstream Road to the north and the southern block extends to Northbrook Road to the south.
- The overall topography of the site is relatively flat but there is a general drop in the site elevations from north to south by up to 15m over 2.4km.
- The site is currently accessed from off Kippenberger Ave, via an unsealed driveway to the homestead, yards and milking shed in the northern block, and by a farm track into the southern block. There is also a stock underpass that links the northern and southern blocks but it is not suitable for vehicle traffic.
- Both the northern and southern blocks have been converted to dairy and as such the site is mostly bare pastural land and light duty fencing. The northern block is more developed with hedge rows separating paddocks and large mature trees surrounding the homestead and yards, with a number of sheds and buildings around the homestead.
- There are no permanent large natural sources of surface water across the site, however small ephemeral streams or abandoned channels exist in gullies that run to the south east across the northern block of the property. In the southern block there are several manmade drainage channels that flow to the south. At the time of the investigation the majority of these had flowing water that was possibly discharging from natural springs in the southern block.
- The southern block becomes progressively wetter towards its southern end near Northbrook Road, with numerous surface springs spread throughout the paddocks. The most southern paddock was avoided entirely due to the west and soft ground, which the land owner had advised not entering. The current farm infrastructure has field tile drains that drain into the open drainage channel and a couple of these could be seen flowing, most likely fed by springs.

2.2 Regional Geology

The geology of the area of the site has been described in the 1:250,000 scale Geological Map of the Christchurch Area, New Zealand by Forsyth et al, (2008). This map indicates that the site is underlain by *"Grey to brownish-grey river alluvium beneath plains or low-level terraces."* An active shallow fold is mapped just to the west of the site crossing the Rangiora township.

Further subdivision of quaternary gravels is made by Brown et al, (1988) with the gravels underlying the site consisting of the Yaldhurst Member of the Springston Formation.

2.3 Site History

The earliest aerial imagery for the site dates from 1942, at which time both the northern and southern blocks were already developed into farmland. The homestead is built and the trees around the property also appear to be quite mature. Aerial photos through to the current day show that the site has undergone little development since first being converted into farmland. The largest scale changes made to the land are in the northern block where it seems the surface which had been characterised by old braid channel features has been partially smoothed, likely through ploughing, and the trees along the two main drainage channels have been cleared. Some buildings around the homestead have been constructed more recently, including a milking shed, but other than these changes there are no apparent significant changes to the site since the earliest set of aerial photographs.

3 Geotechnical Investigation

3.1 General

The geotechnical investigations comprised a review of relevant previous site geotechnical investigations in the area and site-specific investigations across the site. The site specific geotechnical investigations comprised of the following:

- Undertake a site walkover and reconnaissance of the surroundings to identify site specific hazards from a geotechnical perspective.
- Four geotechnical boreholes with Standard Penetration Test (SPT) to 15m depth. The purpose of the boreholes was to confirm the ground conditions at depth and to calibrate the CPTs.
- Install piezometers in two the boreholes to 4.5m depth to measure groundwater levels.
- Twenty-four CPTs across the site to 10m depth or refusal, to identify the soil profile and to provide information for liquefaction analyses.

As the development is at the initial stage there is no layout plans from which to base investigations on. Therefore, investigation locations were spread out to provide an understanding of sub-surface ground conditions across the entire site. Details of our review and investigations are summarised in the sections below.

Ten machine excavated test pits were planned across the site, but due to concerns from the landowner regarding the excavations and the possibility of intersecting artesian aquifer pressures, these were not carried out.

3.2 Previous Investigations

A review of previous geotechnical investigations on the New Zealand Geotechnical Database (NZGD) revealed investigations to the west of the southern block, which comprised CPTs and boreholes, and some shallow hand auger investigations to the west of the northern block. The investigations to the to the west of the northern block indicate silts overlying gravels from shallow depths of less than 1.5m. The investigations to the west of the southern block indicate clayey silt and silty clay, with possible peat layers and sand to depths of 5m to 6m bgl, underlain by gravel.

Additionally, Aurecon has previously completed ground investigations for the Highgate Subdivision, approximately 500m west of the southern block. Investigations for this subdivision found the following:

- Near the Northbrook Road end of the site, soft silts and peat layers were present to 5m to 6m depth, and the soft upper layer extended part way to Kippenberger Avenue.
- Further to the north, near Kippenberger Avenue, the upper ground conditions comprise firm silts and medium dense sands overlying soft silts at depth.
- Gravel was present at 5m to 8m below ground level, and artesian pressures were encountered within the gravels, particularly along Northbrook Road. The presence of artesian pressure can manifest as springs, which are present in this area of Rangiora.
- Shallow groundwater levels were present from a depth of 1m to 1.5m and perched groundwater levels occurred in the more permeable peat layers.

3.3 Boreholes

Four boreholes were drilled to investigate sub-surface stratigraphy across the site, with two in the northern block and two in the southern. The boreholes were carried out by McMillan Drilling from the 1 to 4 July 2019 using a Geoprobe 8140LS rotary sonic rig. The borehole was taken to a depth of 15m bgl with core recovery and SPT testing at 1.5m centres. In two boreholes (Boreholes BH1 and BH3), flush mounted piezometer wells were installed to allow ongoing groundwater monitoring. However, after installation the piezometer in Borehole BH3 had artesian water pressure so the piezometer was grouted.

The logging of the recovered core was undertaken in accordance with the New Zealand Geotechnical Society's "Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes: 2005". The borehole locations are shown in Drawing 1 in Appendix A and the borehole logs are presented in Appendix B.

3.4 Cone Penetrometer Tests (CPT)

Twenty four CPTs were carried out across the site by McMillan Drilling from the 1 to 4 July 2019 using a track mounted CPT rig. CPT's were initially advanced to a target depth of 10m or refusal, but as investigations moved into the southern block, artesian groundwater pressures were encountered. CPTs were then terminated once dense gravels were encountered, or at a maximum depth of 7m bgl, to try and avoid punching through to the artesian aquifer. Backfilling with bentonite was not possible with the artesian pressures and many of the CPT holes in the southern block were sealed with cement grout instead. The CPT locations are shown in Drawing 1 in Appendix A and the CPT logs are presented in Appendix B.

3.5 Groundwater

The hydrogeology of the Rangiora area is complex. Regional piezometric contours and chemical analyses suggest groundwater is primarily recharged via the Ashely river and generally flows to the south west (Brown et al, 1988). A combination of shallow unconfined groundwater, interaction with variable near surface geology and a consistent eastward dipping shallow slope have resulted in a varied groundwater regime in the local area.

Within the site, measured groundwater levels ranged from 4.1m bgl up to 0.6m agl (Drawing 2 in Appendix A). Groundwater in the northern block was consistently at depth and only encountered in boreholes. CPTs in the northern block did not intersect groundwater, or the hole collapsed before any measurement could be made. The ground water encountered was associated with dense sandy gravels extending to at least 15m bgl.

When investigations moved into the southern block groundwater levels increased dramatically, and south of Borehole BH3, groundwater became fully artesian and flowed at the surface. The sudden rise in groundwater pressures was accompanied by the presence of thick accumulations of silt, to approximately 5m to 7m bgl. It is interpreted that these silts have a low hydraulic conductivity and form a surface aquitard, confining the groundwater in the gravels below. Coupled with the sloping gradient of the surface, confinement of the groundwater leads to artesian conditions downslope of where the silt accumulation begins. The artesian groundwater will flow when the silts are penetrated through to the gravel, or if there are preferential flow paths through the upper silt layers. Further evidence of the artesian groundwater is the presence of numerous small natural springs in the southern end of the property.

It is difficult to determine if there is a perched groundwater level within the upper silts layer, as the majority of the test holes encountered artesian groundwater, but it is likely that any perched groundwater level will be directly influenced by, and possibly fed, by the artesian groundwater at depth. A cross-section illustrating the hydraulic gradient across the site can be found in Appendix A.

3.6 Ground Model

Based on the results of our geotechnical investigations the site is underlain by recent alluvial deposits, which consist of sand, silt and peat, that vary both horizontally and vertically, overlying gravel.

The ground conditions at the site can be separated into the northern and the southern blocks, and the typical ground profiles are summarised in Tables 1 and 2.

Table 1 **Inferred Ground Model – Northern Block**

Unit	Depth to top of layer	Depth to bottom of layer	Material
1	0.0m	0.15m to 0.5m	Topsoil: Sandy SILT with trace rootlets; dark brown.
2	0.15m to 0.5m	0.5m to 2m	Silty SAND and SILT; yellowish brown. Sand - medium dense to dense, Silt – stiff to hard, moist.
3	0.5m to 2m	Greater than 15m (i.e. depth investigated)	Sandy and Silty GRAVEL with sand and silt layers; light brown. Medium dense to very dense, ranging from dry to wet.

Table 2 **Inferred Ground Model – Southern Block**

Unit	Depth to top of layer	Depth to bottom of layer	Material
1	0.0m	0.3m to 0.6m	Topsoil: Sandy SILT with trace rootlets; dark brown.
2	0.3m to 0.6m	3.7m to 6.2m	SILT with minor fine sand and occasional peat; light brown. Soft, moist to wet, low plasticity; often organic.
3	3.7m to 6.2m	Greater than 15m (i.e. depth investigated)	Sandy and Silty GRAVEL with minor silt; light brown. Dense to very dense, wet.

The northern block has a relatively thin layer of silt and sand overlying gravels. The southern block has a thicker sequence of soft silts with peat and sand layers ranging between 4m to 6m deep, overlying gravel. There is an abrupt deepening of the silt layer just south of Kippenberger Ave between the northern and southern blocks.

The marked change between the northern and southern blocks is illustrated on the Geological Cross-section in Appendix A. This section, running through the northern and southern blocks, shows the silts deepen to the south of Kippenberger Ave.

Based the surface geomorphology of the site (refer to the Digital Elevation Model (DEM) - Drawing 2, Appendix A) we infer that a south east trending abandoned braid plain of the Ashely River cuts across most of the northern block. While no longer active, channel bends, banks and braid bar features are still visible in the landscape. Alluvial gravels are therefore expected near the surface, as confirmed in by the intrusive investigations in the northern block.

Looking to the south of Kippenberger Ave, the DEM appears flat and featureless. The landscape in the southern block is markedly different from what is seen in the northern block. The lack of surface features in the southern block coincides with the approximate extent of the deeper silt deposits (refer to Drawing 2, Appendix A). The composition of the silt varies, often containing significant organic content, and in Borehole BH4 up to two meters of peat. Silt, and especially peat, are indicative of a low energy depositional environment. Based on the proximity to the Ashley river, we interpret the silt and peat as overbank floodplain deposits, likely associated with the now abandoned braided plain that runs through the northern block of the property.

4 Engineering Recommendations

4.1 General

Westpark Rangiora Ltd are investigating the potential of subdividing land on the eastern outskirts of Rangiora township. At this stage a preliminary geotechnical assessment report is required to gain an understanding of the ground conditions at the site and identify the likely geotechnical hazards specific risks that may affect the construction of the proposed subdivision. Based on the investigations, the geotechnical aspects that need to be considered for future development of the site are as follows:

- Potential for seismically induced liquefaction and lateral spreading.
- The presence of organic soil and peat, and the potential for long-term consolidation settlement.
- Likely shallow and artesian groundwater conditions to be encountered.
- Implications for building foundations.
- Recommendations for infrastructure construction.

Specific details of the future development are not yet known; however, we understand this subdivision will be developed for residential housing. This will likely include both single and doubled storeyed structures, as well as roads and underground services. Preliminary geotechnical recommendations for the proposed development are provided in the following sections.

4.2 Site Subsoil Classification

We have assessed the sites flexibility based on the following:

- Site stratigraphy comprises gravel, sand and silt to over 15m depth, as found during investigations, and over 300m deep based on geological cross sections for the region.
- Clause 3.1.3 and Table 3.2 of NZS 1170.5:2004.

We consider that the site subsoil category in terms of NZS 1170.5:2004 Clause 3.1.3 is **Class D (Deep or soft soil).**

4.3 Liquefaction Analysis

Based on the New Zealand Geotechnical Database's (NZGD, 2019) observed liquefaction maps for both the 4 September 2010 Darfield earthquake and the 22 February 2011 Christchurch earthquake, the Rangiora area has experienced minor amounts of liquefaction induced ground damage. No damage attributed to liquefaction has been recorded on the NZGD for either earthquake. However, based on the site stratigraphy and high groundwater levels, the site may be susceptible to seismically induced liquefaction and we have therefore undertaken a CPT based liquefaction assessment. Our liquefaction analysis and results are detailed in the following sections.

4.3.1 Potential for Liquefaction

Three primary factors contribute to liquefaction potential:

- Soil grading and density;
- Groundwater; and
- Earthquake intensity and level of ground shaking.

Each of these is discussed below.

Soil Grading and Density

Our intrusive investigations indicate that the underlying soils typically have a variety of fines content. Based on the variation of fines in the core retrieved from boreholes, and the corresponding CPT data, we have assessed CFC values based on correlations suggested by Boulanger and Idriss (2014) and have assumed a conservative CFC of 0 for our liquefaction analysis. This assumption should be reviewed following further geotechnical investigation and laboratory testing at the next stage of geotechnical investigations.

Groundwater

Based on the groundwater levels recorded in the existing geotechnical investigations, we have adopted two groundwater depths for our analysis. In the northern block groundwater was recorded in boreholes between 4.0 and 4.1 m bgl, and therefore we have assumed a groundwater level of 4m bgl for all CPTs in the northern block (CPT1 to CPT13). In the southern block, groundwater was either less than 1m bgl or flowing at the surface. While the artesian pressures encountered in the southern end of the site are not indicative of the true shallow groundwater levels, we have assumed a level of 1m bgl for CPTs in the southern block. Soils below these depths are therefore susceptible to liquefaction from a saturation criterion. These assumptions will need to be confirmed with shallow geotechnical investigations at the next stage of geotechnical investigations.

Earthquake Intensity and Shaking

For structures in the Canterbury earthquake region, the MBIE/NZGS “Module 1: Overview of the guidelines” dated March 2016, recommends the following design earthquake events for liquefaction triggering analysis for Importance Level 2 (IL2) buildings:

- SLS-a shaking a Mw7.5 earthquake with 0.13g PGA
- SLS-b shaking a Mw6.0 earthquake with 0.19g PGA
- ULS shaking a Mw7.5 earthquake with 0.35g PGA

The damage criteria for each design event as stated in NZS1170.5 and is summarised in the table below.

Table 3 Design Earthquake Objectives

Design Earthquake	Damage Criteria
SLS	It is expected that there should not be damage to the structure or non-structural elements that would prevent the building from being used as originally intended.
ULS	Buildings/structures designed for the ULS event are expected to retain their structural integrity and form during an earthquake and not endanger life. Some plastic deformation of structural elements within the structure is expected to occur but ideally the damage can be repaired and the structure can be returned to service after the event, although repair may be uneconomical.

4.3.2 Liquefaction Assessment

Methodology

The ability for subsoils to resist the effect of ground shaking associated with the design level earthquakes has been assessed from the subsoil information obtained from the relevant CPTs. In our assessment, we have considered the liquefaction induced reconsolidation settlement and the likelihood of lateral spreading.

The liquefaction assessment has been carried out using the references in the table below.

Table 4 Liquefaction Assessment Methodology Summary

Test	Liquefaction Assessment (1)	Fines Content	Liquefaction Cut Off	Liquefaction Settlement Method (2)
CPT	Boulanger and Idris (2014)	Based on a soil Character Index (I_C) with a Fines Content Correction Factor (C_{FC}) = 0.0	Based on a 2.6 I_C cut off	Zhang et al (2002)

(1) A 15% probability of liquefaction (PL) has been considered.

(2) We note that there is an inherent uncertainty when identifying liquefiable layers in CPT analysis, due to this inherent uncertainty, calculated settlements will likely differ from actual settlements experienced on site.

As part of our liquefaction assessment we have also calculated the Liquefaction Severity Number (LSN) as it tends to better reflect the more damaging effects of shallow liquefaction, which is more critical for shallow founded structures. Tonkin & Taylor (T&T) have developed LSN based on investigation data and observations made following major earthquake events in Christchurch. The calculated LSN was based on Boulanger and Idriss (2014) triggering methodology with Zhang et al (2002) volumetric densification strain.

We are also aware of the Tonkin and Taylor (2015) report, “Canterbury Earthquake Sequence: Increased Liquefaction Vulnerability Assessment Methodology”, prepared for the EQC, which indicates that a LSN value of 16 is considered generally representative of the transition between land which is materially vulnerable to liquefaction and land which is not.

The level of ground damage associated with LSNs is summarised in Table 5, based on T&T (2013) observations.

Table 5 LSN Ranges and Observed Effects (Tonkin & Taylor, 2013)

LSN Range	Predominant Performance
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with sand boils and some structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlement of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services

When compared to the broad descriptions of expected land performance in TC1, TC2 and TC3, the LSN number can be approximately correlated to technical categories as follows:

- TC1 = $LSN_{(ULS)} < 10$
- TC2 = $LSN_{(SLS)} < 20$ and $LSN_{(ULS)} < 30$
- TC3 = $LSN_{(SLS)} > 20$ or $LSN_{(ULS)} > 30$

Liquefaction Results

Additionally, none of the CPTs used in the analysis reached beyond 10m bgl, so indexing of settlements was not required. The results from our liquefaction assessment are summarised below and a detailed summary of results are presented in Appendix C:

Northern block

- Settlements are only predicted in three CPTs (CPT5, CPT8 and CPT9) with settlements of less than 15mm for the ULS earthquake case only. No settlement is calculated for SLS loading.
- Calculated LSNs are between 1 and 3 for the ULS earthquake case.

Southern block

- Liquefaction induced settlements are less than 30mm under the SLS earthquake case and less than 60mm under ULS earthquake case.
- Calculated LSNs are between 1 and 14 under the SLS earthquake case and between 1 and 30 for the ULS earthquake case.
- Settlement over 30mm was limited to CPT14, CPT15, CPT17 and CPT19 indicating that liquefaction susceptibility varies across the southern block.

Lateral Spreading

The site is approximately flat and level, and we assume that the development of the subdivision will likely not create significant height differences. Given the liquefaction potential and the flat nature of the site, at this stage we consider that the potential for lateral spreading on site is low. However, if future development requires deep stormwater basins or water features with free edges, then the lateral spreading potential will need to be reassessed.

Land Classification Technical Categories

For the Christchurch Region the Ministry of Business, Innovation and Employment (MBIE, 2012) has released a classification system for residential “Green Zone’ land on the flat regarding liquefaction susceptibility. This classification system is divided into three technical categories that reflect both the liquefaction experience to date and future performance expectations. The categories and corresponding criteria are summarised as follows:

- **Technical Category 1 (TC1)** – Future land damage from liquefaction is unlikely, and ground settlements are expected to be within normally accepted tolerances.
- **Technical Category 2 (TC2)** – Minor to moderate land damage form liquefaction is possible in future large earthquakes.
- **Technical Category 3 (TC3)** – Moderate to significant land damage from liquefaction is possible in future large earthquakes.

The MBIE Guidelines indicate the following liquefaction deformation limits for house foundations as summarised in Table 6.

Table 6 Liquefaction Deformation Limits and House Foundation Requirements

Technical Category	Liquefaction Deformation Limits				Likely Implication for House Foundations (subject to individual assessment)
	Vertical		Lateral		
	SLS	ULS	SLS	ULS	
TC1	15mm	25mm	Nil	Nil	Standard NZS3604 type foundations with tied slabs
TC2	50mm	100mm	50mm	100mm	MBIE enhanced foundation solutions
TC3	>50mm	>100mm	>50mm	>100mm	Site specific foundation solution

Based on the results of the liquefaction assessment the land in the northern block can be classified as Technical Category TC1 equivalent. The land in the southern block can be classified as Technical Category TC1 and TC2 equivalent as there is some variation in ground conditions across this part of site. However, given that none of the tests did not reach 10m (depth required for assessing against the MBIE index settlements), we consider that at this stage the southern block of site should be considered Technical Category TC2 equivalent.

4.3.3 Conclusions

Based on our seismic hazard assessment we draw the following conclusions:

- Liquefaction induced settlements are expected under SLS and ULS earthquake events for the southern block of the site, with calculated settlements to be less than 30mm under SLS and 60mm under ULS earthquake case.
- Negligible total settlements are expected under SLS and ULS loadings for the northern block of the site, with calculated settlements of less than 15mm.
- For the southern block, based on the calculated LSNs and Table 5, little to no expressions of liquefaction are expected during a SLS earthquake case, and minor to moderate expressions are expected under ULS earthquake case.
- Little to no expressions of liquefaction are expected in the northern block for both SLS or ULS earthquake cases.
- Lateral spreading potential on site is considered low, due to the site being relatively flat and away from any free edges. Reassessment of lateral spreading may be required to account for any slopes created during site earthworks.
- The land in the northern block is likely to perform to equivalent Technical Category TC1.
- The land in the southern block is likely to perform to equivalent Technical Category TC2.

4.4 Organic Soil and Peat Layers

The geotechnical investigations indicate that there is a thick layer of soft silt and organic silt with peat layers underlying the southern block, which are 4m to 6m thick. The material is relatively low strength and may have the potential for short and long-term consolidation settlement from loads such as residential dwellings, or long-term vehicle loads. In addition, the finished ground level of any future development may include filling across the site, which would cause further settlement issue with the peat/organic silt. Preliminary recommendations with regard to building foundations and infrastructure are provided in the following sections.

4.5 Foundation Considerations

When considering likely foundations for any future structures at the site, potential for liquefaction induced ground damage needs to be considered as well as artesian groundwater presence and consolidation of organic soils and peat. If liquefaction induced ground damage was the only issue, then enhanced foundation systems for Technical Category 2 areas provided in the MBIE Guidelines (2012) may be used (refer Table 6). However, with the presence of soft/organic soils and peat, such a foundation system alone may not be suitable.

Without knowing the exact development that may be undertaken on the site, specific recommendations are not possible, but we have reviewed likely foundation options for the northern and southern blocks and discussed these in Tables 7 and 8.

Table 7 Foundation Options for the Northern Block

Option	Details	Comments
Standard NZS 3604:2011 Foundations	Install NZS 3604:2011 standard shallow foundations on TC1 equivalent land.	This foundation option will likely be appropriate across the northern block of the property where 300kPa ultimate bearing capacity is available from the insitu soil.
Raft Foundations	Install raft type foundations on the current soil profile with no additional work.	This foundation option will likely be appropriate across the northern block of the property where the available ultimate bearing capacity from the insitu soil is less than 300kPa..

Table 8 Foundation Options for the Southern Block

Option	Details	Comments
TC2 Enhanced Raft Foundations	Install TC2 type foundations on the current soil profile with no additional work.	This foundation option would be suitable to address issues associated with liquefaction induced ground damage and may be suitable where the soft/organic layers are present at greater depths (i.e. 1.5m to 1.8m depth). However, where soft soils or peat are at shallower depths the building could be affected by differential settlements and a raft option may not be suitable.
TC3 Relevelable Raft	Install TC3 relevelable foundation on the current soil profile with no additional work.	Although designed for TC3 ground, these slabs can be easily re-levelled if differential settlement occurs and hence it could be used in parts of the site where soft soils peat are relatively shallow. With this option it would need to be accepted that differential settlement would occur, and the building owner would need to allow for it to be re-levelled if required.
Piled Foundations	Install piles to below the organic soil into the underlying dense gravel and sand.	This would separate the building from issues associated with shallow liquefaction and the settlement of organic layers. The piles will need to be installed at depths where the piles are unlikely to be affected by liquefiable soil layers below the organic layer. Piles may therefore need to be in the order of 7m to 8m deep. However, it is noted that the local council is generally not in favour of piles as they may provide a conduit for artesian water pressures. Given the extent of artesian pressures observed in the southern part of the site, piles are likely to allow groundwater to reach the surface.

Option	Details	Comments
Pre-load Ground	Pre-load the ground with a stockpile of soil until the majority of the settlement in the underlying organic soil has occurred. Once settlement has occurred and the stockpile is removed, the buildings can be constructed.	This option would require relatively high soil stock piles (in the order of 3m high) that may need to be in place for a significant period of time (12 to 18 months). Once the majority of the settlement has occurred then a shallow foundation system such as a TC2 enhanced raft may be used. As the ground has been pre-loaded the shallow foundations are unlikely to be affect by differential settlement. This option would be considered a form of ground improvement and would be the lowest risk option.

Depending on the nature of any future development and the level of acceptable risk a number of foundation options are available to use at the site. The density of housing will likely decide the most appropriate foundation method. As an example, for sparsely situated houses a raft or pile foundation option may be the most suitable, but if the site was to be subdivided into higher density lots then ground improvement by pre-loading on a subdivision scale may become the most cost-effective option.

Once the nature and extent of the subdivision development is finalised, a geotechnical engineer will need to be engaged to carry out subdivision specific investigations and to recommend suitable ground improvement / foundation systems to be used.

4.6 Infrastructure

Despite the minor to moderate potential liquefaction risk in the southern block of the site, buried services installed here are still potentially vulnerable to seismically induced liquefaction if located in potentially liquefiable upper sandy and silty soils. The liquefaction analysis indicates that potential liquefaction induced ground damage is unlikely in a SLS event, but potential ground damage in a ULS event may occur in some areas of the southern block. In addition, the buried services are likely to be affected by the presence of the organic soils and peat in the southern block where it is at shallower depths (i.e., less than 1m) and shallow groundwater fed by springs from the artesian aquifer below.

Services installed in the northern block are unlikely to encounter any of the above conditions, however the southern end of the northern block (adjacent to Kippenberger Ave) may present similar issues.

To ensure robustness of the buried services it is recommended that the buried services be designed to accommodate the potentially adverse effect of seismically induced liquefaction as well as settlement associated with soft/organic soils and peat. This may require installing a gravel raft trench detail in the base of the buried services excavation where soft soils are encountered.

It is anticipated that further assessment of infrastructure will be required at part of the detailed design for any future development. The design will need to take into account the nature of the buried service, the depth of the soft/organic layers, strength of the soft/organic layers and whether specific mitigation measures such as the use of geogrid/geotextile will be required. For deep and/or heavy infrastructure, specific foundation design will be required. Shallow groundwater and artesian groundwater conditions will need to be considered in the design of all site infrastructure and appropriate mitigation measures determined at the detailed design phase.

If ground improvement was to be considered, as discussed in Section 4.4, then consideration should be given to extending it into the road reserves so that specific mitigation measures for the buried services may be reduced.

4.7 Pavement

The development will require an extensive roading layout. Based on the preliminary site testing in the northern block, it is inferred that once any topsoil, silt or loose material is stripped, the subgrade is likely to be suitable for conventional road pavement.

In the southern block it is inferred from our liquefaction assessment that any pavement is unlikely to be significantly affected by seismically induced liquefaction in a SLS event, but some areas may be affected in a larger event. Additionally, the pavement may be affected by the presence of organic soils and peat where it is at shallower depths (i.e., less than 1m below carriage way level). Where organic soils and peat are relatively deep the pavement may not be significantly affected. However, to ensure robustness of the pavement it is recommended that the pavement be designed to accommodate the potentially adverse effect of seismically induced liquefaction as well as settlement associated with the peat.

The pavement will require specific engineering design. The design will need to take into account the likely vehicular loading, the depth of the soft/organic layers, strength of the soft/organic layers and whether specific mitigation measures such as the use of geogrid/geotextile or bulk excavation are required. Considerations to sub pavement drainage should be made as artesian groundwater may have the potential to flood subgrade.

If bulk ground improvement was to be considered, as discussed in Section 4.5, extending ground improvement into the roadways could reduce specific mitigation measures required for the pavement.

4.8 Groundwater

The investigations identified artesian groundwater pressures in the southern part of the site in the investigation holes and there were a number of flowing springs in the southern part of the block, close to Northbrook Road. The current farm infrastructure has field tile drains that drain into the open drainage channel and a couple of these could be seen flowing, most likely fed by springs.

The springs are likely to be fed from the artesian groundwater pressures in the underlying gravels, which is not uncommon for this part of Rangiora. The artesian groundwater will flow when the silts were penetrated through to the gravel or if there are preferential flow paths through the upper silt layers.

It is difficult to determine if there is a perched groundwater level within the upper silts layer, but it is likely that any perched groundwater level will be directly influenced and possibly fed by the artesian groundwater at depth.

Both the presence of the perched groundwater level and the artesian groundwater at depth will have an effect on the development of the southern block, as excavations for earthworks, underground service or foundations could intercept springs feed by artesian groundwater. Especially in the southern half of the southern block, as site observations indicate this is where the majority of the springs were located as well as flowing field tile drains.

To provide certainty on the groundwater levels in the southern block, an option is install a network of subsoil drains (similar to the field tile drains that are currently there) to intercept the groundwater flows and levels. These drains would need to discharge into a drainage network, which will require resource consent and council approval. Another option is to build the site up so the excavation below existing ground level is kept to a minimum. The groundwater regime in the southern block will require further investigation and assessment in conjunction with the civil design to determine the appropriate engineering measures.

4.9 General Site Development Recommendations

4.9.1 Cut Excavations

Based on the investigation results we make the following comments:

- Cuts in the northern block are likely to encounter typically thin silty and sandy soils overlying dense alluvial gravels at shallow depths. We anticipate that the soils will be easy to excavate with conventional earth moving equipment.
- Cuts in the southern block are likely to encounter predominantly silty soil with the potential for sand, organic silt and shallow peat layers. These soils will also be easily excavated with conventional earthmoving plant.
- Cuts greater than 1.5m in height should be inspected by a geotechnical engineer or engineering geologist as work proceeds to confirm the acceptability of the actual slopes;
- Cut slopes of 3H:1V are likely to maintain global stability for static and seismic cases.
- Cut slopes will be vulnerable to erosion and therefore should be hydroseeded/planted or otherwise protected as soon as practicable after excavation.
- Groundwater seepages maybe encountered in cut excavations, especially in the southern block. If significant groundwater inflows are encountered and left untreated, slumping of cuts could occur. If groundwater seepages are encountered these should be inspected by a geotechnical engineer or engineering geologist and site-specific treatment adopted, as required.
- Deep cuts in the southern block are to be avoided. The artesian aquifer extending across most of the southern block will present significant challenges to excavations and dewatering. Puncturing through the confining silt layer will likely result in uncontrollable amounts of groundwater infiltration into excavations.

4.9.2 Earthfill

We make the following recommendations with regard to the placement of fill:

- Filling shall generally be carried out in accordance with NZS4431:1989 – Code of Practice for Earth Fill for Residential Development, with appropriate on-site quality control;
- Depending on the nature of the fill material the appropriate compaction standard will need to be applied. A geotechnical engineer should review the compaction standard prior to site earthworks.
- All areas where earthfill is to be placed should be stripped of topsoil and other organic material and stockpiled.
- Fill slopes are likely to be stable at a slope of 3H:1V. If fill slopes are required to be steeper, then the use of geogrids may be required to reinforce the fill edge. This should be assessed by a geotechnical engineer as part of the detail design.
- The fill slope could be vulnerable to erosion if concentrated stormwater flows develop. To control runoff from the fill batters and scouring of the fill, the front face should be planted and stormwater runoff directed away from the fill face.
- The design of any fill slope will need to take into account the potential for liquefiable soils or the presence of peat at the base of the slope.
- If fill depths exceed 0.5m, we recommend a geotechnical engineer carries out an assessment to confirm the affect the fill surcharge will have on the settlement potential of the organic soils.

4.10 Further Investigations

If the site is to be developed, then further geotechnical investigation and design will be required. The extent of the investigation will depend on the nature of the development but could include the following:

- Additional deep investigation (including CPTs and boreholes) to further define the soil profile across the site.
- Test pitting to identify the depth to organic soils across the site.
- Investigations to assess shallow groundwater levels, especially around Kippenberger Ave and the southern block.
- Further delineate areas of probable liquefaction susceptibility.
- Investigate the extent of peat in the southern end of the property.
- Laboratory testing of the soft/organic soils and peat to provide soil parameters for settlement analysis.
- Assess the extent of settlement during construction in the southern block and determine possible remediation measures.

4.11 Safety in Design

Safety in design is an important consideration during design and construction of the new subdivision. The geotechnical hazards that will need to be considered are uncertain at this stage of the project but could include:

- Surface runoff or groundwater seeps could cause soft slippery subgrade.
- Falls into foundation excavation during construction.
- Construction safety around machinery and traffic etc., associated with foundation excavation and preparation.
- Construction issues associated with foundation excavations in potentially contaminated soils.

A detailed safety in design hazard assessment will be required as part of final design.

Safety in design should be considered a ‘Live’ process and the type and scope of identified hazards may change during the design and construction phases of the project. Therefore, the Safety and Design Register should be periodically updated throughout the life of the project.

5 References

Boulanger, R.W.; Idriss, I.M., 2014. *CPT and SPT based liquefaction triggering procedures*. Report No. UCD/CGM-14/01. Center for Geotechnical Modelling, Department of Civil and Environmental Engineering, University of California, Davis, California.

Brown, L.J.; Wilson, D.D.; Moar, D.C.; Mildenhall D.C., 1988. Stratigraphy of the late Quaternary deposits of the northern Canterbury Plains, New Zealand. New Zealand Journal of Geology and Geophysics.

Forsyth, P.J.; Barrell, D.J.A.; Jongens, R. (compilers) 2008. *Geology of the Christchurch area*. Institute of Geological and Nuclear Sciences, 1:250,000 geological map 16. Lower Hutt, New Zealand.

Ministry of Business, Innovation and Employment, 2012. *Repairing and rebuilding houses affected by the Canterbury earthquakes.* Version 3, Revised Issue

New Zealand Geotechnical Database accessed on 16 July 2019, from https://www.nzgd.org.nz

NZGS, 2016. *Earthquake geotechnical engineering practice – Module 1: Overview of the guidelines*. NZ Geotechnical Society Inc, Wellington, New Zealand.

NZGS, 2005. *Guidelines for the Classification and Field Description of Soils and Rocks in Engineering*. NZ Geotechnical Society Inc, Wellington, New Zealand.

NZS 1170.5:2004 *Structural design actions - Part 5: Earthquake actions.* Standards New Zealand, Wellington, New Zealand.

NZS 3604:2011. *Timber Framed Buildings*. Standards New Zealand, Wellington, New Zealand.

NZS 4402:1986 *Methods of testing soils for civil engineering purposes.* Standards New Zealand, Wellington, New Zealand.

NZS 4431:1989 *Code of practice for earth fill for residential development*. Standards New Zealand, Wellington, New Zealand.

Tonkin and Taylor Ltd, 2015b. *Canterbury Earthquake Sequence: Increased Liquefaction Vulnerability Assessment Methodology*. Prepared for the Earthquake Commission, T&T Ref. 52010.140.v1.0.

Tonkin and Taylor Ltd, 2013. *Liquefaction Vulnerability Study.* Prepared for the Earthquake Commission, T&T Ref. 52020.0200/v1.0.

Zhang, G.; Robertson, P.K.; Brachman, R.W.I., 2002. *Estimating liquefaction-induced ground settlements from CPT for level ground*. Canadian Geotechnical Journal, Vol. 39, pp.1168 – 1180.

6 Explanatory Statement

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client for the purpose of building consent application only, and no responsibility or liability will be accepted to any other third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data collected at specific locations and by using suitable investigation techniques with limited site coverage. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the Client’s brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground and groundwater between test locations has been inferred using experience and judgment and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

This report is not to be reproduced either wholly or in part without our prior written permission.

Appendix A

Drawings

Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence . Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRI

Coordinate System: New Zealand Transverse Mercator 2000

Path: C:\Users\Fraser.Monteith\OneDrive - Aurecon Group\Documents\Projects - Local\Kippenberger Ave\Kippenberger_Ave_Subdivision\Kippenberger_Ave_Subdivision.aprx

Date: 22/07/2019

LEGEND

- ⊕ BOREHOLE
- ▲ CPT
- ▭ PROPERTY BOUNDARY

NOTES:

Locations and boundaries approximate only, located using handheld GPS accurate to +/- 10m.

Aerial imagery from LINZ Data Service (Creative Commons License).

aurecon
www.aurecongroup.com

CLIENT
WESTPARK
RANGIORA

REV	DATE	REVISION DETAILS	APPROVED
A	22.07.19	PRELIMINARY	

SCALE	SIZE
1:7,500	A3

DRAWN
F. MONTEITH

REVIEWED
J. MUIRSON

VERIFIED
J. KUPEC

PRELIMINARY
NOT FOR CONSTRUCTION

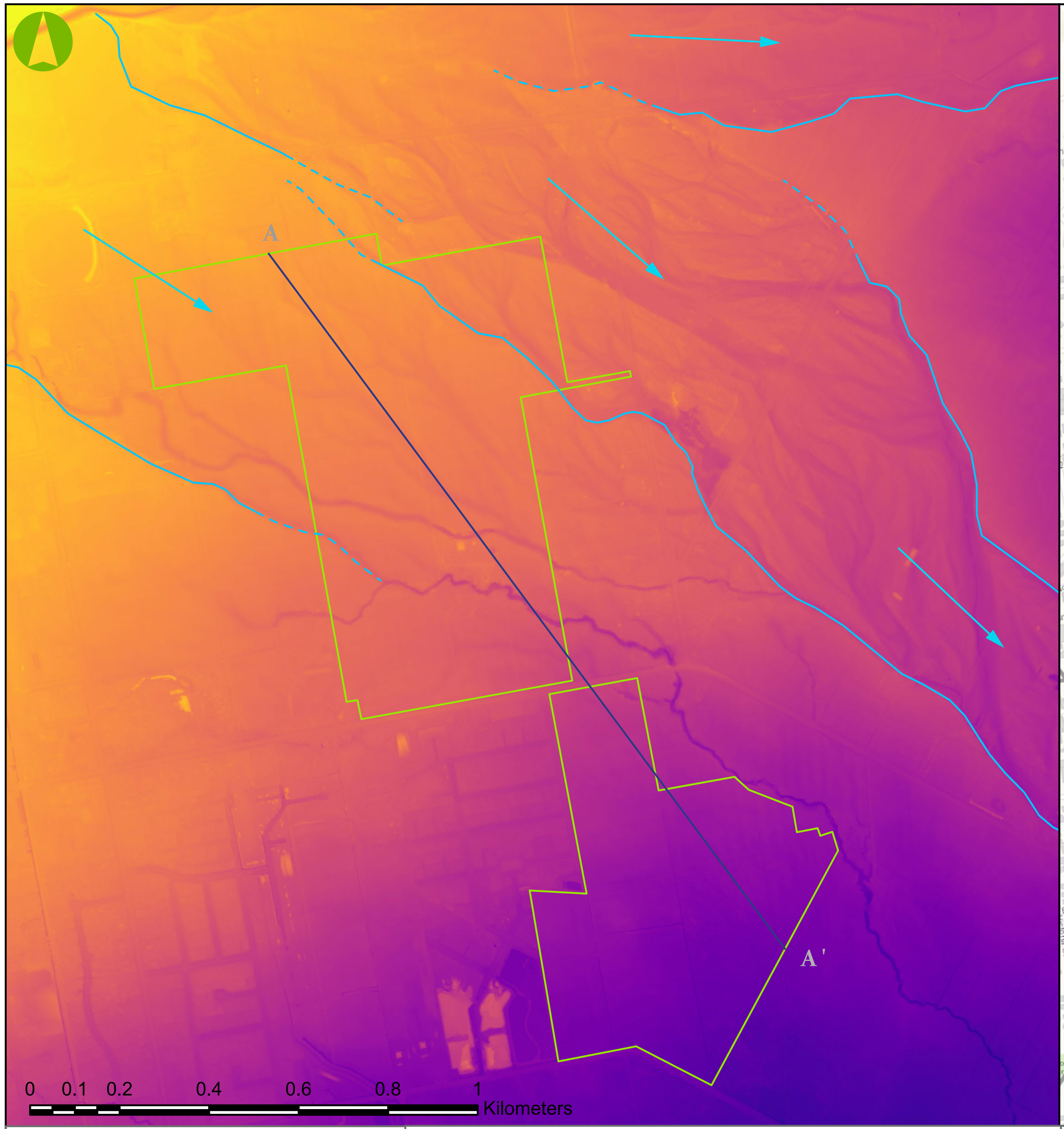
APPROVED
DATE
22.07.19
J. TRIST

PROJECT: INCH LAND - KIPPENBERGER AVE SUBDIVISION DEVELOPMENT

TITLE: PRELIMINARY SITE INVESTIGATION LOCATION PLAN

DOCUMENT	PROJECT		ZONE		DISCIPLINE		ELEMENT		TYPE		SHEET		REVISION
	506685	–	0001	–	GG	–	0001	–	DRG	–	01	–	A

Coordinate System: New Zealand Transverse Mercator 2000   Date: 19/07/2019
Path: C:\Users\Fraser.Monteith\OneDrive - Aurecon Group\Documents\Projects - Local\Kippenberger Ave\Kippenberger_Ave_Subdivision\Kippenberger_Ave_Subdivision.aprx



LEGEND

- —— CROSS-SECTION
- —— BRAID CHANNEL BANK
- ▭ PROPERTY BOUNDARY
- → FLOW DIRECTION

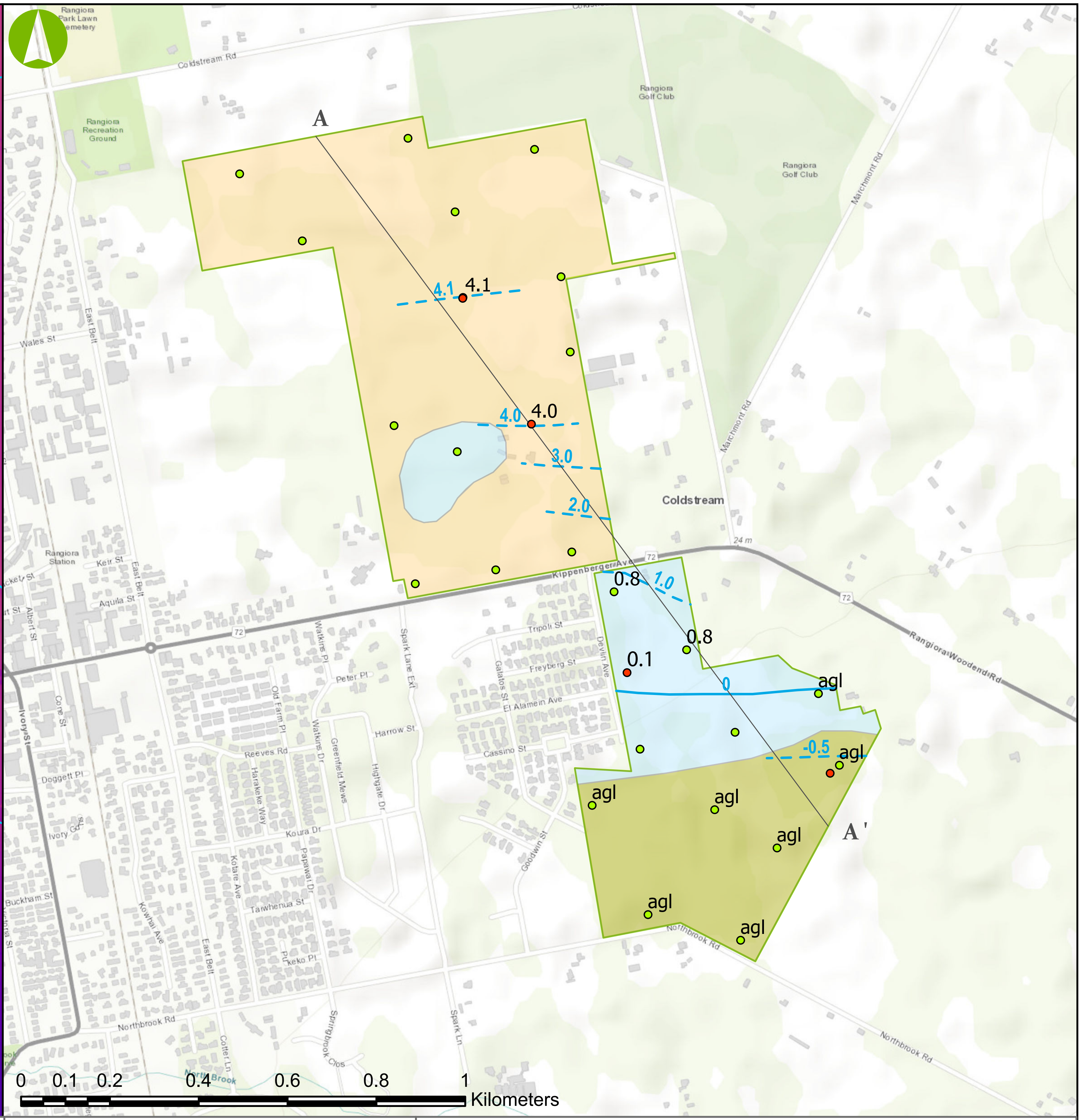
NOTES:

Boundaries are approximate only.

Braid channel banks depicted are suggestive of the most prominent features in the DEM. These may not be evident in the field.

Flow directions are based on the slope of the ground surface.

Digital Elevation Model (DEM) sourced from LINZ Data Service and contoured to show show small elevation differences.



LEGEND

- ● CPT WITH WATER DEPTHS (m)
- ● BOREHOLES WITH WATER DEPTHS (m)
- - - - PIEZOMETRIC CONTOURS (m)
- —— CROSS-SECTION
- ▭ GRAVELS, SAND
- ▭ SILT, ORGANIC SILT, PEAT
- ▭ SILT, SAND
- ▭ PROPERTYBOUNDARY

NOTES:

Locations mapped using handheld GPS accurate to +/- 5m.

Geology depicted shows the approximate spatial distribution of stratigraphy at 1.0m below the surface only (to account for topsoil).

The boundaries of stratigraphic units have been determined based only on the CPT and borehole data and are approximate only.

Piezometric contours derived from measured groundwater levels and are approximate only. Seasonal variations are will likely affect these levels.

aurecon
www.aurecongroup.com

CLIENT
WESTPARK
RANGIORA

REV	DATE	REVISION DETAILS	APPROVED
A	23.05.19	PRELIMINARY	

SCALE	SIZE
1:12,000	A3

DRAWN
F. MONTEITH

REVIEWED
J. MUIRSON

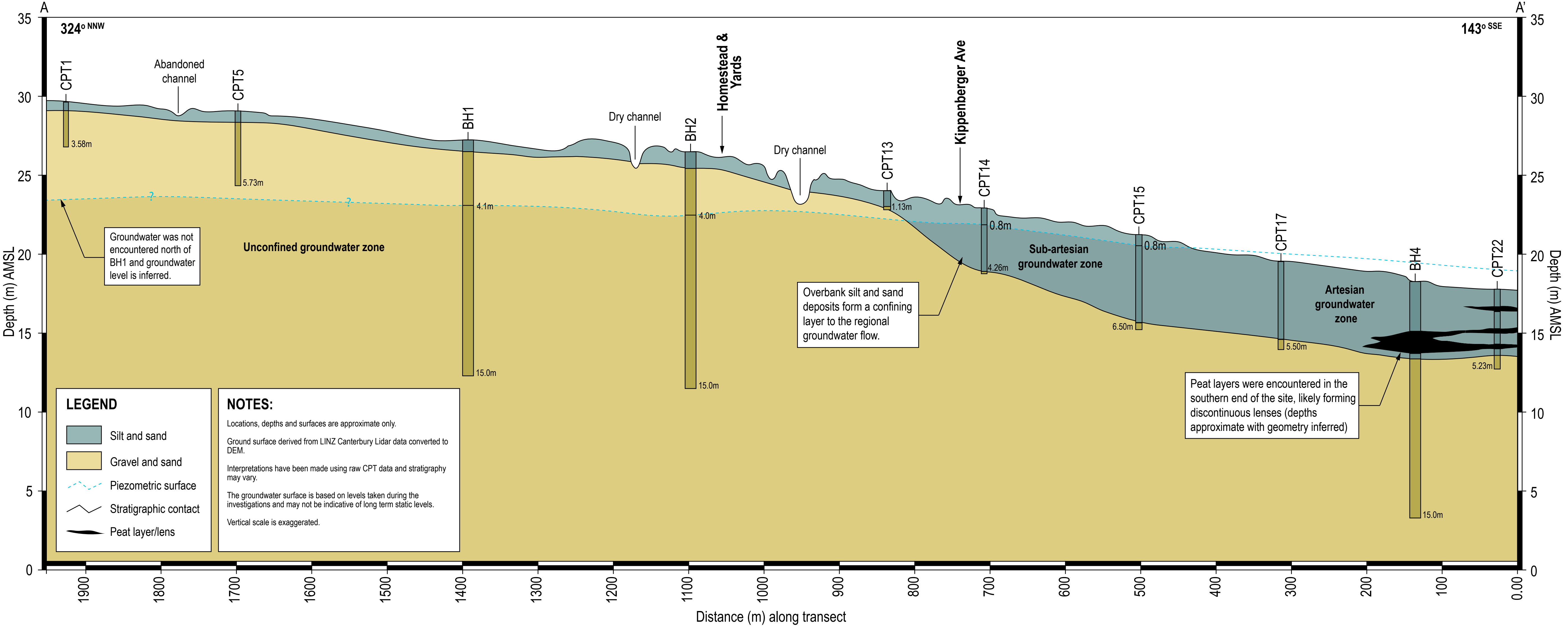
VERIFIED
J. KUPEC

PRELIMINARY
NOT FOR CONSTRUCTION

APPROVED
DATE
19.07.19
J. TRIST

PROJECT	INCH LAND - KIPPENBERGER AVE SUBDIVISION DEVELOPMENT
TITLE	SURFACE GEOLOGICAL AND GEOMORPHOLOGICAL MAP

DOCUMENT	PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
	506685	0001	GG	0001	DRG	02	A



Groundwater was not encountered north of BH1 and groundwater level is inferred.

Overbank silt and sand deposits form a confining layer to the regional groundwater flow.

Peat layers were encountered in the southern end of the site, likely forming discontinuous lenses (depths approximate with geometry inferred)

NOTES:

Locations, depths and surfaces are approximate only.

Ground surface derived from LINZ Canterbury Lidar data converted to DEM.

Interpretations have been made using raw CPT data and stratigraphy may vary.

The groundwater surface is based on levels taken during the investigations and may not be indicative of long term static levels.

Vertical scale is exaggerated.

www.aurecongroup.com

CLIENT

REV	DATE	REVISION DETAILS	APPROVED
A	17/07/19	PRELIMINARY	

SCALE	SIZE
NOT TO SCALE	A3

DRAWN
F. MONTEITH

REVIEWED
J. MUIRSON

VERIFIER
J. KUPEC

PRELIMINARY
NOT FOR CONSTRUCTION

APPROVED
DATE
17.07.2019
J. TRIST

PROJECT
INCH LAND - KIPPENBERGER AVE SUBDIVISION DEVELOPMENT

TITLE
GEOLOGICAL CROSS SECTION

DOCUMENT	PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
	506685	0001	GG	0001	SKT	03	A

Appendix B

Borehole and CPT Logs

NZ GEOTECHNICAL SOCIETY INC

ROCK > field guide sheet

FIELD DESCRIPTION OF ROCK

SEQUENCE OF TERMS – weathering – colour – fabric – rock name – strength – discontinuities – additional

SCALE OF ROCK MASS WEATHERING

Term	Grade	Abbreviation	Description
Unweathered (fresh rock)	I	UW	Rock mass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.
Slightly Weathered	II	SW	The rock mass is not significantly weaker than when fresh. Rock may be discoloured along defects, some of which may have been opened slightly.
Moderately Weathered	III	MW	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to a soil. Rock material may be discoloured and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration.
Highly Weathered	IV	HW	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass is changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
Completely Weathered	V	CW	Original rock strength is lost and the rock mass changed to a soil either by decomposition (with some rock fabric preserved) or by physical disintegration.
Residual Soil	VI	RS	Rock is completely changed to a soil with the original fabric destroyed (pedological soil).

ROCK STRENGTH TERMS

Term	Field Identification of Specimen	Unconfined uniaxial compressive strength q_u (MPa)	Point load strength $I_{s(50)}$ (MPa)
Extremely strong	Can only be chipped with geological hammer	> 250	>10
Very strong	Requires many blows of geological hammer to break it	100 – 250	5 – 10
Strong	Requires more than one blow of geological hammer to fracture it	50 – 100	2 – 5
Moderately strong	Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer	20 – 50	1 – 2
Weak	Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer	5 – 20	<1
Very weak	Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife	1 – 5	
Extremely weak (soil description required)	Indented by thumb nail or other lesser strength terms used for soils	<1	
Note: • No correlation is implied between q_u and $I_{s(50)}$			

SPACING OF DEFECTS/ DISCONTINUITIES

Term	Spacing
Very widely spaced	>2 m
Widely spaced	600 mm – 2 m
Moderately widely spaced	200 mm – 600 mm
Closely spaced	60 mm – 200 mm
Very closely spaced	20 mm – 60 mm
Extremely closely spaced	<20 mm

APERTURE OF DISCONTINUITY SURFACES

Term	Aperture (mm)	Description
Tight	Nil	Closed
Very Narrow	> 0 – 2	
Narrow	2 – 6	
Moderately Narrow	6 – 20	Gapped
Moderately Wide	20 – 60	Open
Wide	60 – 200	
Very Wide	> 200	

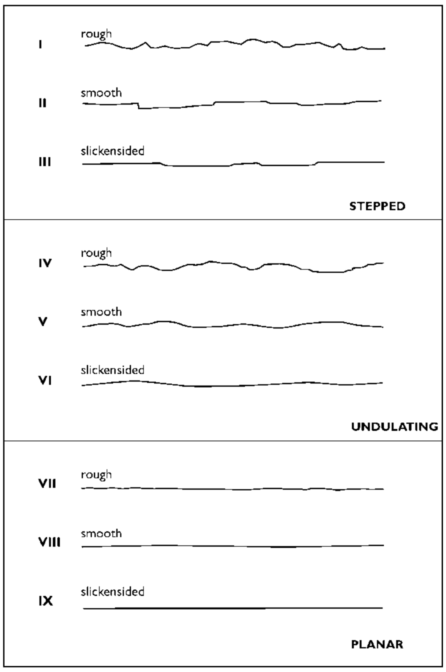
BEDDING THICKNESS TERMS

Term	Bed Thickness
Thinly laminated	< 2 mm
Laminated	2 mm - 6 mm
Very thin	6 mm - 20 mm
Thin	20 mm - 60 mm
Moderately thin	60 mm - 200 mm
Moderately thick	0.2 m - 0.6 m
Thick	0.6 m - 2 m
Very thick	> 2 m

BEDDING INCLINATION TERMS

Term	Inclination (from horizontal)
Sub-horizontal	0° – 5°
Gently inclined	6° – 15°
Moderately inclined	16° – 30°
Steeply inclined	31° – 60°
Very steeply inclined	61° – 80°
Sub-vertical	81° – 90°

ROUGHNESS AND APERTURE



compiled by KATE WILLIAMS design KARRYN MUSCHAMP

NZ GEOTECHNICAL SOCIETY INC

This field sheet has been taken from and should be used and read with reference to the document FIELD DESCRIPTION OF SOIL AND ROCK. Guideline For the Field Classification and Description of Soil and Rock for Engineering Purposes. NZ Geotechnical Society Inc, December 2005. **www.nzgeotechsoc.org.nz**

NZ GEOTECHNICAL SOCIETY INC

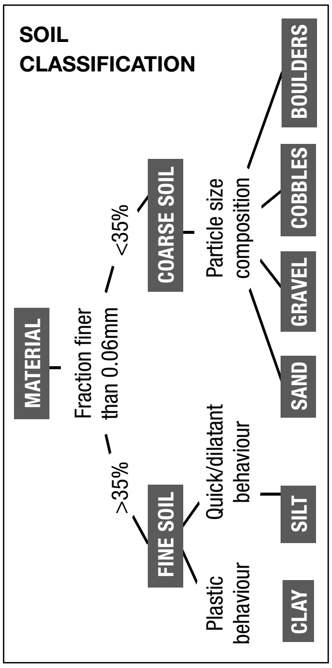
SOIL > field guide sheet

FIELD DESCRIPTION OF SOIL

SEQUENCE OF TERMS – fraction – colour – structure – strength – moisture – bedding – plasticity – sensitivity – additional

GRAIN SIZE CRITERIA

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		
Graphic Symbol	●	● ●	○○○	○○○	○○○	· · ·	· · ·	· · ·	×××	≡	ѱ ѱ ѱ



PROPORTIONAL TERMS DEFINITION (COARSE SOILS)

Fraction	Term	% of Soil Mass	Example
Major	(….) [UPPER CASE]	≥ 50 [major constituent]	GRAVEL
Subordinate	(….) y [lower case]	20 – 50	Sandy
Minor	with some … with minor …	12 – 20 5 – 12	with some sand with minor sand
	with trace of (or slightly)…	< 5	with trace of sand (slightly sandy)

DENSITY INDEX (RELATIVE DENSITY) TERMS

Descriptive Term	Density Index (R_D)	SPT "N" value (blows / 300 mm)	Dynamic Cone (blows / 100 mm)
Very dense	> 85	> 50	> 17
Dense	65 – 85	30 – 50	7 – 17
Medium dense	35 – 65	10 – 30	3 – 7
Loose	15 – 35	4 – 10	1 – 3
Very loose	< 15	< 4	0 – 2

Note:
- No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Test values.
- SPT "N" values are uncorrected.
- Dynamic Cone Penetrometer (Scala)

CONSISTENCY TERMS FOR COHESIVE SOILS

Descriptive Term	Undrained Shear Strength (kPa)	Diagnostic Features
Very soft	< 12	Easily exudes between fingers when squeezed
Soft	12 – 25	Easily indented by fingers
Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
Stiff	50 – 100	Cannot be indented by thumb pressure
Very stiff	100 – 200	Can be indented by thumb nail
Hard	200 – 500	Difficult to indent by thumb nail

ORGANIC SOILS/ DESCRIPTORS

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should then be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidise rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. ***Firm***: Fibres already compressed together ***Spongy***: Very compressible and open stucture ***Plastic***: Can be moulded in hand and smears in fingers ***Fibrous***: Plant remains recognisable and retain some strength ***Amorphous***: No recognisable plant remains
Rootlets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill)
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

MOISTURE CONDITION

Condition	Description	Granular Soils	Cohesive Soils
Dry	Looks and feels dry	Run freely through hands	Hard, powdery or friable
Moist	Feels cool, darkened in colour	Tend to cohere	Weakened by moisture, but no free water on hands when remoulding
Wet			Weakened by moisture, free water forms on hands when handling
Saturated	Feels cool, darkened in colour and free water is present on the sample		

PLASTICITY (CLAYS & SILTS)

Term	Description
High plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendency to volume change
Low plasticity	When moulded can be crumbled in the fingers; may show quick or dilatant behaviour

GRADING (GRAVELS & SANDS)

Term	Description	
Well graded	Good representation of all particle sizes from largest to smallest	
Poorly graded	Limited representation of grain sizes - further divided into:	
	Uniformly graded	Most particles about the same size
	Gap graded	Absence of one or more intermediate sizes

compiled by KATE WILLIAMS design KARRYN MUSCHAMP

NZ GEOTECHNICAL SOCIETY INC

This field sheet has been taken from and should be used and read with reference to the document FIELD DESCRIPTION OF SOIL AND ROCK. Guideline For the Field Classification and Description of Soil and Rock for Engineering Purposes. NZ Geotechnical Society Inc, December 2005. **www.nzgeotechsoc.org.nz**

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO.	**BH1**
PROJECT NO.	**506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1568297** **N 5206283**	SHEET **1** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **01/07/2019** to **02/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+28.00** m RL

STRATA DESCRIPTION
SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC....
(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples Type Ref Depth	Reduced Level	Depth (m)	Legend	STRATA DESCRIPTION	Instrument/ Backfill
								0.00		0.00			
			100						+27.85	0.15		Sandy SILT with trace rootlets; dark brown. *Firm* , moist, non-plastic; sand, fine. (TOPSOIL)	
									+27.60	0.40		Silty SAND with trace rootlets and gravel; brown. *Dense* , moist; gravel, fine to coarse, rounded to sub rounded; sand, medium.	
												Sandy GRAVEL with minor silt and trace cobbles; yellowish brown. *Dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, medium to coarse. 1.60m Becomes dry.	
							(15, 14, 13, 13, 9, 10) N = 45/450 mm						
							(22, 20, 18, 15, 16, 11) N = 60/445 mm						
	▼ ▼												
							(8, 7, 7, 7, 7, 11) N = 32/450 mm		+23.60	4.40		Sandy GRAVEL with some silt and trace cobbles; yellowish brown. *Dense to very dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, medium to coarse.	
			60				(16, 30, 25, 22, 13) N = 60/350 mm						
			55				(11, 11, 8, 7, 6, 10) N = 31/450 mm						
			100				(13, 33, 40, 20) N = 60/265 mm						

● Small Disturbed Sample	▼ Water Level
Large Disturbed Sample	Impression Packer Test
SPT Liner Sample	Standard Penetration Test
Thin Wall Undisturbed Sample	Permeability Test
■ U100 Undisturbed Sample	Piezometer / Standpipe Tip
▷▷ Pocket Penetrometer Test	Packer Test
PS Piston Sample	∨ In-situ Vane Shear Test

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels:

4.50m bgl at casing depth of 15.08; 2/07/2019, 1:30pm. 4.10m bgl in piezometer standpipe; 4/07/2019, 2.00pm

Report ID: AGS4 BOREHOLE RECORD WITH INSTALLATION || Project: WESTPARK - INCH LAND.GPJ || Library: AGS 4_0.GLB || Date: 30 July 2019

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO.	**BH1**
PROJECT NO.	**506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1568297** **N 5206283**	SHEET **2** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **01/07/2019** to **02/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+28.00** m RL

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples (Type Ref Depth)	Reduced Level	Depth (m)	Legend	STRATA DESCRIPTION SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*	Instrument/ Backfill
			100							10.00			
							(15, 23, 21, 19, 18, 2) N = 60/385 mm						
							(21, 26, 23, 27, 10) N = 60/330 mm		+15.60	12.40			
									+15.10	12.90		SILT with minor sand and gravel; brownish grey. *Very dense* , moist, low plasticity; gravel, medium, sub-rounded to sub-angular; sand, fine to coarse.	
							(18, 17, 18, 15, 12, 11) N = 56/450 mm		+13.50	14.50		Silty sandy GRAVEL; light brownish grey. *Very dense* , moist; gravel, fine to coarse, sub-rounded to sub-angular; sand, fine to coarse; silt, low plasticity.	
							(14, 20, 22, 25, 13) N = 60/330 mm		+12.92	15.08		SILT with minor sand; light brown. *Very dense* , dry, low plasticity; sand, fine.	

End of Sonic core drilling at 15.08m, on 02/07/2019
Termination Reason: Target depth reached.

•	**Small Disturbed Sample**
↓	**Large Disturbed Sample**
▨	**SPT Liner Sample**
‖	**Thin Wall Undisturbed Sample**
■	**U100 Undisturbed Sample**
▷▷	**Pocket Penetrometer Test**
PS	**Piston Sample**
▼	**Water Level**
	Impression Packer Test
↓	**Standard Penetration Test**
⊥	**Permeability Test**
▲ △	**Piezometer / Standpipe Tip**
	Packer Test
∨	**In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels:

4.50m bgl at casing depth of 15.08; 2/07/2019, 1:30pm. 4.10m bgl in piezometer standpipe; 4/07/2019, 2.00pm

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO.	**BH2**
PROJECT NO.	**506685**

PROJECT	**Westpark - Inch Land Geotechnical Investigation** **Rangiora**
METHOD	**SNC**
MACHINE & NO.	**Geoprobe 8140LS - Track**
FLUSHING MEDIUM	**Water**
CO-ORDINATES (NZTM)	**E 1568436** **N 5205930**
ORIENTATION	**VERTICAL**
SHEET	**1** of **2**
DATE from	**02/07/2019** to **03/07/2019**
GROUND-LEVEL	**+26.90** m RL

STRATA DESCRIPTION: SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*

Depth 0.00 m; Samples Depth 0.00

Water level (m) shift start/ end	Total core Recovery %	Tests	Reduced Level	Depth (m)	Strata Description
	100		+26.40	0.50	Sandy SILT with trace rootlets; dark brown. *Firm* , moist, non-plastic; sand, fine. (TOPSOIL)
			+25.50	1.40	Silty SAND; yellowish brown. *Medium dense* , moist. Sand, fine; silt, non-plastic.
	85 60	(4, 4, 1, 2, 4, 6) N = 13/450 mm (8, 7, 4, 3, 3, 5) N = 15/450 mm	+23.40	3.50	Silty sandy GRAVEL with minor cobble; yellowish brown. *Medium dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, fine to coarse; silt, non-plastic.
▼			+22.46	4.44	Silty sandy GRAVEL; yellowish brown. *Medium dense* , moist; gravel, fine to medium, rounded to sub-rounded; sand, fine to coarse; silt, non-plastic.
	40 60	(6, 4, 4, 3, 2, 3) N = 12/450 mm (8, 7, 9, 7, 7, 7) N = 30/450 mm	+20.50	6.40	GRAVEL with minor cobble; yellowish brown. *Medium dense* , moist; gravel, fine to coarse, rounded to sub-rounded. (Drilled with water, fines lost)
			+19.40	7.50	Silty sandy GRAVEL with minor cobble; yellowish brown. *Medium dense to dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, fine to coarse; silt, non-plastic.
	40	(6, 10, 10, 8, 7, 8) N = 33/450 mm	+17.90	9.00	GRAVEL with minor cobble; yellowish brown. *Dense* , moist; gravel, fine to coarse, rounded to sub-rounded. (Drilled with water, fines lost)
	100	(12, 19, 19, 20, 2) N = 60/385 mm			Silty sandy GRAVEL with minor cobble; yellowish brown. *Dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, fine to coarse; silt, non-plastic.

- ● **Small Disturbed Sample**
- **Large Disturbed Sample**
- **SPT Liner Sample**
- **Thin Wall Undisturbed Sample**
- ■ **U100 Undisturbed Sample**
- ▷ **Pocket Penetrometer Test**
- **Piston Sample**
- ▼ **Water Level**
- **Impression Packer Test**
- **Standard Penetration Test**
- **Permeability Test**
- **Piezometer / Standpipe Tip**
- **Packer Test**
- **In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels:

4.00m bgl at casing depth of 15.08; 3/07/2019, 8:50pm

Report ID: AGS4 BOREHOLE RECORD WITH INSTALLATION || Project: WESTPARK - INCH LAND.GPJ || Library: AGS 4_0.GLB || Date: 30 July 2019

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO.	**BH2**
PROJECT NO.	**506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1568436** **N 5205930**	SHEET **2** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **02/07/2019** to **03/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+26.90** m RL

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples Type Ref Depth	Reduced Level	Depth (m) 10.00	Legend	STRATA DESCRIPTION SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*	Instrument/ Backfill
			100										
			90				(9, 13, 12, 12, 13, 15) N = 52/450 mm						
			100				(13, 24, 19, 18, 14, 9) N = 60/387 mm					12.00m Becomes wet.	
							(19, 30, 28, 20, 12) N = 60/360 mm						
									+12.40	14.50		Gravelly SILT with minor sand; yellowish brown with some orange mottling. *Very stiff to hard* , moist, non-plastic; gravel, fine to medium, sub-rounded; sand, fine.	
							(7, 19, 22, 22, 16) N = 60/360 mm		+11.82	15.08		End of Sonic core drilling at 15.08m, on 03/07/2019 *Termination Reason:* Target depth reached.	

•	**Small Disturbed Sample**	▼	**Water Level**
↕	**Large Disturbed Sample**		**Impression Packer Test**
▨	**SPT Liner Sample**	↓	**Standard Penetration Test**
‖	**Thin Wall Undisturbed Sample**	↨	**Permeability Test**
■	**U100 Undisturbed Sample**		**Piezometer / Standpipe Tip**
▷▷	**Pocket Penetrometer Test**		**Packer Test**
PS	**Piston Sample**	∨	**In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels:

4.00m bgl at casing depth of 15.08; 3/07/2019, 8:50pm

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO.	**BH3**
PROJECT NO.	**506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1568665** **N 5205436**	SHEET **1** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **03/07/2019** to **03/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+21.50** m RL

STRATA DESCRIPTION: SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples (Type Ref Depth)	Reduced Level	Depth (m) 0.00	STRATA DESCRIPTION
	▼		100					0.00	+20.90	0.60	Sandy SILT with trace rootlets; dark brown. *Firm* , moist, non-plastic; sand, fine. (TOPSOIL)
									+20.50	1.00	SILT with minor clay; light grey brown. *Firm* , moist, low to moderate plasticity.
			80				(0, 0, 0, 1, 1, 1) N = 3/450 mm		+18.80	2.70	SILT with minor fine sand; light grey with orange mottling. *Firm* , moist, low to moderate plasticity; sand, fine.
									+18.58	2.92	Silty SAND; light brown. *Medium dense* , moist; sand, fine.
	▼		100				(1, 2, 1, 1, 1, 1) N = 4/450 mm		+17.30	4.20	SILT; bluish grey. *Soft to firm* , moist, moderate plasticity.
									+17.00	4.50	Oragnic SILT; dark grey. *Soft* , moist, moderate plasticity.
							(0, 0, 0, 1, 1, 1) N = 3/450 mm		+16.40	5.10	Sandy SILT with trace wood fragments; bluish grey. *Soft* , wet, low plasticity; sand, fine.
									+16.00	5.50	Oragnic SILT with trace wood fragments; dark grey. *Soft* , moist, moderate plasticity.
			85				(9, 11, 10, 12, 13, 14) N = 49/450 mm (13, 14, 15, 16, 15, 15) N = 61/450 mm		+13.90	7.60	Sandy GRAVEL with minor cobble; yellowish brown. *Dense to very dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, medium to coarse.
									+13.10	8.40	Sandy GRAVEL; yellowish brown. *Dense to very dense* , moist; gravel, fine, rounded to sub-rounded; sand, medium to coarse.
			40				(13, 18, 16, 19, 20, 5) N = 60/400 mm				Silty GRAVEL with minor sand; yellowish brown. *Very dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, fine to coarse. 8.80m Drilled with water from 8.8 to 10.52, fines lost.

●	**Small Disturbed Sample**	▼	**Water Level**
↕	**Large Disturbed Sample**		**Impression Packer Test**
▯	**SPT Liner Sample**	↓	**Standard Penetration Test**
‖	**Thin Wall Undisturbed Sample**	↕	**Permeability Test**
■	**U100 Undisturbed Sample**	▲ △	**Piezometer / Standpipe Tip**
▷▷	**Pocket Penetrometer Test**		**Packer Test**
PS	**Piston Sample**	⌄	**In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS

Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels: 3.50m bgl at casing depth of 15.08; 2/07/2019, 2:00pm. 0.1m agl after casing withdrawl; 3/07/2019, 4:00pm

Piezometer install abandoned and backfilled with grout.

www.aurecongroup.com

BOREHOLE RECORD

HOLE NO. **BH3**

PROJECT NO. **506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1568665** **N 5205436**	SHEET **2** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **03/07/2019** to **03/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+21.50** m RL

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples Type Ref Depth	Reduced Level	Depth (m) 10.00	Legend	STRATA DESCRIPTION SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*	Instrument/ Backfill
			40				(12, 12, 15, 20, 22, 3) N = 60/395 mm		+10.98	10.52			
			95									Silty sandy GRAVEL; light yellowish brown. *Very dense* , moist; gravel, fine to coarse, rounded to sub-rounded; sand, fine to coarse.	
			100				(9, 13, 18, 17, 22, 3) N = 60/385 mm						
							(15, 24, 30, 28, 2) N = 60/380 mm						
							(17, 20, 20, 20, 20) N = 60/370 mm		+6.42	15.08		End of Sonic core drilling at 15.08m, on 03/07/2019 *Termination Reason:* Target depth reached.	

●	**Small Disturbed Sample**	▼	**Water Level**
↕	**Large Disturbed Sample**		**Impression Packer Test**
▯	**SPT Liner Sample**	↓	**Standard Penetration Test**
‖	**Thin Wall Undisturbed Sample**		**Permeability Test**
■	**U100 Undisturbed Sample**		**Piezometer / Standpipe Tip**
▷▷	**Pocket Penetrometer Test**		**Packer Test**
PS	**Piston Sample**	⌄	**In-situ Vane Shear Test**

LOGGED **F. MONTEITH**

DATE **05/07/2019**

CHECKED **S. MCRAE**

DATE **23/07/2019**

REMARKS

Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m.

Static water levels: 3.50m bgl at casing depth of 15.08; 2/07/2019, 2:00pm. 0.1m agl after casing withdrawl; 3/07/2019, 4:00pm

Piezometer install abandoned and backfilled with grout.

Report ID: AGS4 BOREHOLE RECORD WITH INSTALLATION || Project: WESTPARK - INCH LAND.GPJ || Library: AGS 4_0.GLB || Date: 30 July 2019

aurecon
www.aurecongroup.com

BOREHOLE RECORD

HOLE NO. **BH4**

PROJECT NO. **506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**

MACHINE & NO. **Geoprobe 8140LS - Track**

FLUSHING MEDIUM **Water**

CO-ORDINATES (NZTM)
E 1569122
N 5205207

ORIENTATION **VERTICAL**

SHEET **1** of **2**

DATE from **04/07/2019** to **04/07/2019**

GROUND-LEVEL **+18.40** m RL

Drilling Progress	Water level (m) shift start/ end	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples (Type, Ref, Depth)	Reduced Level	Depth (m) 0.00	Legend	STRATA DESCRIPTION SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*	Instrument/ Backfill
	▼		100					0.00	+18.10	0.30		Sandy SILT with trace rootlets; dark brown. *Firm* , moist, non-plastic; sand, fine. (TOPSOIL)	
									+17.00	1.40		SILT with minor sand; light brown. *Soft* , moist, low plasticity; sand, fine.	
							(0, 0, 0, 0, 0, 0) N = 0/450 mm		+16.75	1.65		Organic SILT; dark brown. *Soft* , wet, moderate plasticity.	
									+15.40	3.00		SILT with rootlets and minor sand; brown. *Soft* , moist, low plasticity; sand, fine.	
							(0, 0, 0, 0, 0, 1) N = 1/450 mm		+14.90	3.50		PEAT with some silt and trace wood fragments; dark brown. *Very soft* , wet, fibrous, spongy.	
									+14.55	3.85		PEAT with wood fragments and some silt; dark brown. *Very soft* , wet, fibrous, spongy.	
							(0, 0, 0, 0, 0, 2) N = 2/450 mm		+13.30	5.10		PEAT with some silt and trace wood fragments; dark brown. *Very soft* , wet, fibrous, spongy.	
							(9, 7, 8, 8, 8, 8) N = 32/450 mm (23, 20, 14, 15, 20, 11) N = 60/430 mm		+10.80	7.60		Sandy GRAVEL with minor silt; light brown. *Dense to very dense* , wet; gravel, fine to coarse, sub-angular to sub-rounded; sand, fine to coarse, silt non-plastic.	
									+9.40	9.00		Sandy GRAVEL with some silt; light brown. *Very dense* , wet; gravel, fine to coarse, sub-angular to sub-rounded; sand, fine to coarse, silt non-plastic.	
			60				(13, 17, 14, 14, 17, 13) N = 58/450 mm					Sandy GRAVEL with minor silt; light brown. *Very dense* , wet; gravel, fine to coarse, sub-angular to sub-rounded; sand, fine to coarse, silt non-plastic.	

- ● **Small Disturbed Sample**
- **Large Disturbed Sample**
- **SPT Liner Sample**
- **Thin Wall Undisturbed Sample**
- **U100 Undisturbed Sample**
- **Pocket Penetrometer Test**
- **Piston Sample**
- ▼ **Water Level**
- **Impression Packer Test**
- **Standard Penetration Test**
- **Permeability Test**
- **Piezometer / Standpipe Tip**
- **Packer Test**
- **In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m

Static water levels:

0.6m agl at casing depth of 6.00m; 4/07/2019, 10.15am

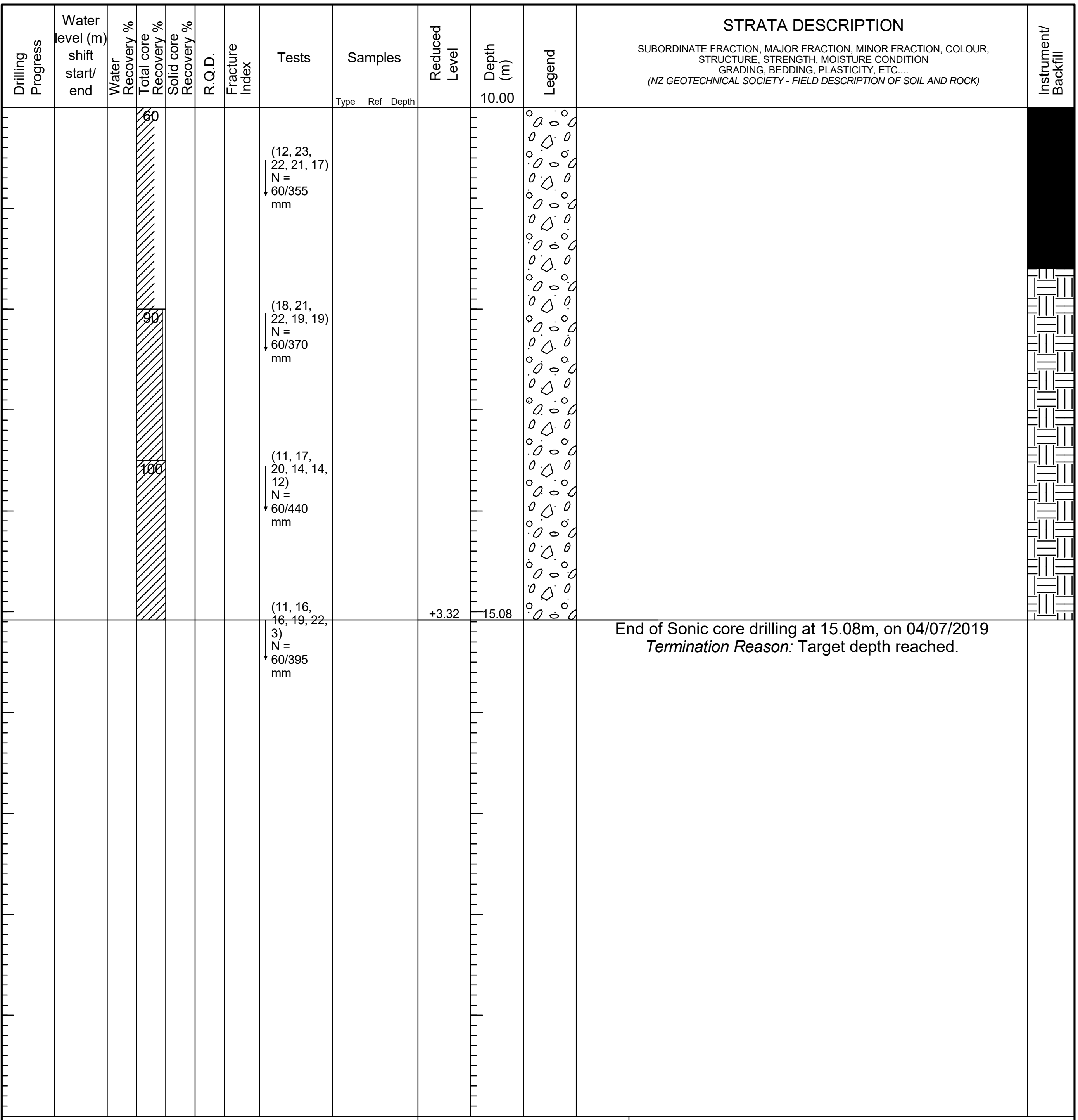
BOREHOLE RECORD

aurecon
www.aurecongroup.com

HOLE NO.	**BH4**
PROJECT NO.	**506685**

PROJECT **Westpark - Inch Land Geotechnical Investigation**
Rangiora

METHOD **SNC**	CO-ORDINATES (NZTM) **E 1569122** **N 5205207**	SHEET **2** of **2**
MACHINE & NO. **Geoprobe 8140LS - Track**		DATE from **04/07/2019** to **04/07/2019**
FLUSHING MEDIUM **Water**	ORIENTATION **VERTICAL**	GROUND-LEVEL **+18.40** m RL



Total core Recovery %	Tests	Reduced Level	Depth (m) 10.00	STRATA DESCRIPTION SUBORDINATE FRACTION, MAJOR FRACTION, MINOR FRACTION, COLOUR, STRUCTURE, STRENGTH, MOISTURE CONDITION GRADING, BEDDING, PLASTICITY, ETC.... *(NZ GEOTECHNICAL SOCIETY - FIELD DESCRIPTION OF SOIL AND ROCK)*
60	(12, 23, 22, 21, 17) N = 60/355 mm			
90	(18, 21, 22, 19, 19) N = 60/370 mm			
100	(11, 17, 20, 14, 14, 12) N = 60/440 mm			
	(11, 16, 16, 19, 22, 3) N = 60/395 mm	+3.32	15.08	End of Sonic core drilling at 15.08m, on 04/07/2019 *Termination Reason:* Target depth reached.

- • **Small Disturbed Sample**
- **Large Disturbed Sample**
- **SPT Liner Sample**
- **Thin Wall Undisturbed Sample**
- **U100 Undisturbed Sample**
- **Pocket Penetrometer Test**
- **Piston Sample**
- **Water Level**
- **Impression Packer Test**
- **Standard Penetration Test**
- **Permeability Test**
- **Piezometer / Standpipe Tip**
- **Packer Test**
- **In-situ Vane Shear Test**

LOGGED **F. MONTEITH**
DATE **05/07/2019**
CHECKED **S. MCRAE**
DATE **23/07/2019**

REMARKS
Coordinates from handheld GPS, accurate to +/- 5m. Elevations from LINZ Data Service 1m LIDAR, accurate to +/- 1m

Static water levels:

0.6m agl at casing depth of 6.00m; 4/07/2019, 10.15am

Report ID: AGS4 BOREHOLE RECORD WITH INSTALLATION || Project: WESTPARK - INCH LAND.GPJ || Library: AGS 4_0.GLB || Date: 30 July 2019

CONE PENETRATION TEST (CPT) REPORT

McMILLAN Drilling

Client: Aurecon NZ Ltd

Location: Kippenberger Avenue, Rangiora

Printed: 08/07/2019

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

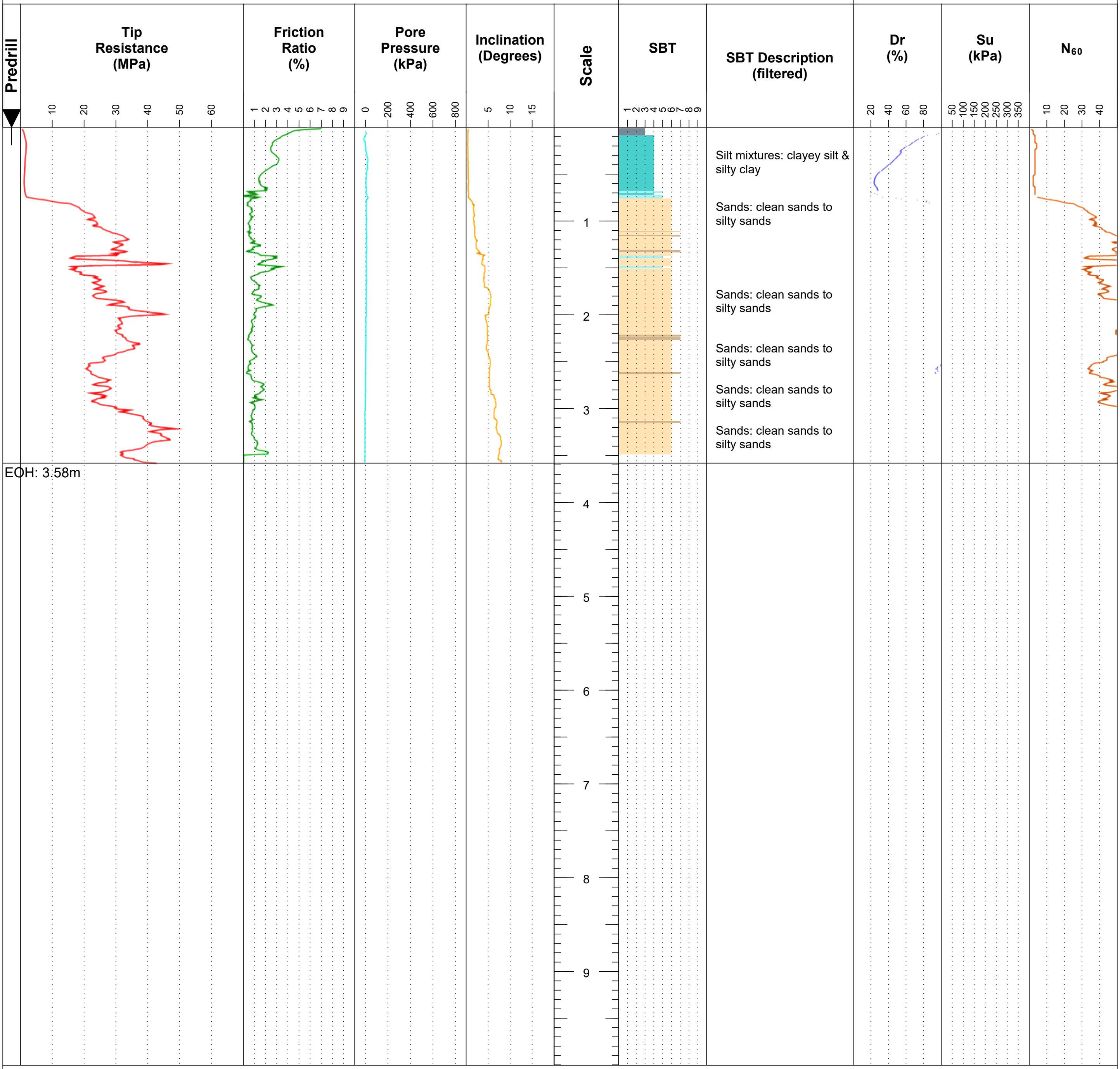
CPT No.: CPTu001

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 3.58
Elevation (m): 0.00
Datum: Ground

North (m): 5206581.05
East (m): 1567780.25
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 0.291
Local Friction (MPa) Initial: 0.0128
Pore Pressure (MPa) Initial: -0.0001

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 1.60

Final: 0.2974
Final: 0.0073
Final: -0.0202

Effective Refusal
Tip:
Gauge: ✓
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 3.58

Sheet 1 of 1

McMILLAN Drilling

CONE PENETRATION TEST

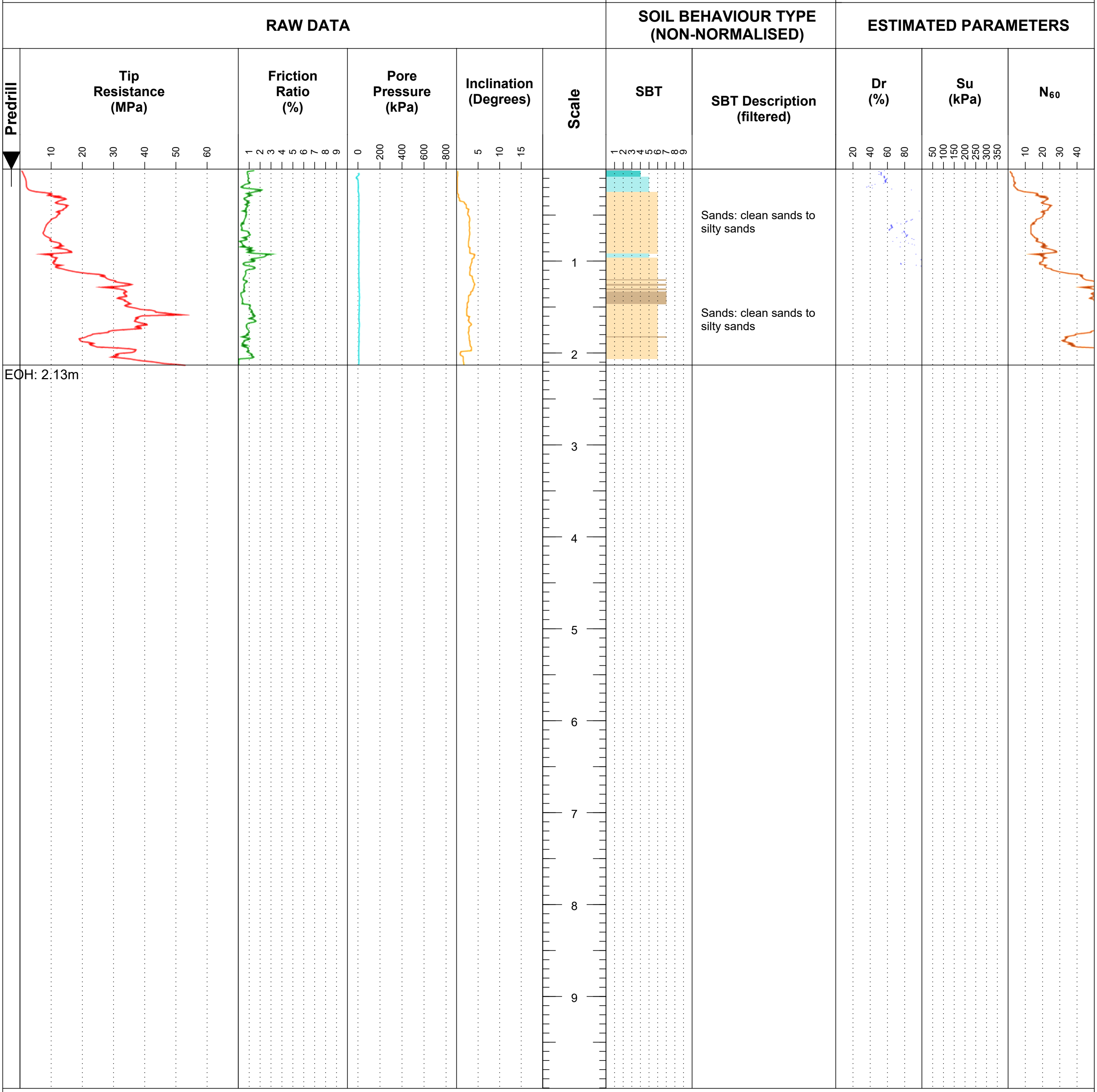
Job: 18207

CPT No.: CPTu002

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 2.13
Elevation (m): 0.00
Datum: Ground

North (m): 5206649.82
East (m): 1568166.42
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.3269 **Final:** 2.4082
Local Friction (MPa) Initial: 0.0324 **Final:** 0.0342
Pore Pressure (MPa) Initial: 0.0378 **Final:** 0.0258

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 2.13

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

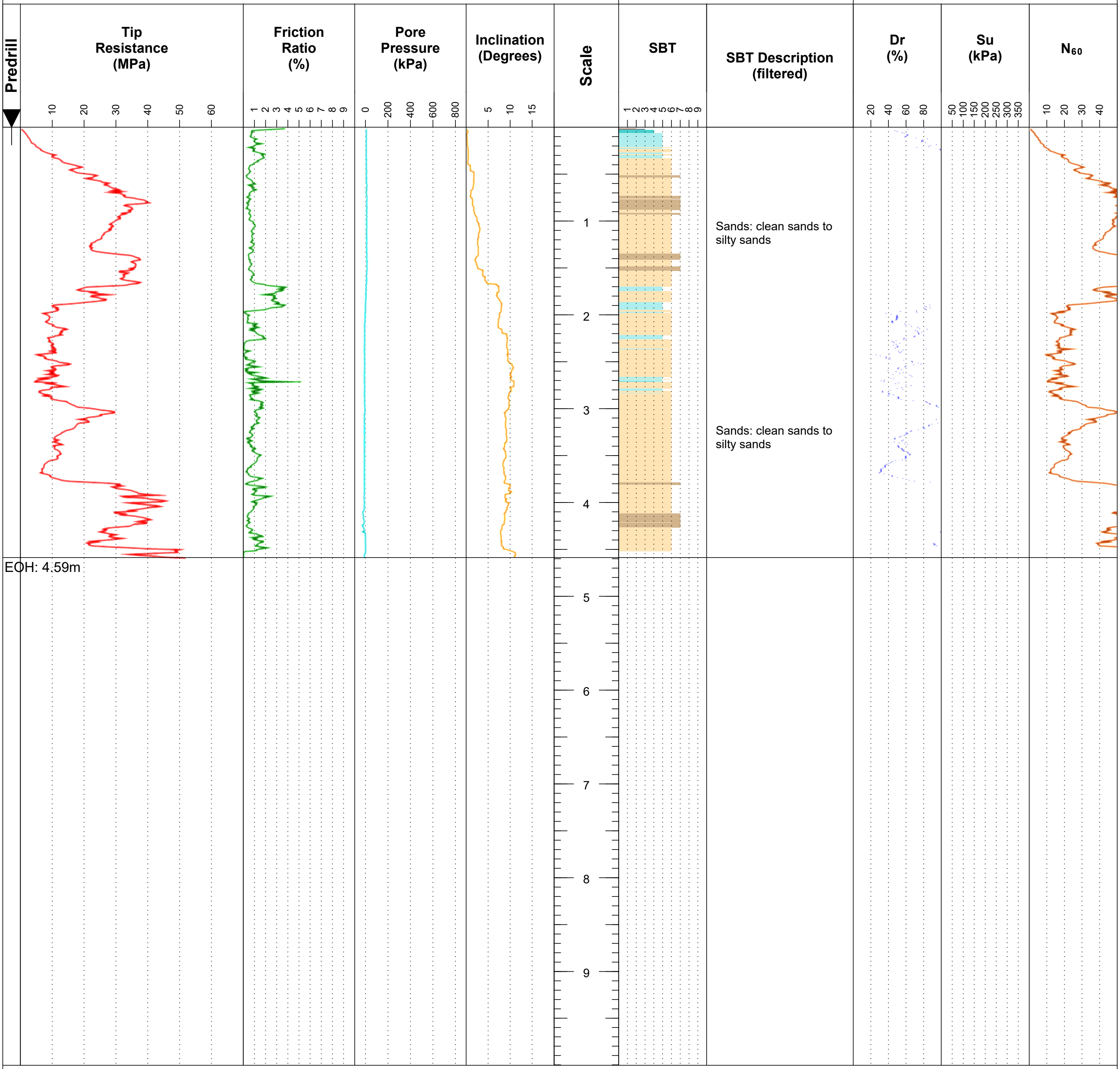
CPT No.: CPTu003

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 4.59
Elevation (m): 0.00
Datum: Ground

North (m): 5206639.31
East (m): 1568447.85
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.3457 **Final:** 2.279
Local Friction (MPa) Initial: 0.0327 **Final:** 0.0366
Pore Pressure (MPa) Initial: 0.0291 **Final:** 0.0144

Date: 02/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 4.59

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

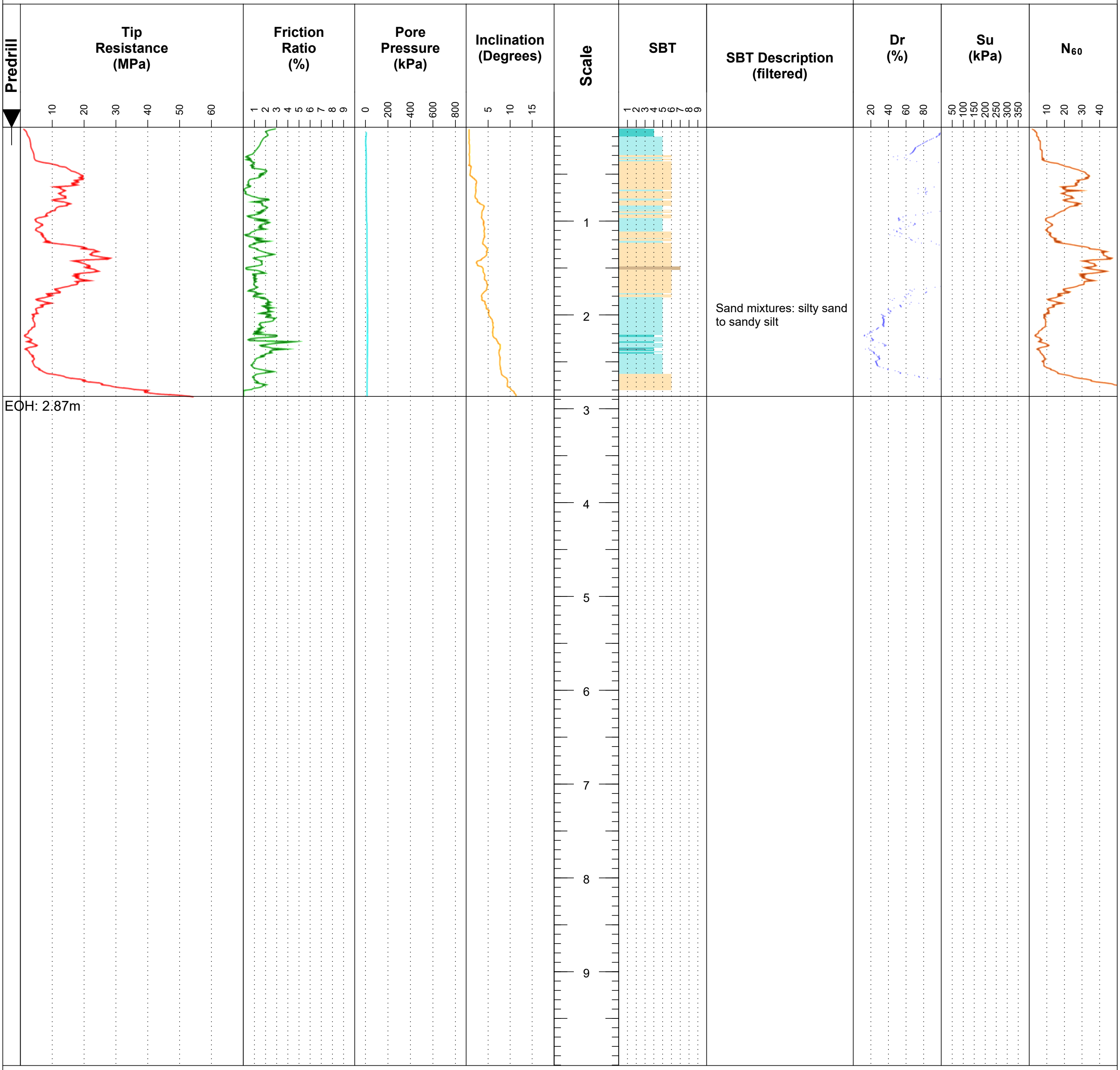
CPT No.: CPTu004

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 2.87
Elevation (m): 0.00
Datum: Ground

North (m): 5206479.43
East (m): 1568282.98
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.3738 **Final:** -0.3645
Local Friction (MPa) Initial: -0.0036 **Final:** -0.004
Pore Pressure (MPa) Initial: 0.0117 **Final:** 0.0087

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.50

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 2.87

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

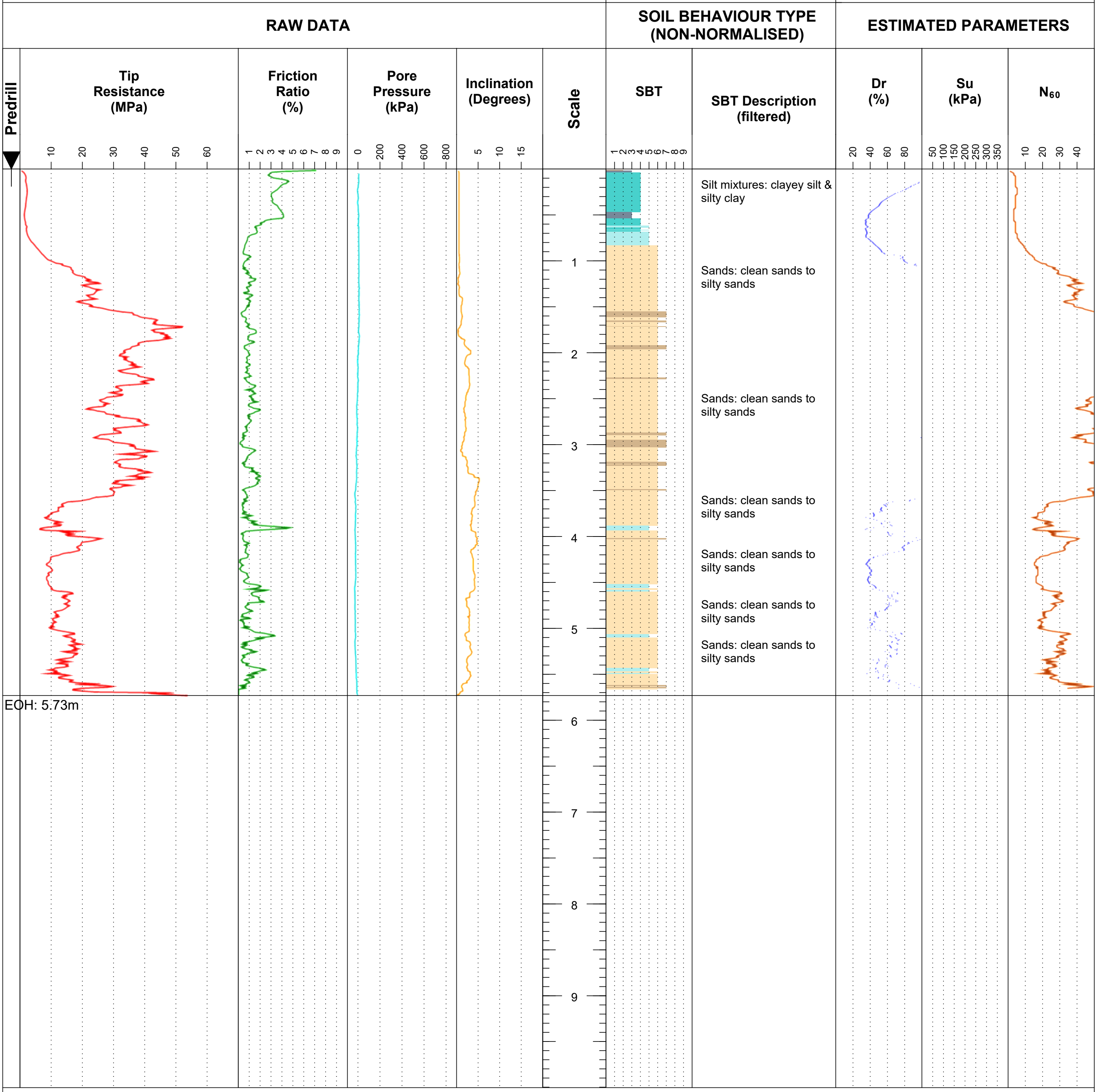
Job: 18207

CPT No.: CPTu005

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.73
Elevation (m): 0.00
Datum: Ground

North (m): 5206412.60
East (m): 1567954.92
Grid: NZTM



Operator: R. Wylie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.7805 **Final:** 0.7935
Local Friction (MPa) Initial: 0.017 **Final:** 0.0164
Pore Pressure (MPa) Initial: -0.0148 **Final:** -0.0296

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 3.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 5.73

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

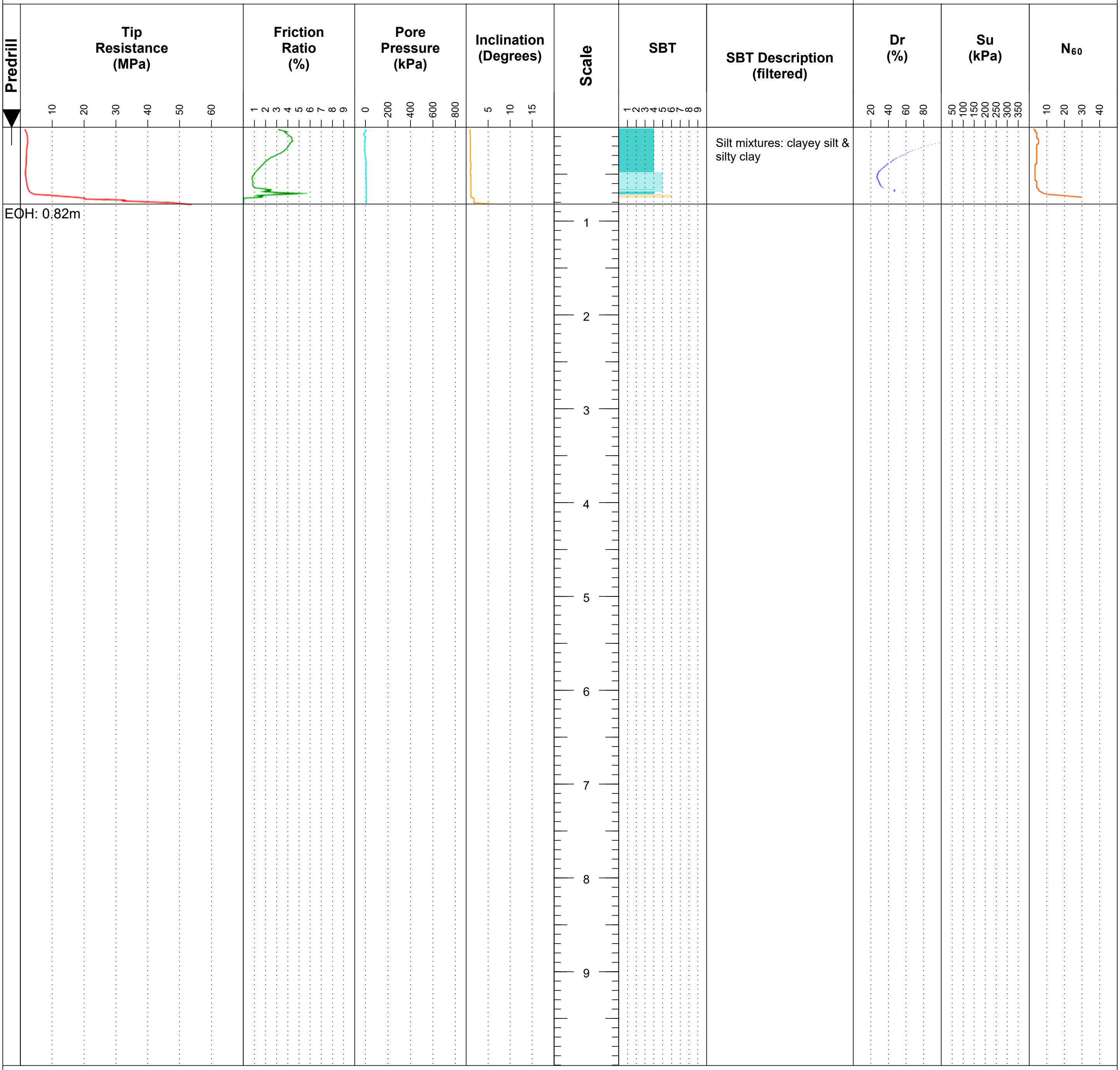
CPT No.: CPTu006

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 0.82
Elevation (m): 0.00
Datum: Ground

North (m): 5206275.12
East (m): 1568301.35
Grid: NZTM

RAW DATA | SOIL BEHAVIOUR TYPE (NON-NORMALISED) | ESTIMATED PARAMETERS



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.7764 **Final:** 0.819
Local Friction (MPa) Initial: 0.017 **Final:** 0.0169
Pore Pressure (MPa) Initial: -0.0135 **Final:** -0.0169

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 0.80

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 0.82

McMILLAN Drilling

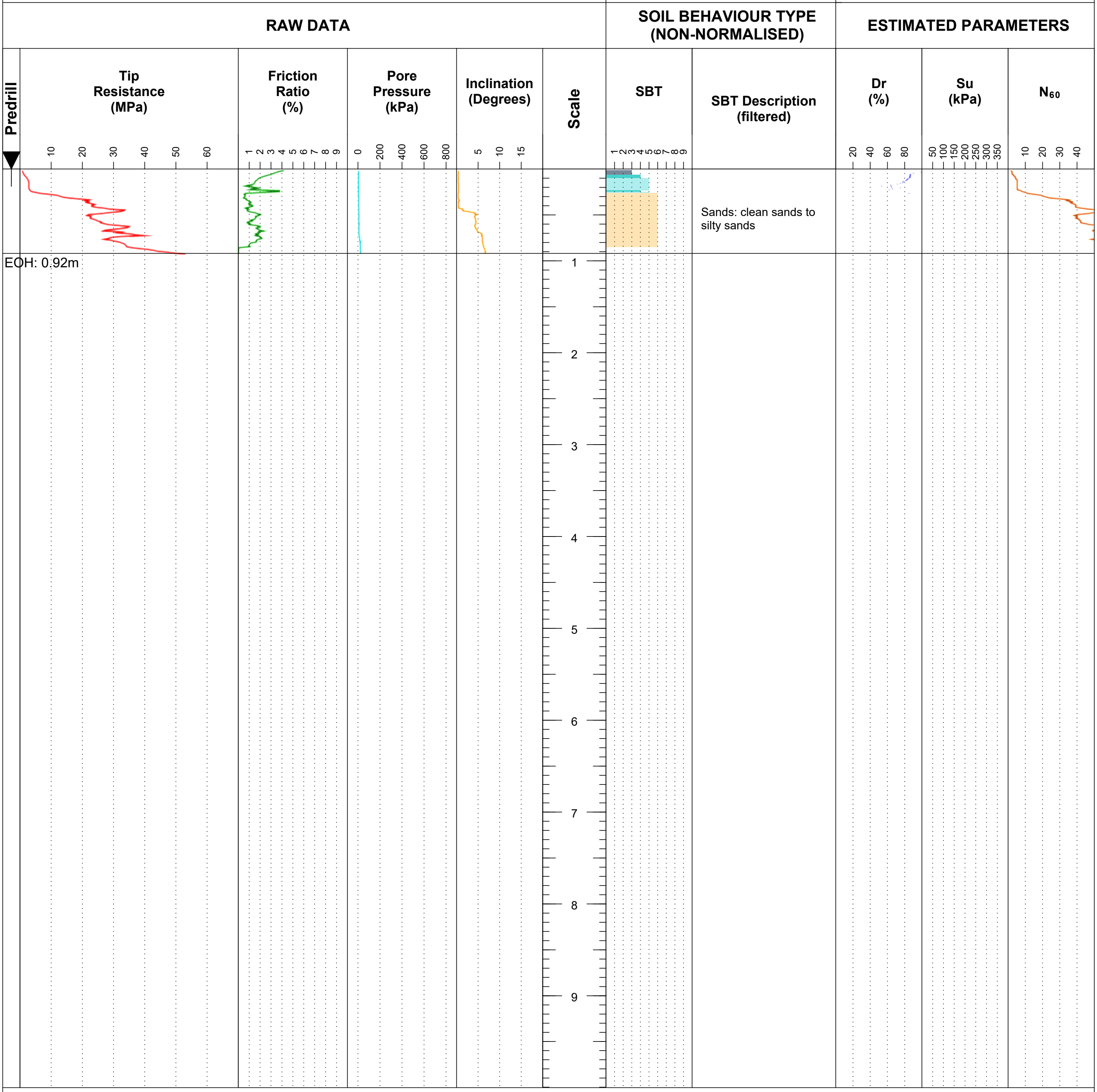
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu007

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 0.92
Elevation (m): 0.00
Datum: Ground

North (m): 5206326.75
East (m): 1568514.25
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.3333 **Final:** -0.3136
Local Friction (MPa) Initial: -0.0023 **Final:** -0.0046
Pore Pressure (MPa) Initial: 0.0133 **Final:** 0.0177

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 0.80

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 0.92

Sheet 1 of 1

McMILLAN Drilling

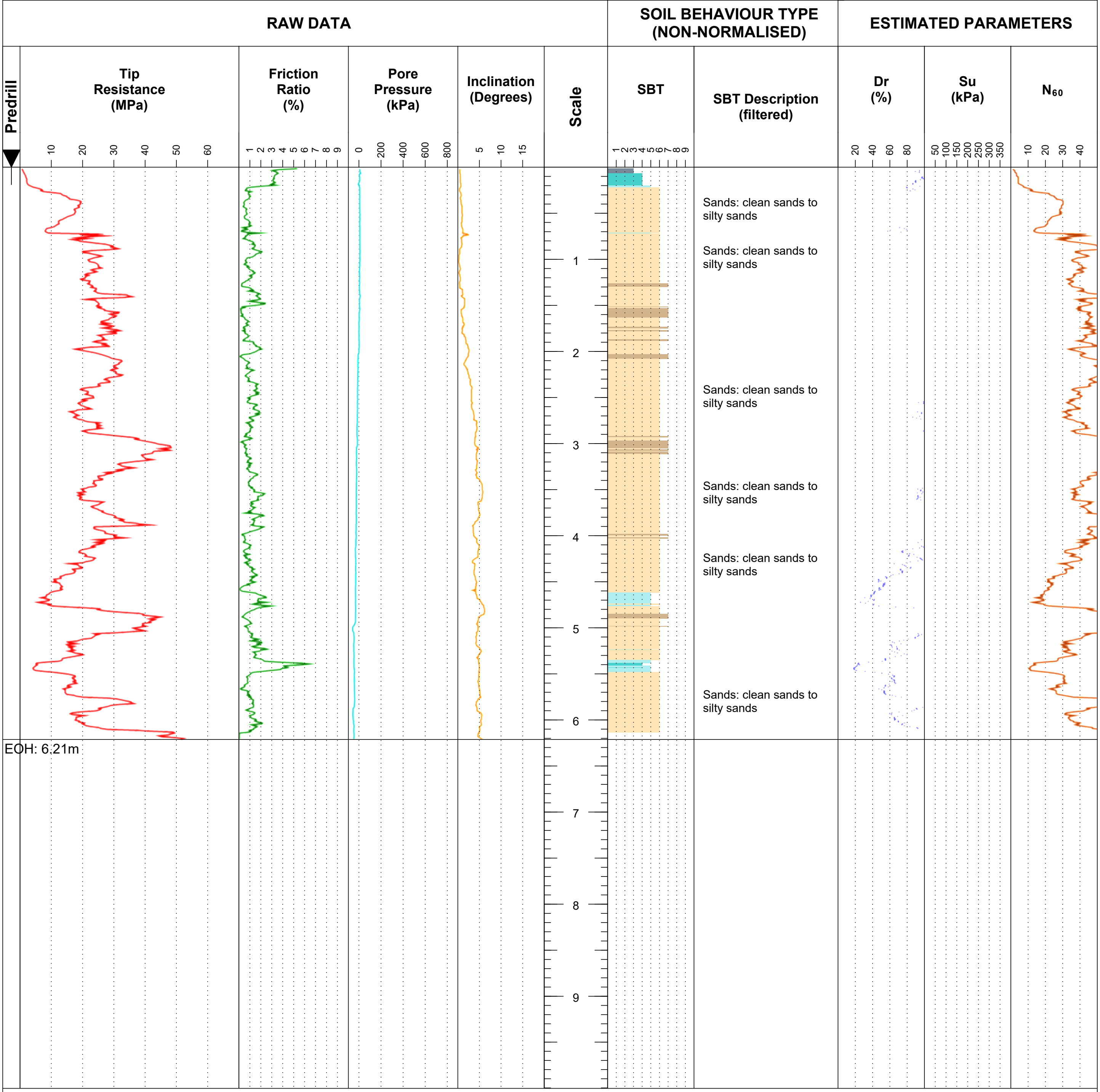
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu008

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.21
Elevation (m): 0.00
Datum: Ground

North (m): 5206150.38
East (m): 1568546.10
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.7746 **Final:** 0.713
Local Friction (MPa) Initial: 0.017 **Final:** 0.0163
Pore Pressure (MPa) Initial: -0.0064 **Final:** -0.0281

Date: 02/07/2019
Predrill: 0.00
Water Level: -
Collapse: 3.10

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 6.21

Sheet 1 of 1

McMILLAN Drilling

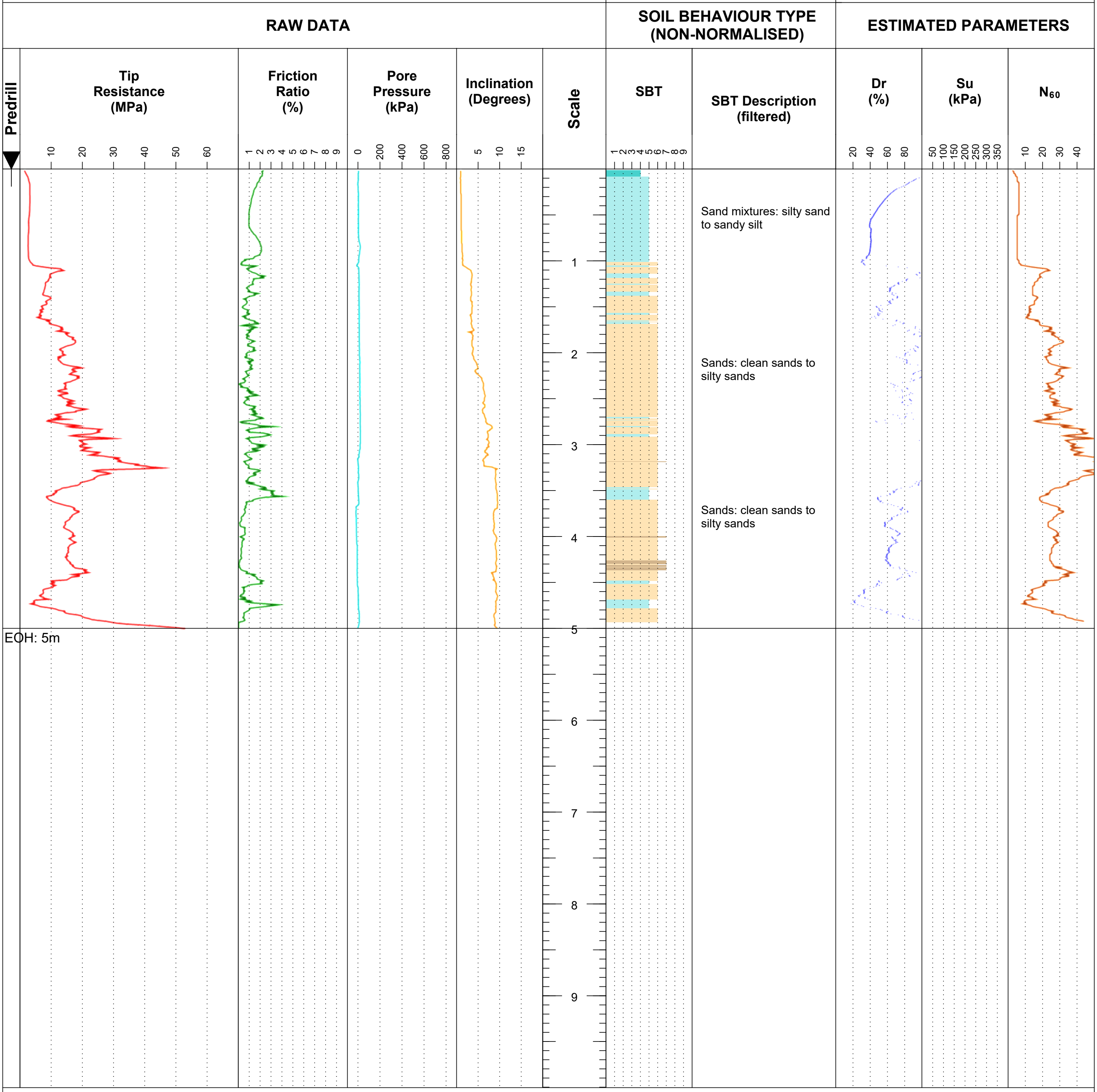
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu009

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.00
Elevation (m): 0.00
Datum: Ground

North (m): 5205997.22
East (m): 1568132.06
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.3905 **Final:** -0.3587
Local Friction (MPa) Initial: -0.0034 **Final:** -0.0044
Pore Pressure (MPa) Initial: 0.0139 **Final:** 0.0093

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.20

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 5.00

Sheet 1 of 1

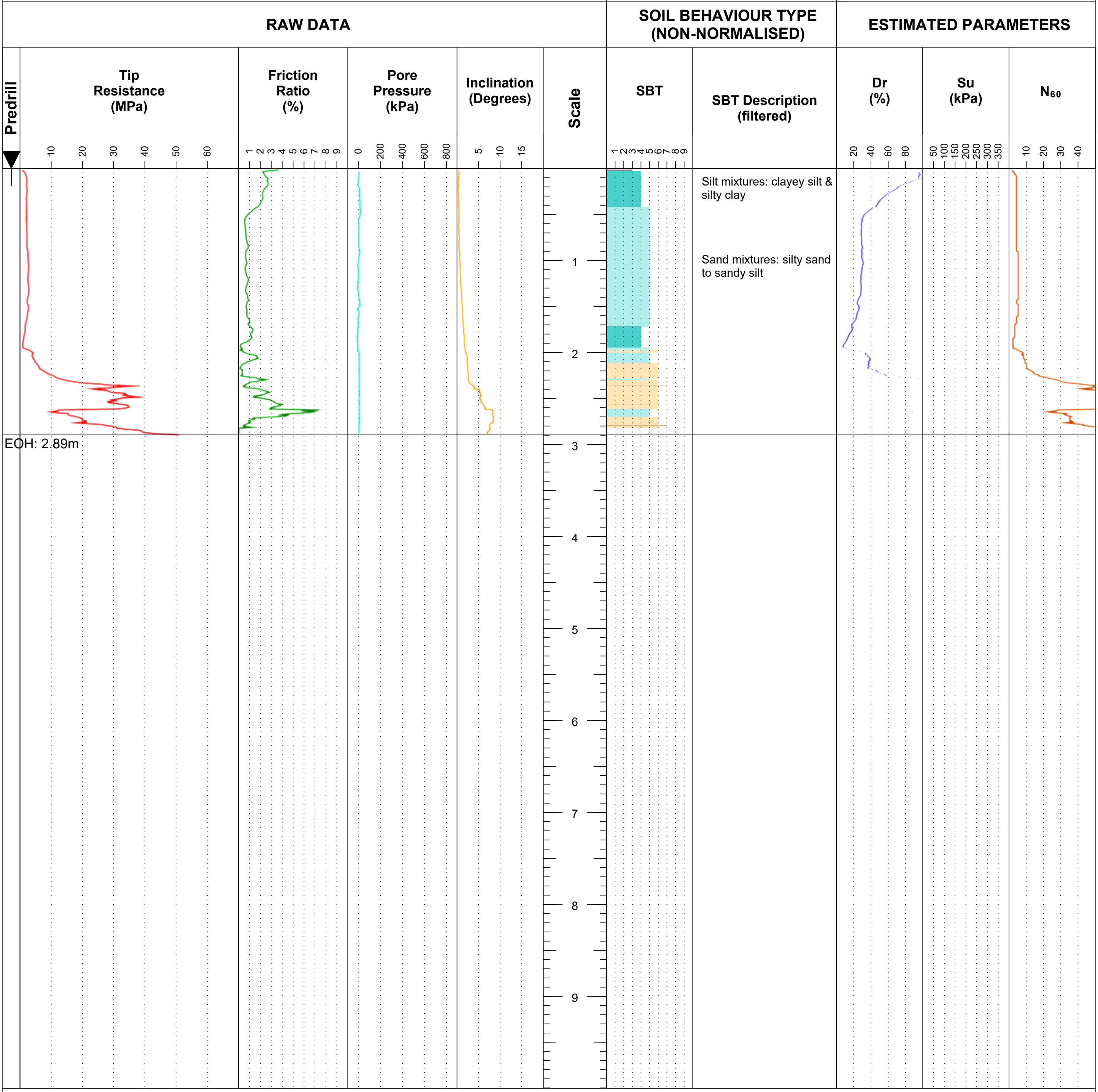
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu010

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 2.89
Elevation (m): 0.00
Datum: Ground

North (m): 5205938.14
East (m): 1568295.62
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.325 **Final:** 2.3614
Local Friction (MPa) Initial: 0.023 **Final:** 0.034
Pore Pressure (MPa) Initial: 0.0353 **Final:** 0.0268

Date: 01/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.80

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0 Undefined	5 Sand mixtures: silty sand to sandy silt
1 Sensitive fine-grained	6 Sands: clean sands to silty sands
2 Clay - organic soil	7 Dense sand to gravelly sand
3 Clays: clay to silty clay	8 Stiff sand to clayey sand
4 Silt mixtures: clayey silt & silty clay	9 Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 2.89

Generated with Core-GS by Geroc

CONE PENETRATION TEST

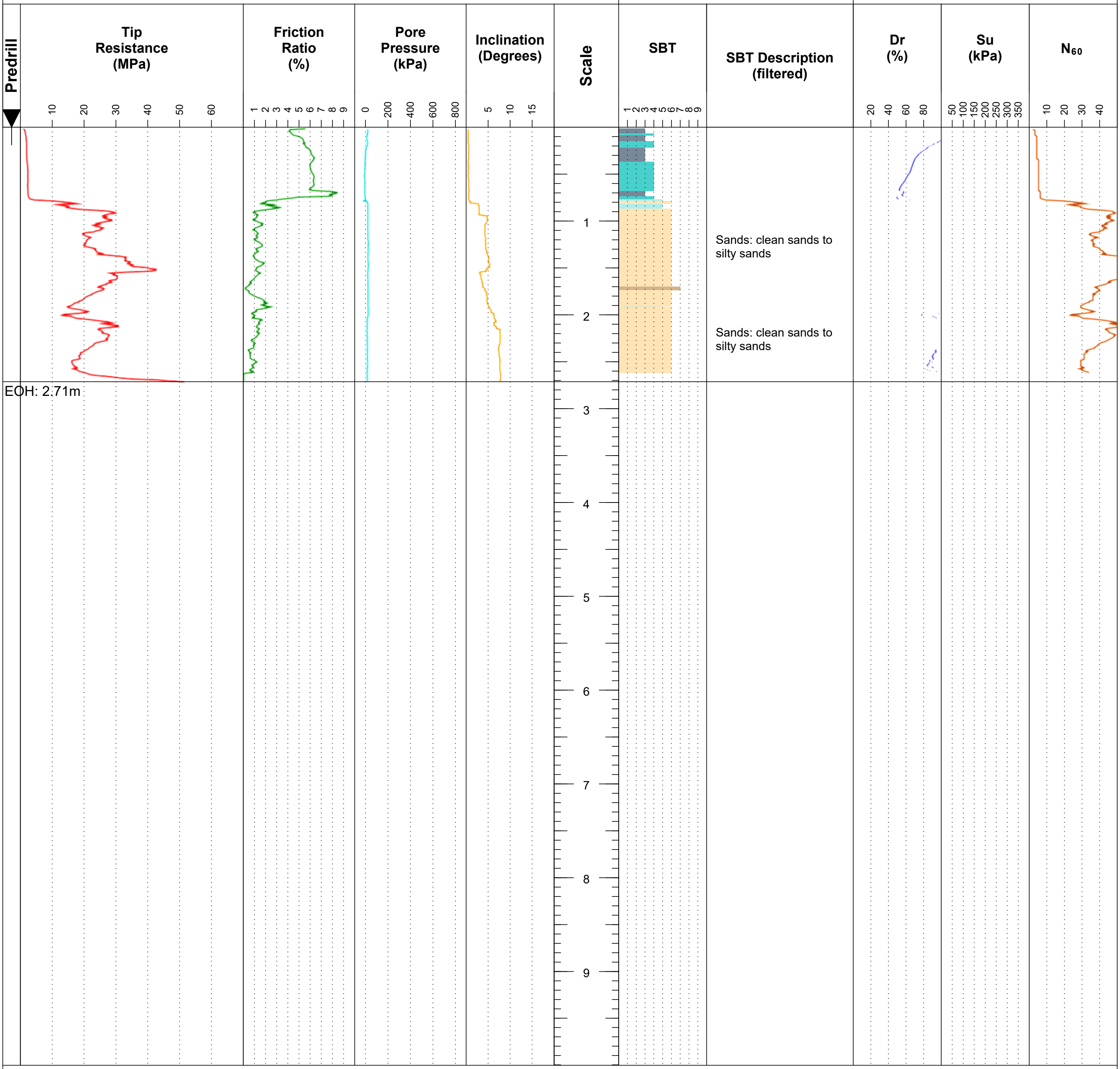
Job: 18207
CPT No.: CPTu011

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 2.71
Elevation (m): 0.00
Datum: Ground

North (m): 5205634.17
East (m): 1568185.68
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 0.1618 **Final:** 0.5314
Local Friction (MPa) Initial: 0.0126 **Final:** 0.0089
Pore Pressure (MPa) Initial: -0.0092 **Final:** -0.0101

Date: 02/07/2019
Predrill: 0.00
Water Level: -
Collapse: 1.90

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0 Undefined	5 Sand mixtures: silty sand to sandy silt
1 Sensitive fine-grained	6 Sands: clean sands to silty sands
2 Clay - organic soil	7 Dense sand to gravelly sand
3 Clays: clay to silty clay	8 Stiff sand to clayey sand
4 Silt mixtures: clayey silt & silty clay	9 Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 2.71

Sheet 1 of 1

CONE PENETRATION TEST

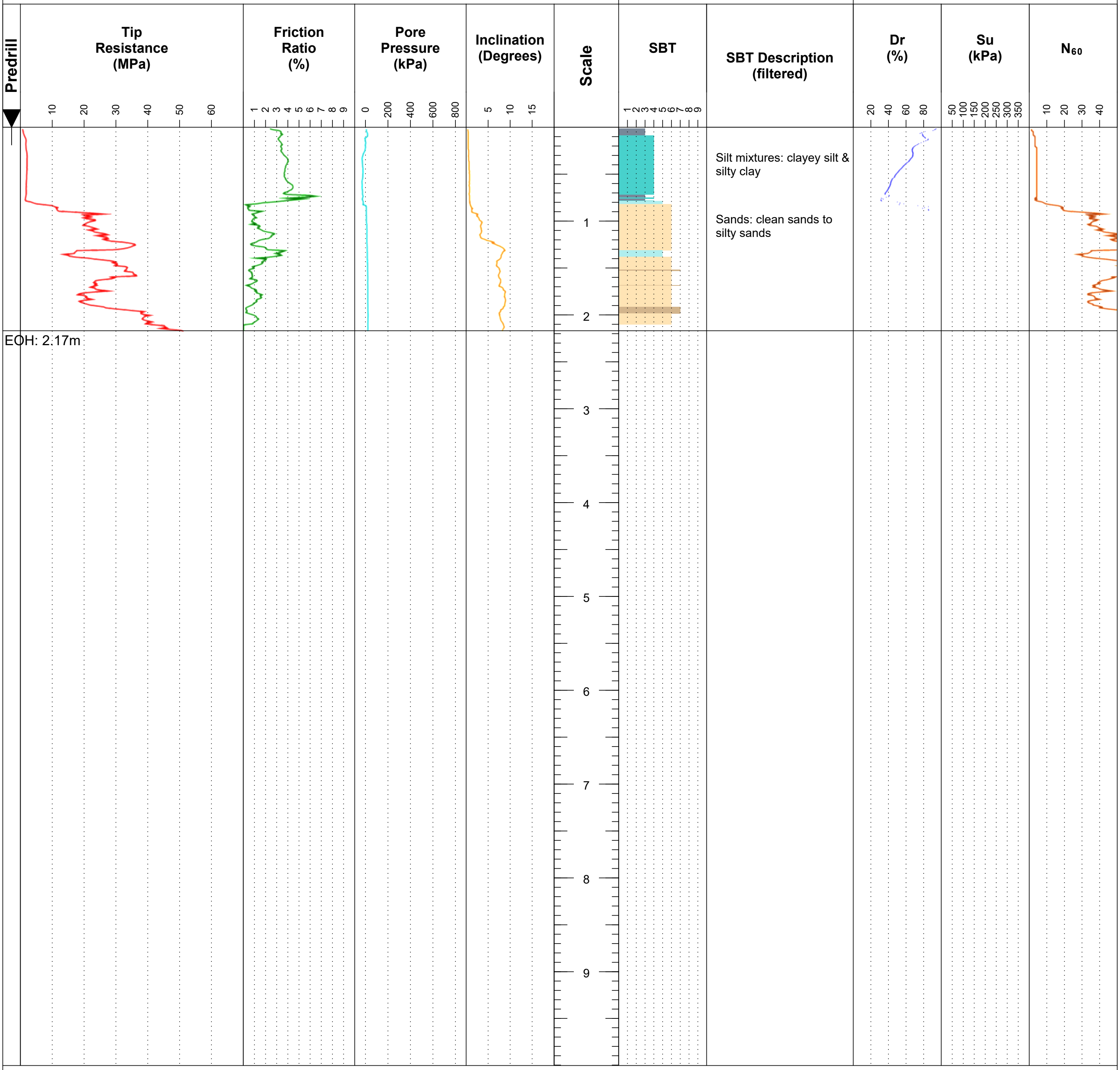
Job:	18207
CPT No.:	CPTu012

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 2.17
Elevation (m): 0.00
Datum: Ground

North (m): 5205674.06
East (m): 1568372.26
Grid: NZTM

RAW DATA	SOIL BEHAVIOUR TYPE (NON-NORMALISED)	ESTIMATED PARAMETERS



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.2314 **Final:** -0.1851
Local Friction (MPa) Initial: -0.0025 **Final:** -0.0034
Pore Pressure (MPa) Initial: 0.0131 **Final:** 0.0102

Date: 02/07/2019
Predrill: 0.00
Water Level: -
Collapse: 2.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 2.17

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

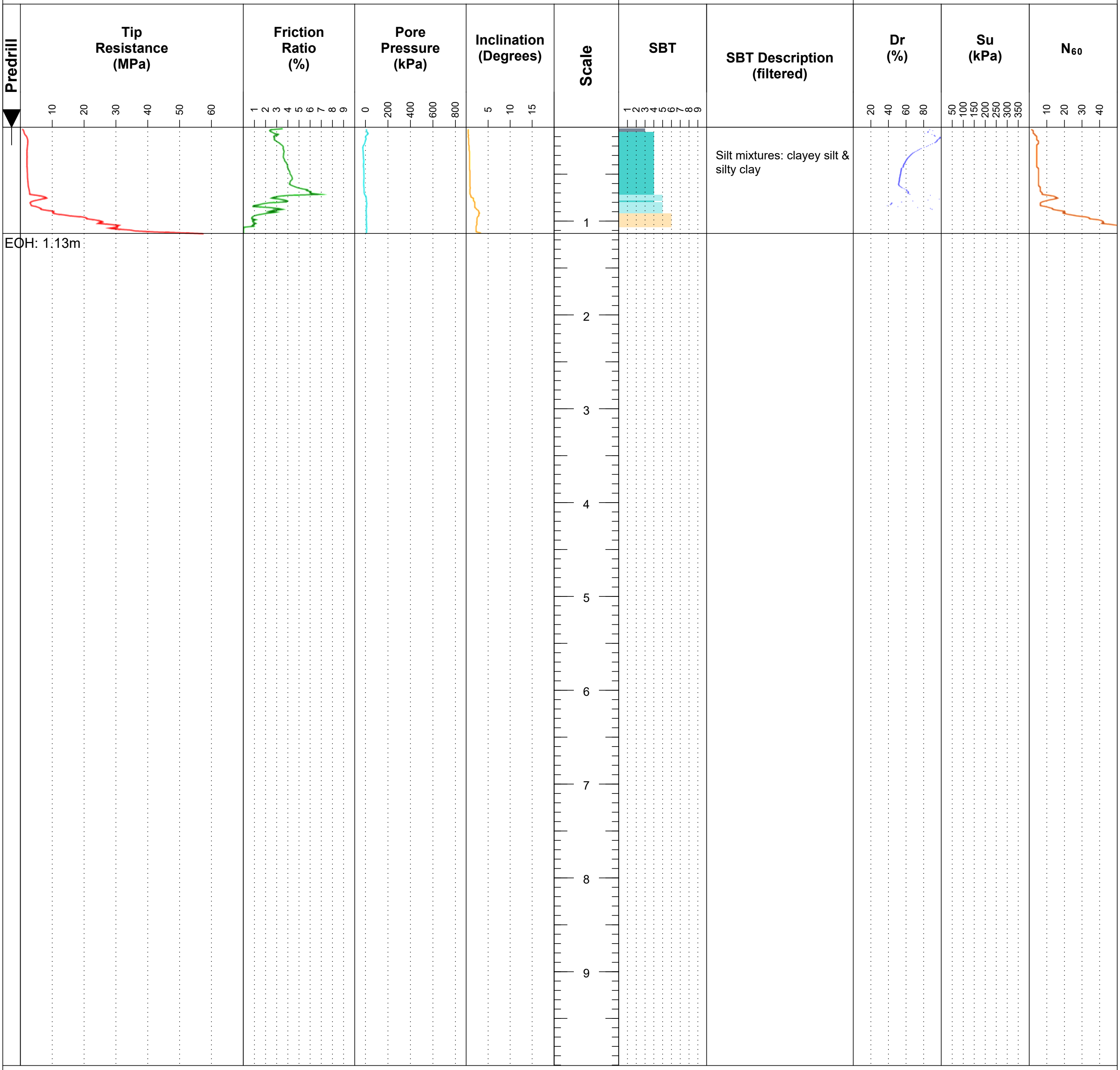
Job: 18207
CPT No.: CPTu013

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 1.13
Elevation (m): 0.00
Datum: Ground

North (m): 5205697.57
East (m): 1568559.95
Grid: NZTM

RAW DATA | SOIL BEHAVIOUR TYPE (NON-NORMALISED) | ESTIMATED PARAMETERS



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.3155 **Final:** 2.3495
Local Friction (MPa) Initial: 0.0376 **Final:** 0.0368
Pore Pressure (MPa) Initial: 0.0145 **Final:** 0.0114

Date: 02/07/2019
Predrill: 0.00
Water Level: -
Collapse: 1.10

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 1.13

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

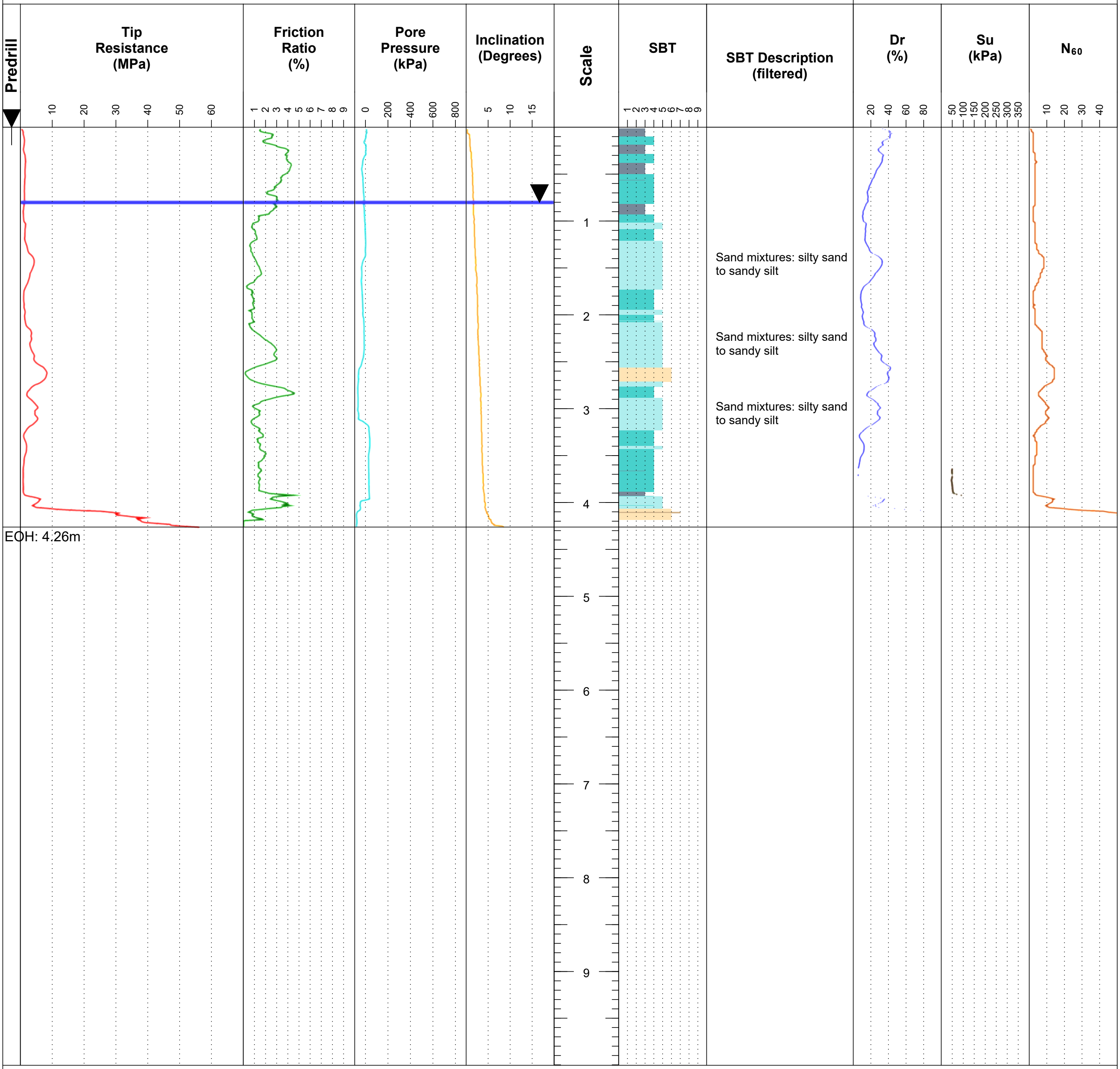
Job: 18207
CPT No.: CPTu014

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 4.26
Elevation (m): 0.00
Datum: Ground

North (m): 5205625.21
East (m): 1568630.39
Grid: NZTM

RAW DATA	SOIL BEHAVIOUR TYPE (NON-NORMALISED)	ESTIMATED PARAMETERS



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.7156 **Final:** 0.7834
Local Friction (MPa) Initial: 0.0168 **Final:** 0.0167
Pore Pressure (MPa) Initial: -0.0171 **Final:** -0.0246

Date: 02/07/2019
Predrill: 0.00
Water Level: 0.80
Collapse: 3.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 4.26

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

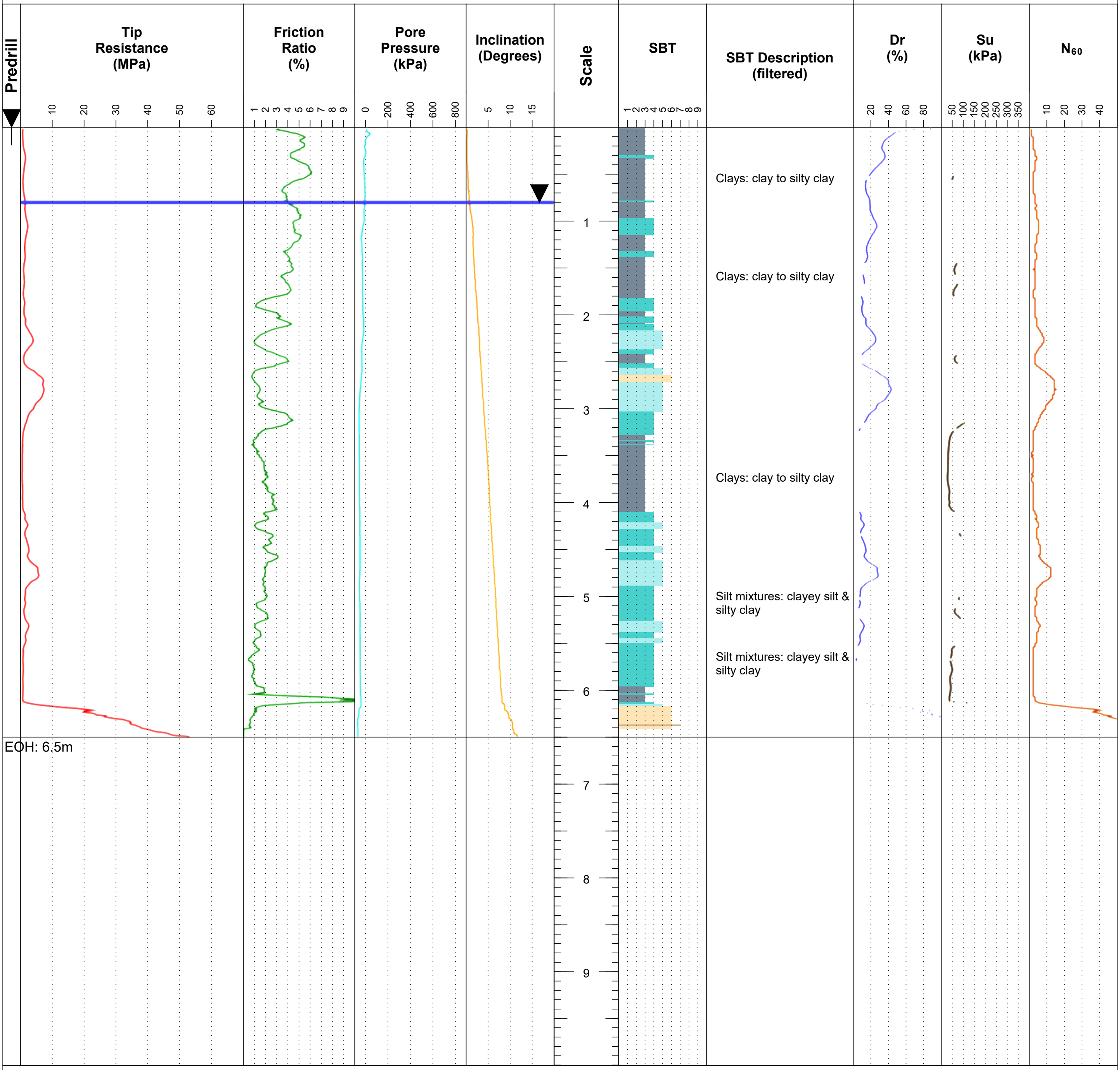
CPT No.: CPTu015

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.50
Elevation (m): 0.00
Datum: Ground

North (m): 5205476.06
East (m): 1568812.79
Grid: NZTM

RAW DATA | SOIL BEHAVIOUR TYPE (NON-NORMALISED) | ESTIMATED PARAMETERS



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 0.3872 **Final:** 0.2761
Local Friction (MPa) Initial: 0.012 **Final:** 0.0085
Pore Pressure (MPa) Initial: -0.0034 **Final:** -0.011

Date: 02/07/2019
Predrill: 0.00
Water Level: 0.80
Collapse: 3.10

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Hole Depth (m): 6.50

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

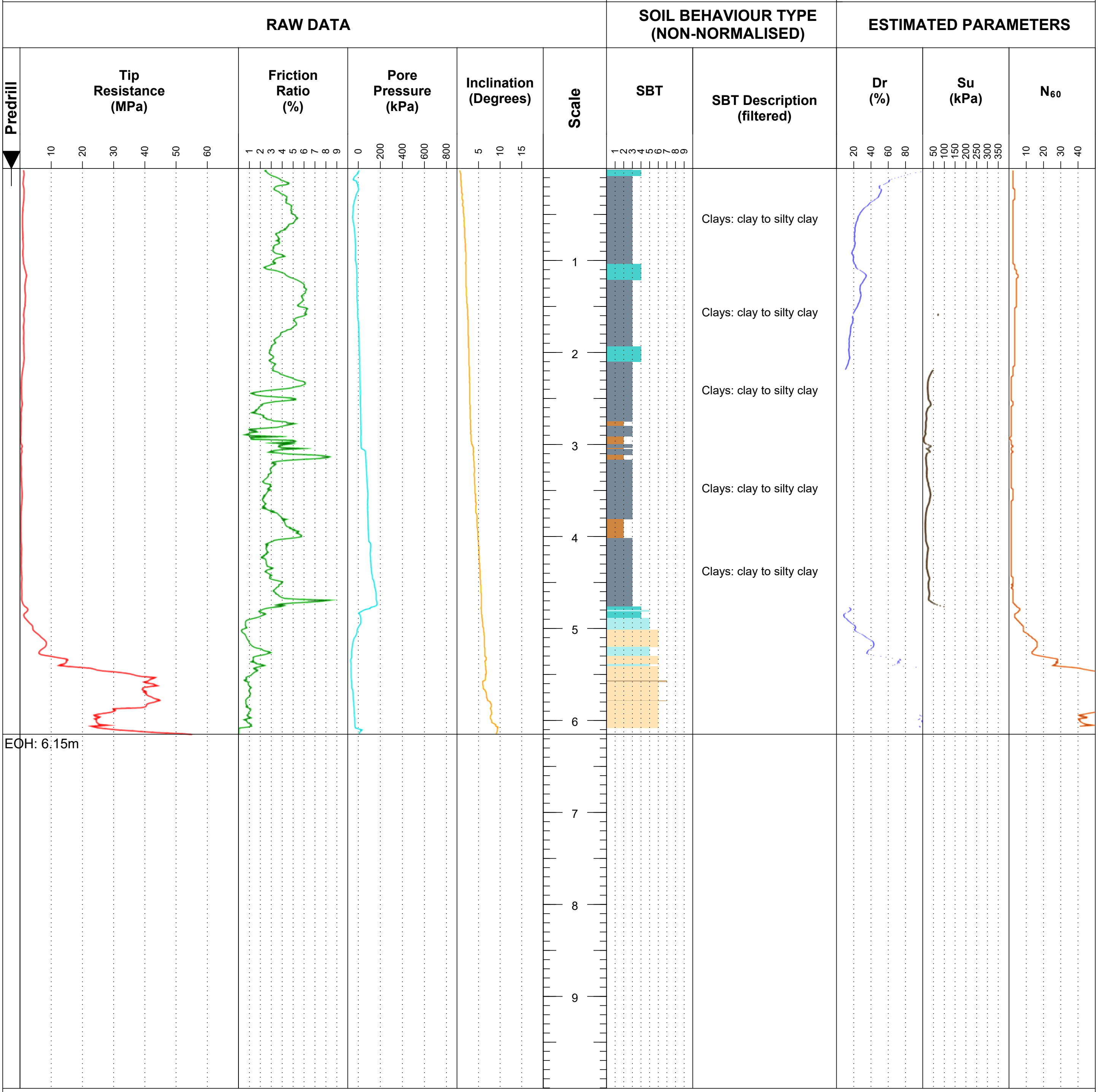
CONE PENETRATION TEST

Job:	**18207**
CPT No.:	**CPTu016**

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.15
Elevation (m): 0.00
Datum: Ground

North (m): 5205294.68
East (m): 1568694.07
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.3637 **Final:** 2.3234
Local Friction (MPa) Initial: 0.0407 **Final:** 0.0367
Pore Pressure (MPa) Initial: 0.0281 **Final:** 0.0264

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 6.15

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

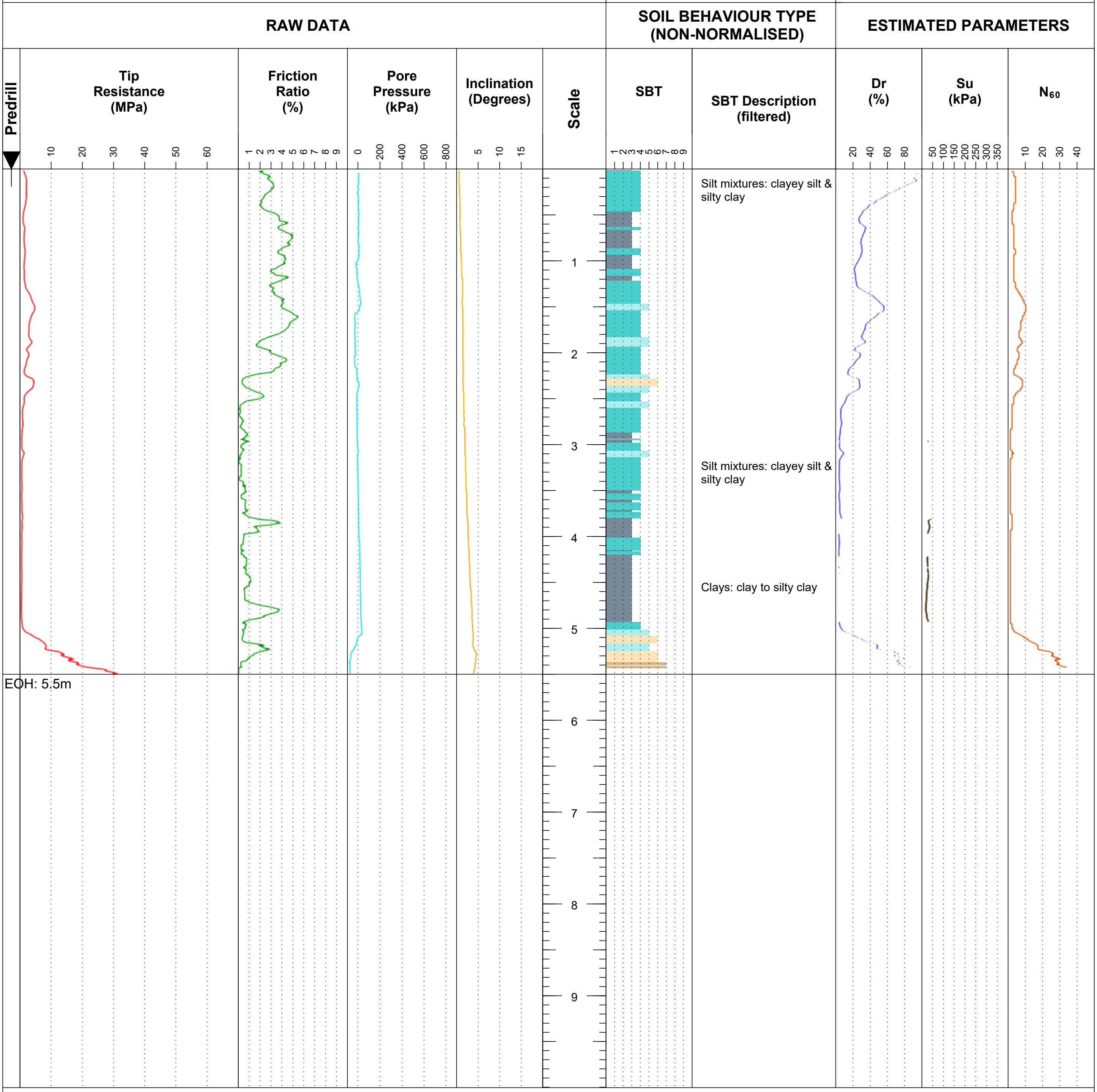
Job: 18207

CPT No.: CPTu017

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.50
Elevation (m): 0.00
Datum: Ground

North (m): 5205312.73
East (m): 1568932.00
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.7984 **Final:** 0.7196
Local Friction (MPa) Initial: 0.0162 **Final:** 0.0165
Pore Pressure (MPa) Initial: -0.0271 **Final:** -0.0264

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 5.50

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

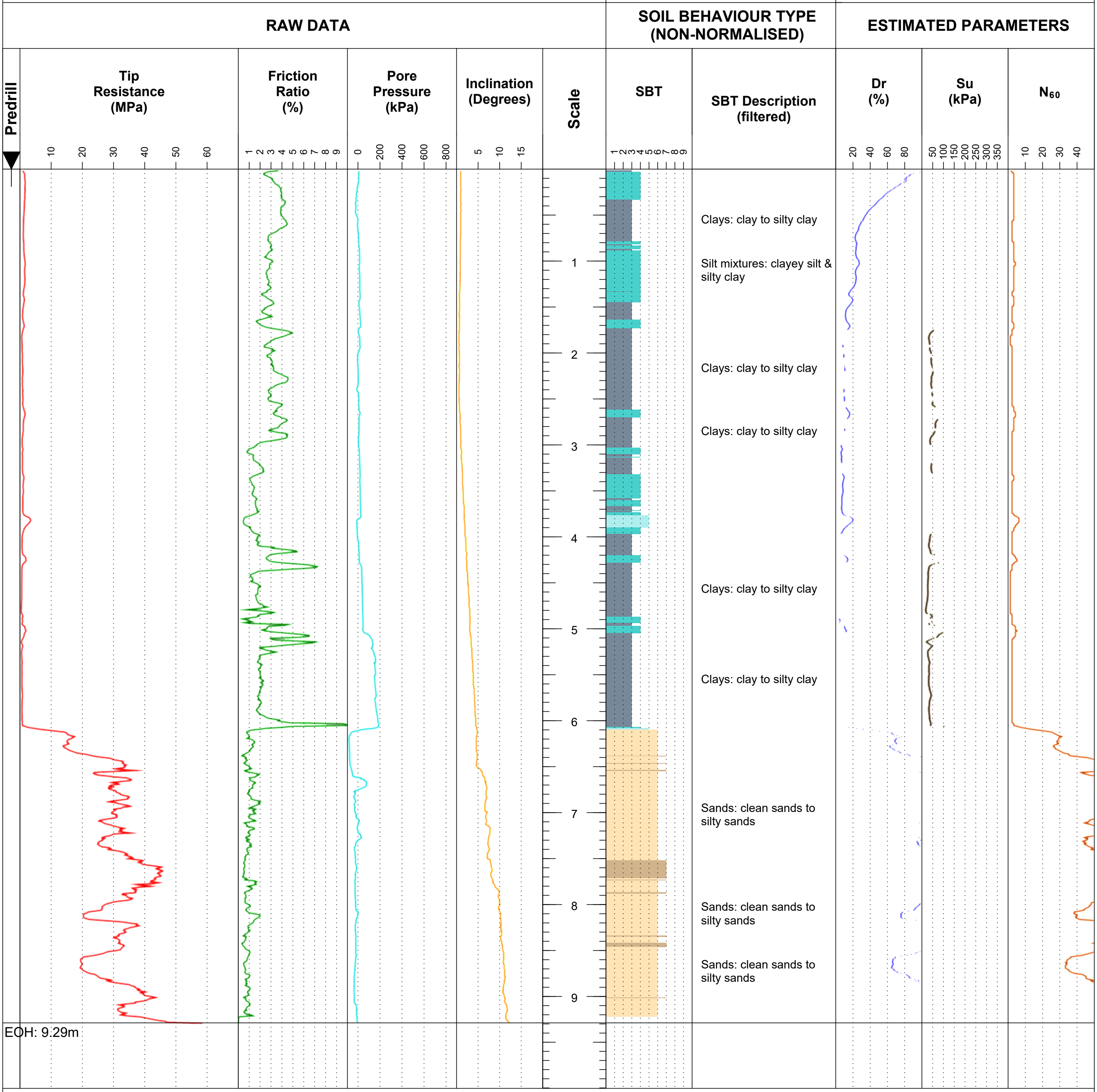
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu018

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 9.29
Elevation (m): 0.00
Datum: Ground

North (m): 5205386.79
East (m): 1569116.88
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.2593 **Final:** -0.2588
Local Friction (MPa) Initial: -0.0024 **Final:** -0.0032
Pore Pressure (MPa) Initial: 0.0086 **Final:** 0.0039

Date: 02/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 9.29

Generated with Core-GS by Geroc

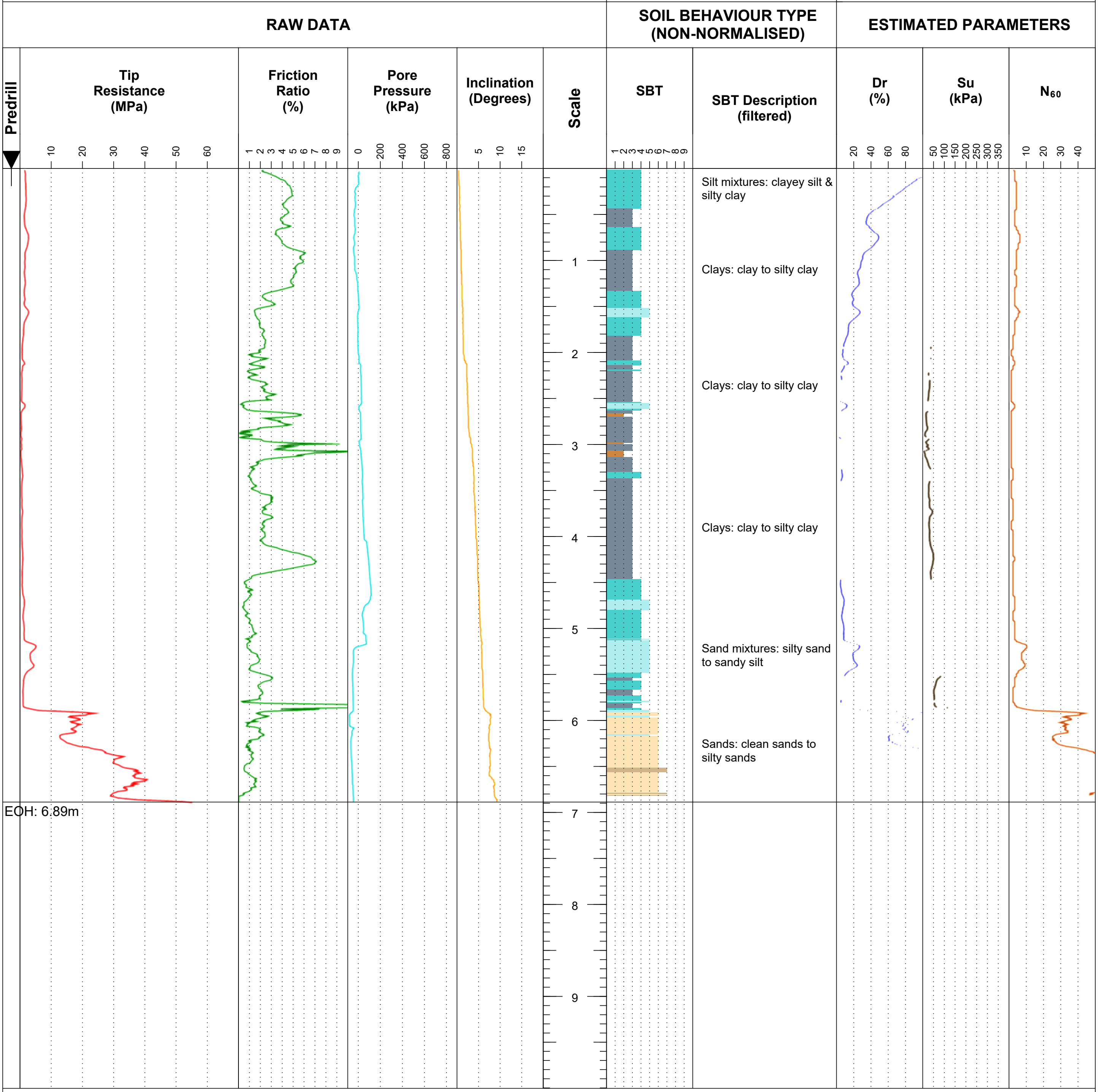
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu019

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.89
Elevation (m): 0.00
Datum: Ground

North (m): 5205132.06
East (m): 1568569.23
Grid: NZTM



Operator: R. Wylie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: 0.1986 **Final:** 0.1733
Local Friction (MPa) Initial: 0.0001 **Final:** 0
Pore Pressure (MPa) Initial: 0.019 **Final:** -0.0105

Date: 04/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse: 6.80

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 6.89

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

Job: 18207

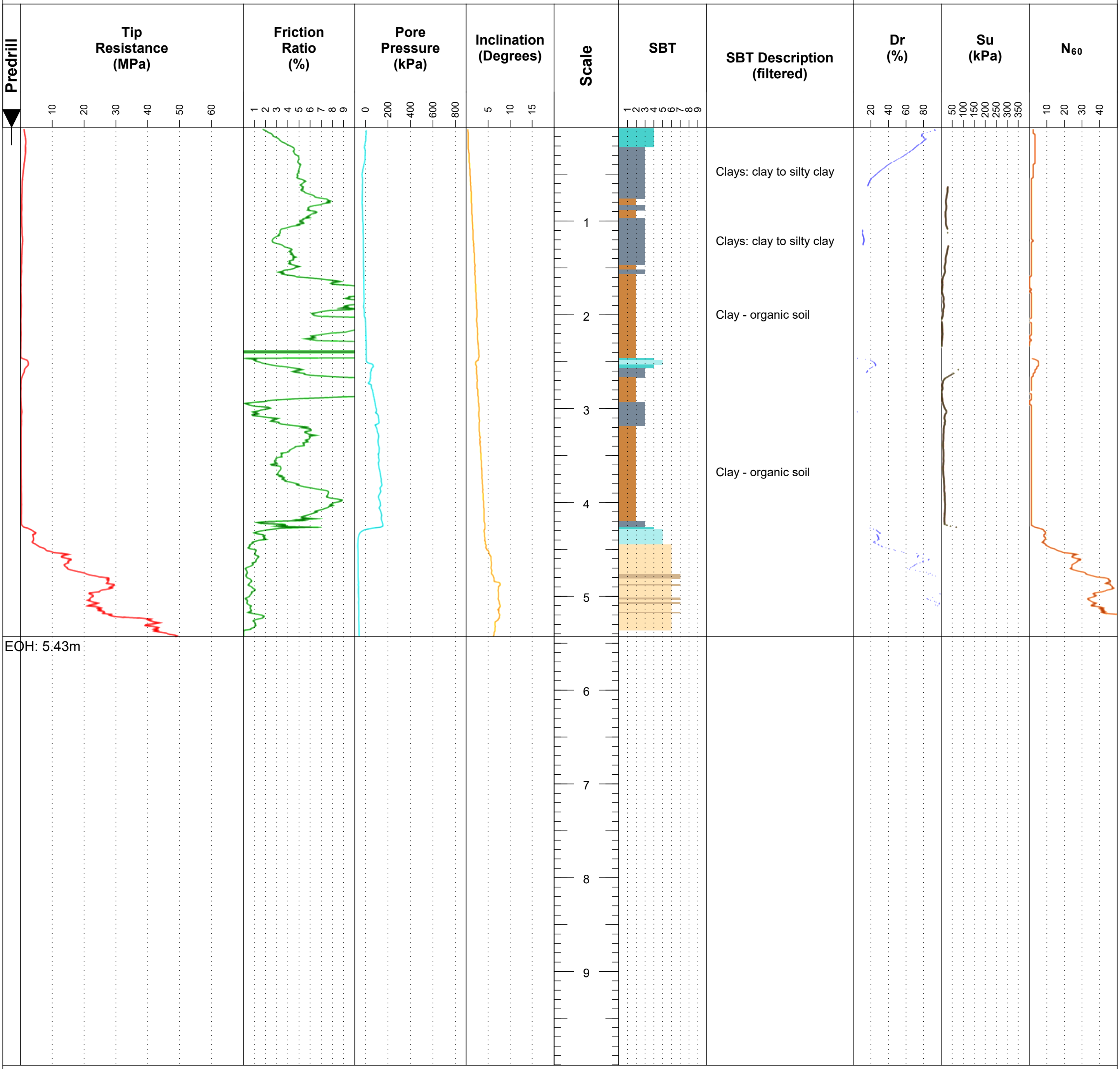
CPT No.: CPTu020

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.43
Elevation (m): 0.00
Datum: Ground

North (m): 5205115.29
East (m): 1568850.20
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 151125
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 2.4558 **Final:** 2.2863
Local Friction (MPa) Initial: 0.0372 **Final:** 0.0366
Pore Pressure (MPa) Initial: 0.0084 **Final:** -0.0558

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 5.43

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

CONE PENETRATION TEST

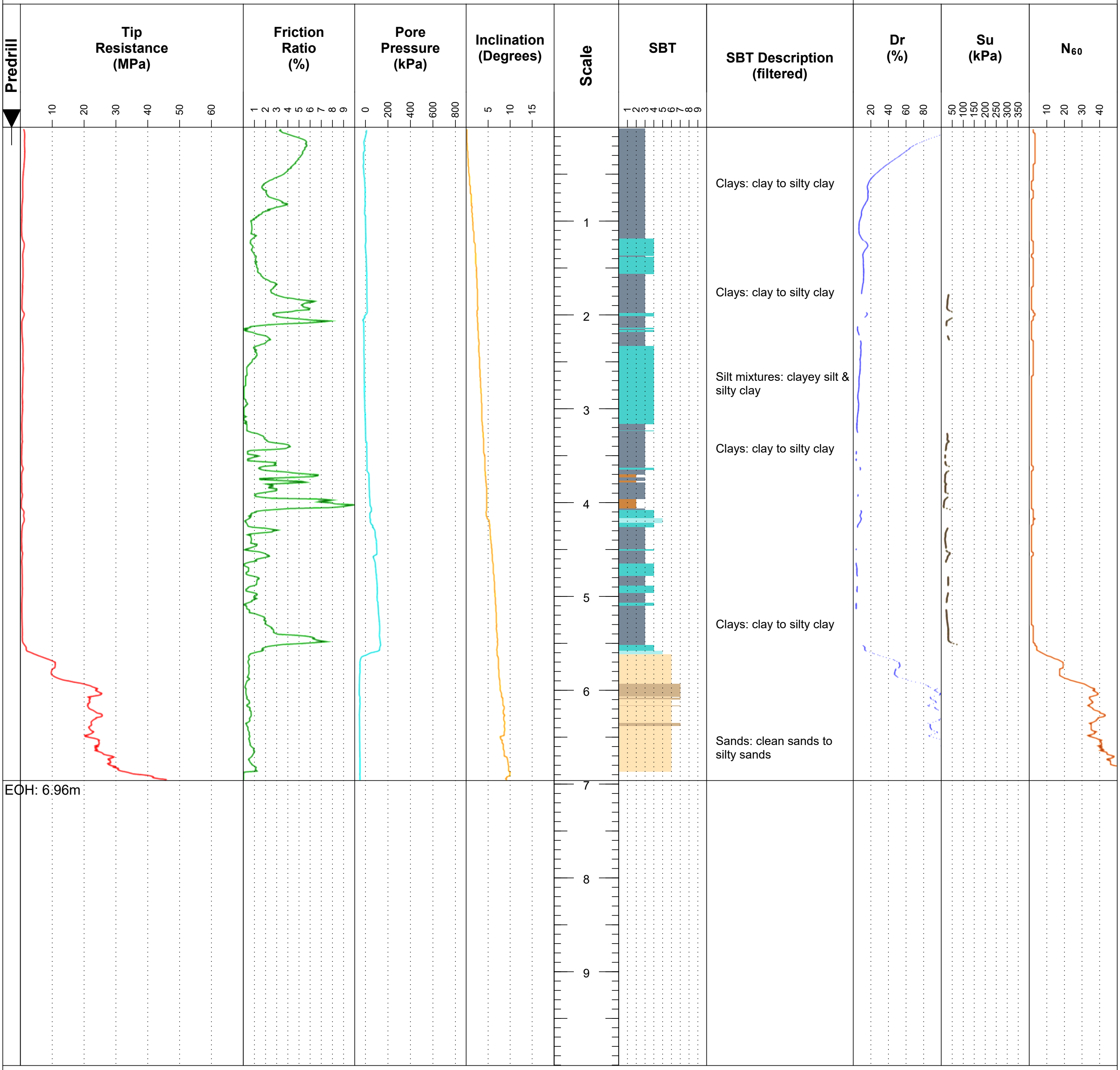
Job: 18207
CPT No.: CPTu021

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.96
Elevation (m): 0.00
Datum: Ground

North (m): 5205279.85
East (m): 1569157.75
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 0.318 **Final:** 0.3095
Local Friction (MPa) Initial: 0.0087 **Final:** 0.0085
Pore Pressure (MPa) Initial: -0.0087 **Final:** -0.0518

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse: 6.00

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 6.96

McMILLAN Drilling

CONE PENETRATION TEST

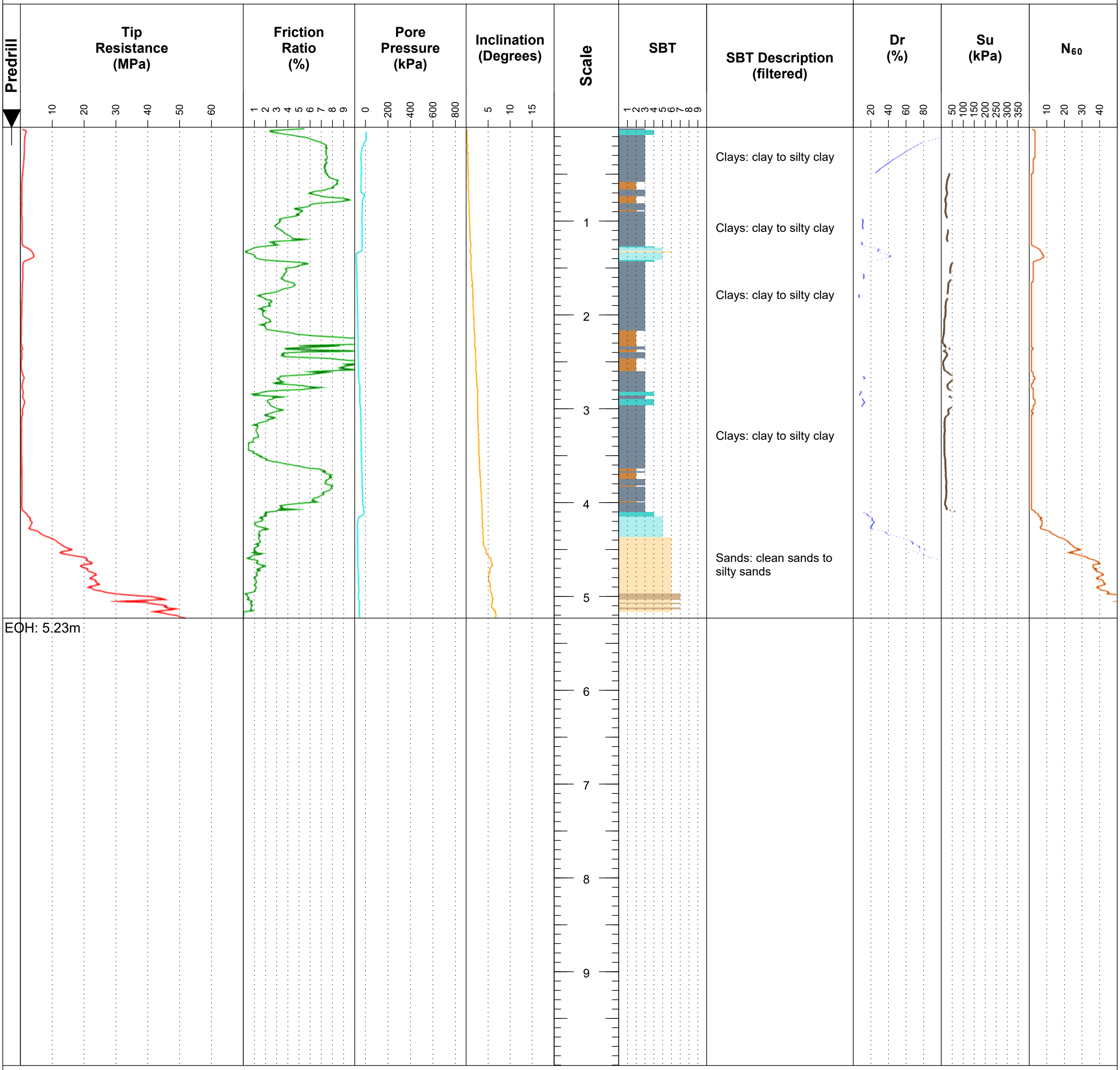
Job: 18207

CPT No.: CPTu022

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.23
Elevation (m): 0.00
Datum: Ground

North (m): 5205058.52
East (m): 1568978.27
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140934
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10
Tip Resistance (MPa) Initial: -0.0646 **Final:** -0.1117
Local Friction (MPa) Initial: -0.0013 **Final:** -0.0013
Pore Pressure (MPa) Initial: 0.0052 **Final:** -0.0432

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0 Undefined
1 Sensitive fine-grained
2 Clay - organic soil
3 Clays: clay to silty clay
4 Silt mixtures: clayey silt & silty clay
5 Sand mixtures: silty sand to sandy silt
6 Sands: clean sands to silty sands
7 Dense sand to gravelly sand
8 Stiff sand to clayey sand
9 Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 5.23

Sheet 1 of 1

Generated with Core-GS by Geroc

McMILLAN Drilling

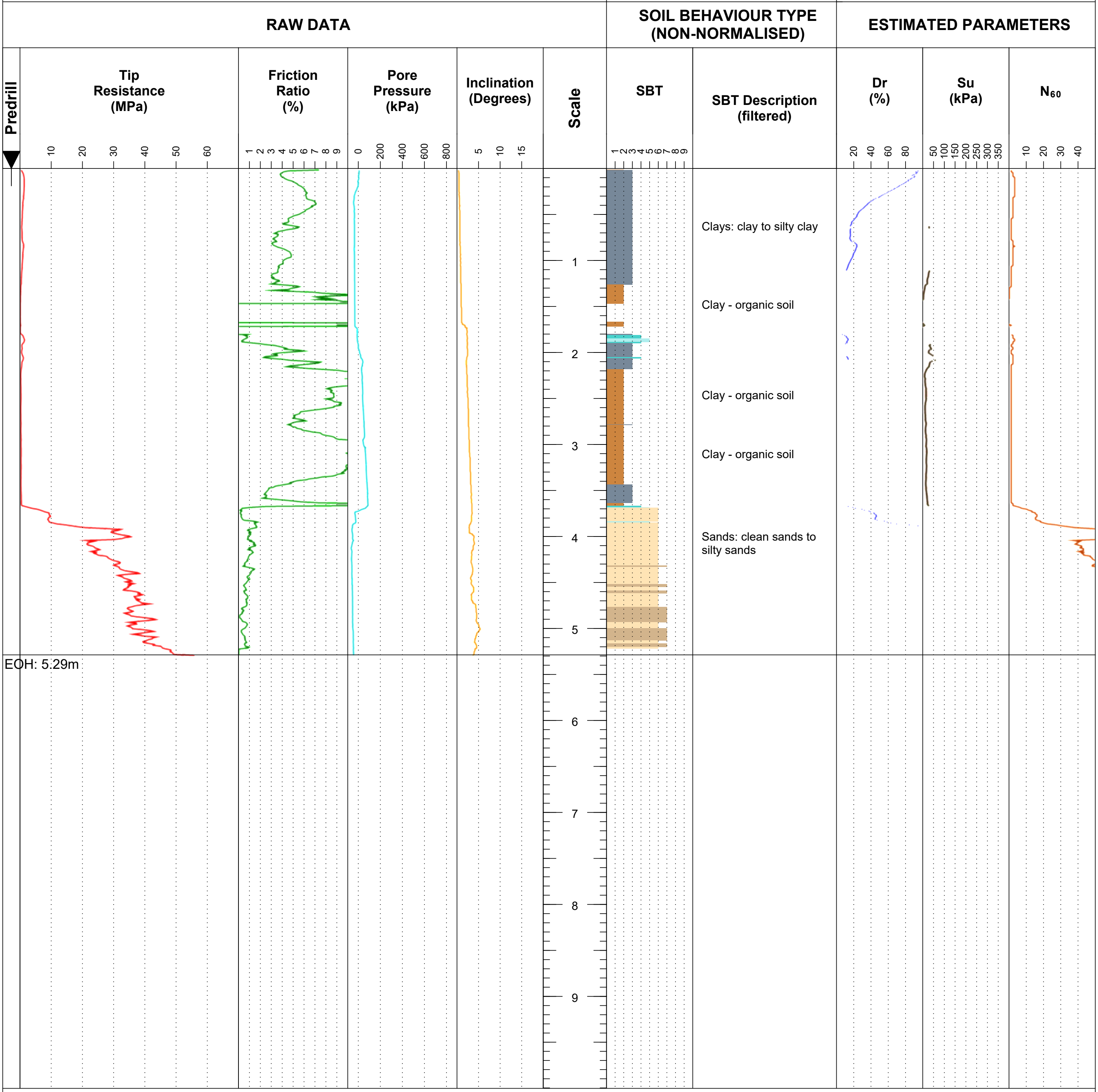
CONE PENETRATION TEST

Job: 18207
CPT No.: CPTu023

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 5.29
Elevation (m): 0.00
Datum: Ground

North (m): 5204837.54
East (m): 1568917.81
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 140912
Cone Area Ratio: 0.75
Cone Type: I-CFXYP100-10

Date: 03/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Tip Resistance (MPa)	**Initial:** 0.7677	**Final:** 0.6988
Local Friction (MPa)	**Initial:** 0.0165	**Final:** 0.0161
Pore Pressure (MPa)	**Initial:** -0.0305	**Final:** -0.0706

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:
Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warrant the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 5.29

Sheet 1 of 1

McMILLAN Drilling

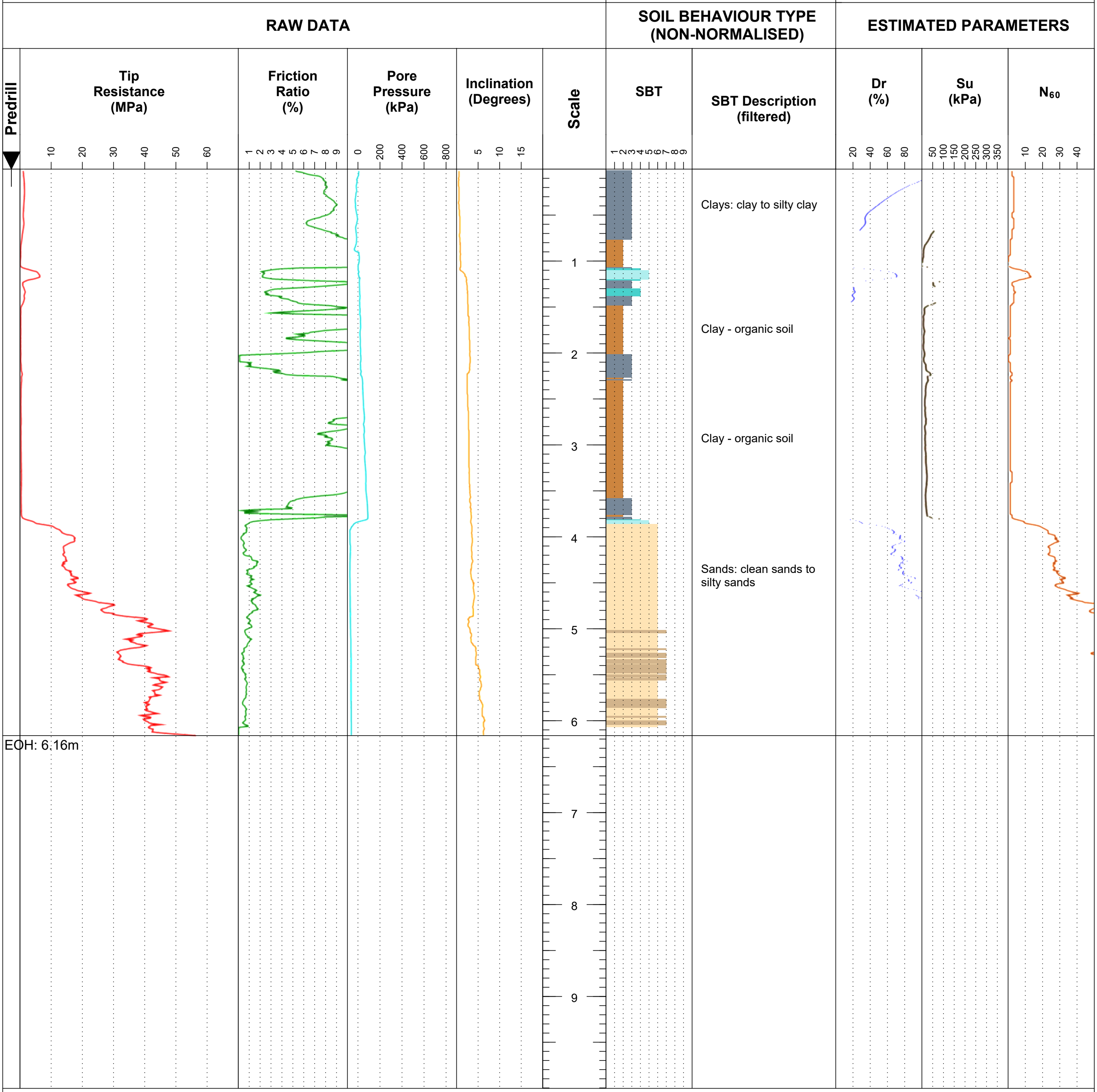
CONE PENETRATION TEST

Job:	**18207**
CPT No.:	**CPTu024**

Name: Kippenberger Avenue, Rangiora
Client: Aurecon NZ Ltd
Location: Kippenberger Avenue, Rangiora

Hole Depth (m): 6.16
Elevation (m): 0.00
Datum: Ground

North (m): 5204894.62
East (m): 1568707.55
Grid: NZTM



Operator: R. Wyllie
Rig: Geomil Panther 100
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 0.2479 **Final:** 0.3329
Local Friction (MPa) Initial: 0.0171 **Final:** 0.0081
Pore Pressure (MPa) Initial: -0.0016 **Final:** -0.0519

Date: 04/07/2019
Predrill: 0.00
Water Level: 0.00
Collapse:

Effective Refusal
Tip: ✓
Gauge:
Inclinometer:
Other:

Target Depth:

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks

Artesian water encountered

Hole Depth (m): 6.16

TEST DETAIL

PointID: CPTu001
Sounding: 4

Operator: R. Wyllie	**Date:** 01/07/2019	**Effective Refusal**
Cone Reference: 160925	**Predrill:** 0.00	**Tip:**
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:** ✓
Cone Type: I-CFXYP20-15	**Collapse:** 1.60	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.291	**Final:** 0.2974	
Local Friction (MPa) Initial: 0.0128	**Final:** 0.0073	
Pore Pressure (MPa) Initial: -0.0001	**Final:** -0.0202	**Target Depth:**

PointID: CPTu002
Sounding: 2

Operator: R. Wyllie	**Date:** 01/07/2019	**Effective Refusal**
Cone Reference: 151125	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP20-10	**Collapse:** 2.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 2.3269	**Final:** 2.4082	
Local Friction (MPa) Initial: 0.0324	**Final:** 0.0342	
Pore Pressure (MPa) Initial: 0.0378	**Final:** 0.0258	**Target Depth:**

PointID: CPTu003
Sounding: 3

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 151125	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP20-10	**Collapse:** 2.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 2.3457	**Final:** 2.279	
Local Friction (MPa) Initial: 0.0327	**Final:** 0.0366	
Pore Pressure (MPa) Initial: 0.0291	**Final:** 0.0144	**Target Depth:**

PointID: CPTu004
Sounding: 1

Operator: R. Wyllie	**Date:** 01/07/2019	**Effective Refusal**
Cone Reference: 140934	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:** 2.50	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: -0.3738	**Final:** -0.3645	
Local Friction (MPa) Initial: -0.0036	**Final:** -0.004	
Pore Pressure (MPa) Initial: 0.0117	**Final:** 0.0087	**Target Depth:**

PointID: CPTu005
Sounding: 5

Operator: R. Wyllie	**Date:** 01/07/2019	**Effective Refusal**
Cone Reference: 140912	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:** 3.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.7805	**Final:** 0.7935	
Local Friction (MPa) Initial: 0.017	**Final:** 0.0164	
Pore Pressure (MPa) Initial: -0.0148	**Final:** -0.0296	**Target Depth:**

TEST DETAIL

PointID: CPTu006
Sounding: 6

Operator: R. Wyllie
Date: 01/07/2019
Effective Refusal
Cone Reference: 140912
Predrill: 0.00
Tip: ✓
Cone Area Ratio: 0.75
Water Level: -
Gauge:
Cone Type: I-CFXYP100-10
Collapse: 0.80
Inclinometer:
Other:
Tip Resistance (MPa) Initial: 0.7764
Final: 0.819
Local Friction (MPa) Initial: 0.017
Final: 0.0169
Pore Pressure (MPa) Initial: -0.0135
Final: -0.0169
Target Depth:

PointID: CPTu007
Sounding: 7

Operator: R. Wyllie
Date: 01/07/2019
Effective Refusal
Cone Reference: 140934
Predrill: 0.00
Tip: ✓
Cone Area Ratio: 0.75
Water Level: -
Gauge:
Cone Type: I-CFXYP100-10
Collapse: 0.80
Inclinometer:
Other:
Tip Resistance (MPa) Initial: -0.3333
Final: -0.3136
Local Friction (MPa) Initial: -0.0023
Final: -0.0046
Pore Pressure (MPa) Initial: 0.0133
Final: 0.0177
Target Depth:

PointID: CPTu008
Sounding: 8

Operator: R. Wyllie
Date: 02/07/2019
Effective Refusal
Cone Reference: 140912
Predrill: 0.00
Tip: ✓
Cone Area Ratio: 0.75
Water Level: -
Gauge:
Cone Type: I-CFXYP100-10
Collapse: 3.10
Inclinometer:
Other:
Tip Resistance (MPa) Initial: 0.7746
Final: 0.713
Local Friction (MPa) Initial: 0.017
Final: 0.0163
Pore Pressure (MPa) Initial: -0.0064
Final: -0.0281
Target Depth:

PointID: CPTu009
Sounding: 9

Operator: R. Wyllie
Date: 01/07/2019
Effective Refusal
Cone Reference: 140934
Predrill: 0.00
Tip: ✓
Cone Area Ratio: 0.75
Water Level: -
Gauge:
Cone Type: I-CFXYP100-10
Collapse: 2.20
Inclinometer:
Other:
Tip Resistance (MPa) Initial: -0.3905
Final: -0.3587
Local Friction (MPa) Initial: -0.0034
Final: -0.0044
Pore Pressure (MPa) Initial: 0.0139
Final: 0.0093
Target Depth:

PointID: CPTu010
Sounding: 10

Operator: R. Wyllie
Date: 01/07/2019
Effective Refusal
Cone Reference: 151125
Predrill: 0.00
Tip: ✓
Cone Area Ratio: 0.75
Water Level: -
Gauge:
Cone Type: I-CFXYP20-10
Collapse: 2.80
Inclinometer:
Other:
Tip Resistance (MPa) Initial: 2.325
Final: 2.3614
Local Friction (MPa) Initial: 0.023
Final: 0.034
Pore Pressure (MPa) Initial: 0.0353
Final: 0.0268
Target Depth:

TEST DETAIL

PointID: CPTu011
Sounding: 11

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 160925	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP20-15	**Collapse:** 1.90	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.1618	**Final:** 0.5314	
Local Friction (MPa) Initial: 0.0126	**Final:** 0.0089	
Pore Pressure (MPa) Initial: -0.0092	**Final:** -0.0101	**Target Depth:**

PointID: CPTu012
Sounding: 12

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 140934	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:** 2.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: -0.2314	**Final:** -0.1851	
Local Friction (MPa) Initial: -0.0025	**Final:** -0.0034	
Pore Pressure (MPa) Initial: 0.0131	**Final:** 0.0102	**Target Depth:**

PointID: CPTu013
Sounding: 13

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 151125	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** -	**Gauge:**
Cone Type: I-CFXYP20-10	**Collapse:** 1.10	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 2.3155	**Final:** 2.3495	
Local Friction (MPa) Initial: 0.0376	**Final:** 0.0368	
Pore Pressure (MPa) Initial: 0.0145	**Final:** 0.0114	**Target Depth:**

PointID: CPTu014
Sounding: 14

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 140912	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.80	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:** 3.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.7156	**Final:** 0.7834	
Local Friction (MPa) Initial: 0.0168	**Final:** 0.0167	
Pore Pressure (MPa) Initial: -0.0171	**Final:** -0.0246	**Target Depth:**

PointID: CPTu015
Sounding: 15

Operator: R. Wyllie	**Date:** 02/07/2019	**Effective Refusal**
Cone Reference: 160925	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.80	**Gauge:**
Cone Type: I-CFXYP20-15	**Collapse:** 3.10	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.3872	**Final:** 0.2761	
Local Friction (MPa) Initial: 0.012	**Final:** 0.0085	
Pore Pressure (MPa) Initial: -0.0034	**Final:** -0.011	**Target Depth:**

TEST DETAIL

PointID: CPTu016

Sounding: 16

Operator:	R. Wyllie	**Date:**	03/07/2019	**Effective Refusal**	
Cone Reference:	151125	**Predrill:**	0.00	**Tip:**	✓
Cone Area Ratio:	0.75	**Water Level:**	0.00	**Gauge:**	
Cone Type:	I-CFXYP20-10	**Collapse:**		**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	2.3637	**Final:**	2.3234		
Local Friction (MPa) Initial:	0.0407	**Final:**	0.0367		
Pore Pressure (MPa) Initial:	0.0281	**Final:**	0.0264	**Target Depth:**	

PointID: CPTu017

Sounding: 17

Operator:	R. Wyllie	**Date:**	03/07/2019	**Effective Refusal**	
Cone Reference:	140912	**Predrill:**	0.00	**Tip:**	
Cone Area Ratio:	0.75	**Water Level:**	0.00	**Gauge:**	
Cone Type:	I-CFXYP100-10	**Collapse:**		**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	0.7984	**Final:**	0.7196		
Local Friction (MPa) Initial:	0.0162	**Final:**	0.0165		
Pore Pressure (MPa) Initial:	-0.0271	**Final:**	-0.0264	**Target Depth:**	✓

PointID: CPTu018

Sounding: 18

Operator:	R. Wyllie	**Date:**	02/07/2019	**Effective Refusal**	
Cone Reference:	140934	**Predrill:**	0.00	**Tip:**	✓
Cone Area Ratio:	0.75	**Water Level:**	0.00	**Gauge:**	
Cone Type:	I-CFXYP100-10	**Collapse:**		**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	-0.2593	**Final:**	-0.2588		
Local Friction (MPa) Initial:	-0.0024	**Final:**	-0.0032		
Pore Pressure (MPa) Initial:	0.0086	**Final:**	0.0039	**Target Depth:**	

PointID: CPTu019

Sounding: 19

Operator:	R. Wyllie	**Date:**	04/07/2019	**Effective Refusal**	
Cone Reference:	140934	**Predrill:**	0.00	**Tip:**	✓
Cone Area Ratio:	0.75	**Water Level:**	0.00	**Gauge:**	
Cone Type:	I-CFXYP100-10	**Collapse:**	6.80	**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	0.1986	**Final:**	0.1733		
Local Friction (MPa) Initial:	0.0001	**Final:**	0		
Pore Pressure (MPa) Initial:	0.019	**Final:**	-0.0105	**Target Depth:**	

PointID: CPTu020

Sounding: 20

Operator:	R. Wyllie	**Date:**	03/07/2019	**Effective Refusal**	
Cone Reference:	151125	**Predrill:**	0.00	**Tip:**	✓
Cone Area Ratio:	0.75	**Water Level:**	0.00	**Gauge:**	
Cone Type:	I-CFXYP20-10	**Collapse:**		**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	2.4558	**Final:**	2.2863		
Local Friction (MPa) Initial:	0.0372	**Final:**	0.0366		
Pore Pressure (MPa) Initial:	0.0084	**Final:**	-0.0558	**Target Depth:**	

TEST DETAIL

PointID: CPTu021

Sounding: 21

Operator: R. Wyllie	**Date:** 03/07/2019	**Effective Refusal**
Cone Reference: 160925	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.00	**Gauge:**
Cone Type: I-CFXYP20-15	**Collapse:** 6.00	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.318	**Final:** 0.3095	
Local Friction (MPa) Initial: 0.0087	**Final:** 0.0085	
Pore Pressure (MPa) Initial: -0.0087	**Final:** -0.0518	**Target Depth:**

PointID: CPTu022

Sounding: 22

Operator: R. Wyllie	**Date:** 03/07/2019	**Effective Refusal**
Cone Reference: 140934	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.00	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:**	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: -0.0646	**Final:** -0.1117	
Local Friction (MPa) Initial: -0.0013	**Final:** -0.0013	
Pore Pressure (MPa) Initial: 0.0052	**Final:** -0.0432	**Target Depth:**

PointID: CPTu023

Sounding: 23

Operator: R. Wyllie	**Date:** 03/07/2019	**Effective Refusal**
Cone Reference: 140912	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.00	**Gauge:**
Cone Type: I-CFXYP100-10	**Collapse:**	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.7677	**Final:** 0.6988	
Local Friction (MPa) Initial: 0.0165	**Final:** 0.0161	
Pore Pressure (MPa) Initial: -0.0305	**Final:** -0.0706	**Target Depth:**

PointID: CPTu024

Sounding: 24

Operator: R. Wyllie	**Date:** 04/07/2019	**Effective Refusal**
Cone Reference: 160925	**Predrill:** 0.00	**Tip:** ✓
Cone Area Ratio: 0.75	**Water Level:** 0.00	**Gauge:**
Cone Type: I-CFXYP20-15	**Collapse:**	**Inclinometer:**
		Other:
Tip Resistance (MPa) Initial: 0.2479	**Final:** 0.3329	
Local Friction (MPa) Initial: 0.0171	**Final:** 0.0081	
Pore Pressure (MPa) Initial: -0.0016	**Final:** -0.0519	**Target Depth:**

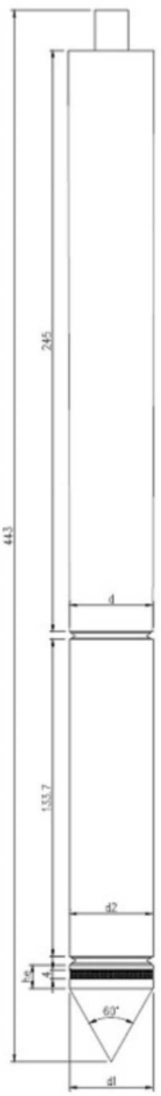
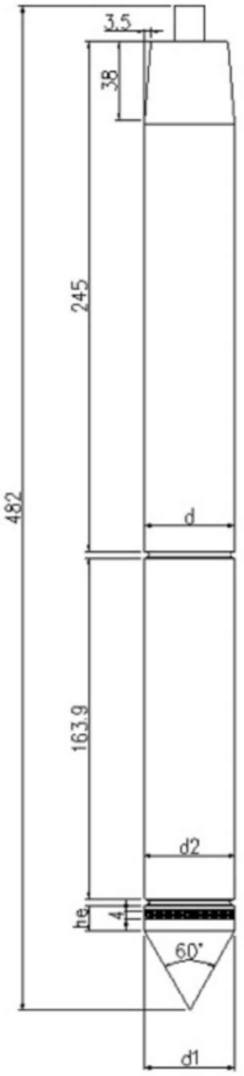
CPT CALIBRATION AND TECHNICAL NOTES

These notes describe the technical specifications and associated calibration references pertaining to the following cone types:

- I-CFXY-10 measuring cone resistance, sleeve friction and inclination (standard cone, 10cm²);
- I-CFXY-15 measuring cone resistance, sleeve friction and inclination (standard cone, 15cm²);
- I-CFXYP20-10 measuring cone resistance, sleeve friction, inclination and pore pressure (piezocone, 10cm²);
- I-CFXYP20-15 measuring cone resistance, sleeve friction, inclination and pore pressure (piezocone, 15cm²);
- I-C5F0p15XYP20-10 measuring sensitive cone resistance, sleeve friction, inclination and pore pressure (piezocone, 10cm²).

Dimensions

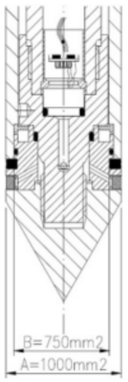
Dimensional specifications for all cone types are detailed below. All tolerances are routinely checked prior to testing and measurements taken are electronically recorded. All records are kept on file and available on request.

A.P. van den Berg Machinefabriek tel.: +31 (0)513-631355 info@apvandenberg.com	**DEVIATION of Straightness + MINIMUM Dimensions tip, friction jacket, cone adapter**		Standards: EN ISO 22476-1 APB-standard	
Type of cone:	Icone 10 cm²		Icone 15 cm²	
ALLOWABLE SIZE VARIATION				
Diameter of tip:	$35{,}3 \le d1 \le 36{,}0$		$43{,}2 \le d_1 \le 44{,}1$	
Diameter of centering ring CFP	$35{,}3 \le d1 \le 36{,}0$		$43{,}2 \le d_1 \le 44{,}1$	
Diameter of friction jacket:	$d_1 \le d_2 < d_1 + 0{,}35$		$d_1 \le d_2 < d_1 + 0{,}43$	
Height dimension of tip edge:	$7 \le h_e \le 10$		$9 \le h_e \le 12$	
PRODUCTION DIMENSIONS				
Tip:	$d_1 = 35{,}7^{+0{,}2}_{0}$		$d_1 = 43{,}8^{+0{,}2}_{0}$	
Jacket (C-cone):	$d_2 = 35{,}7^{+0{,}2}_{0}$		$d_2 = 43{,}7^{+0{,}2}_{0}$	
Friction jacket (CF-cone):	$d_2 = 35{,}9^{+0{,}1}_{0}$		$d_2 = 44{,}0^{+0{,}1}_{0}$	
Tip for used cone:	$d_1 = 35{,}5^{+0{,}1}_{0}$		$d_1 = 43{,}5^{+0{,}1}_{0}$	
MINIMUM DIMENSIONS				
Minimum diameter jacket (C-cone):	$d_2 = 35{,}2$ (APB standard)		$d_2 = 43{,}0$ (APB standard)	
Minimum diameter friction jacket (CF-cone):	$d_2 = 35{,}3$		$d_2 = 43{,}2$	
Use "used cone"-tip when friction jacket diameter:	$d_2 \le 35{,}65$		$d_2 \le 43{,}7$	
Minimum diameter of cone adaptor:	$d = 35{,}3$		$d = 43{,}8$	
Maximum deviation of straightness:	1 mm on a length of 1000 mm (max. oscillation 1,0 mm.)		1 mm on a length of 1000 mm (max. oscillation: 2.0 mm)	

Tip and Local Friction sensor displacement

The different distances of the sensors are compensated depending on the cone types:

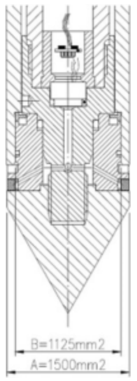
- 10cm² cones: 80mm
- 15cm² cones: 100mm



Cone area ratio

$\alpha = B / A = 0.75$

$\beta = 1 - B / A = 0.25$



CPT CALIBRATION AND TECHNICAL NOTES (cont.)

Calibration

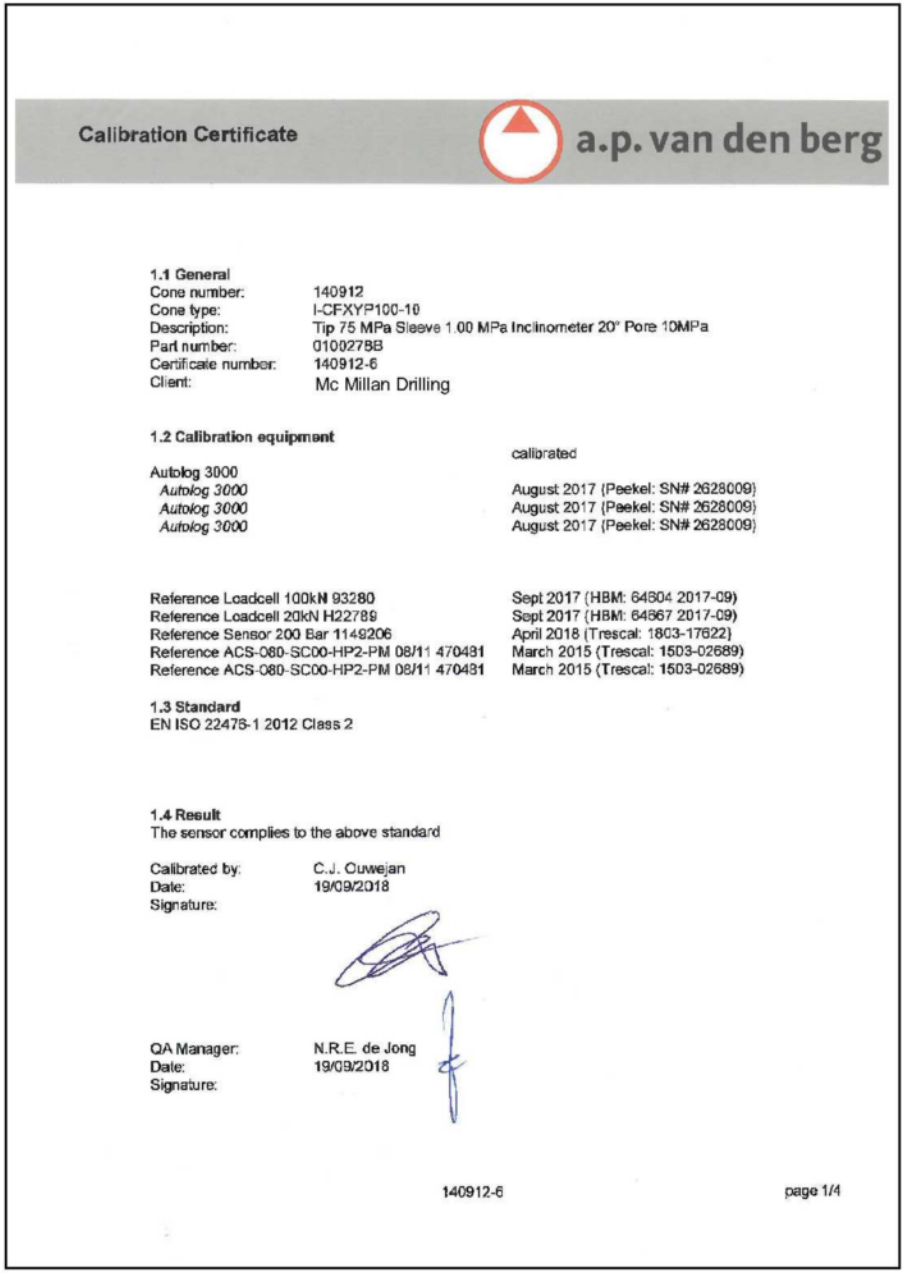
Each cone has a unique identification number that is electronically recorded and reported for each CPT test. The identification number enables the operator to compare 'zero-load offsets' to manufacturer calibrated zero-load offsets.

The recommended maximum zero-load offset for each sensor is determined as ± 5% of the nominal measuring range.

In addition to maximum zero-load offsets, McMillan Drilling also limits the difference in zero load offset before and after the test as ± 2% of the maximum measuring range. See table below:

	Tip (MPa)	Friction (MPa)	Pore Pressure (MPa)
Maximum Measuring Range:	150	1.50	3.00
Nominal Measuring Range:	75	1.00	2.00
Max. 'zero-load offset':	7.5	0.10	0.20
Max 'before and after test':	3	0.03	0.06

Note: The zero offsets are electronically recorded and reported for each test in the same units as that of each sensor.



Calibration Certificate

a.p. van den berg

1.1 General

Cone number:	140912
Cone type:	I-CFXYP100-10
Description:	Tip 75 MPa Sleeve 1.00 MPa Inclinometer 20° Pore 10MPa
Part number:	0100278B
Certificate number:	140912-6
Client:	Mc Millan Drilling

1.2 Calibration equipment

	calibrated
Autolog 3000	
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)

Reference Loadcell 100kN 93280	Sept 2017 (HBM: 64604 2017-09)
Reference Loadcell 20kN H22789	Sept 2017 (HBM: 64667 2017-09)
Reference Sensor 200 Bar 1149206	April 2018 (Trescal: 1803-17622)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)

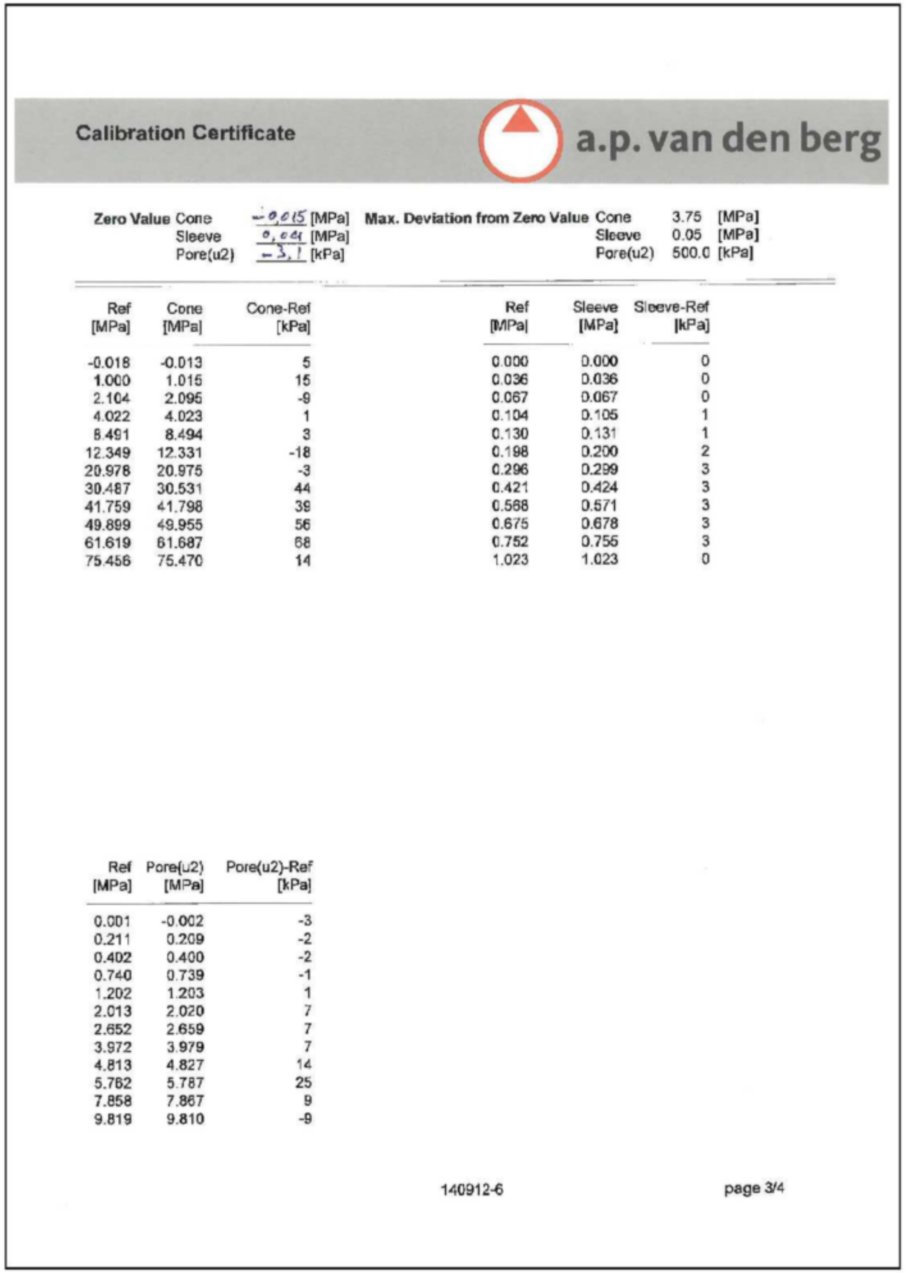
1.3 Standard
EN ISO 22476-1 2012 Class 2

1.4 Result
The sensor complies to the above standard

Calibrated by:	C.J. Ouwejan
Date:	19/09/2018
Signature:	

QA Manager:	N.R.E. de Jong
Date:	19/09/2018
Signature:	

140912-6 page 1/4



Calibration Certificate

a.p. van den berg

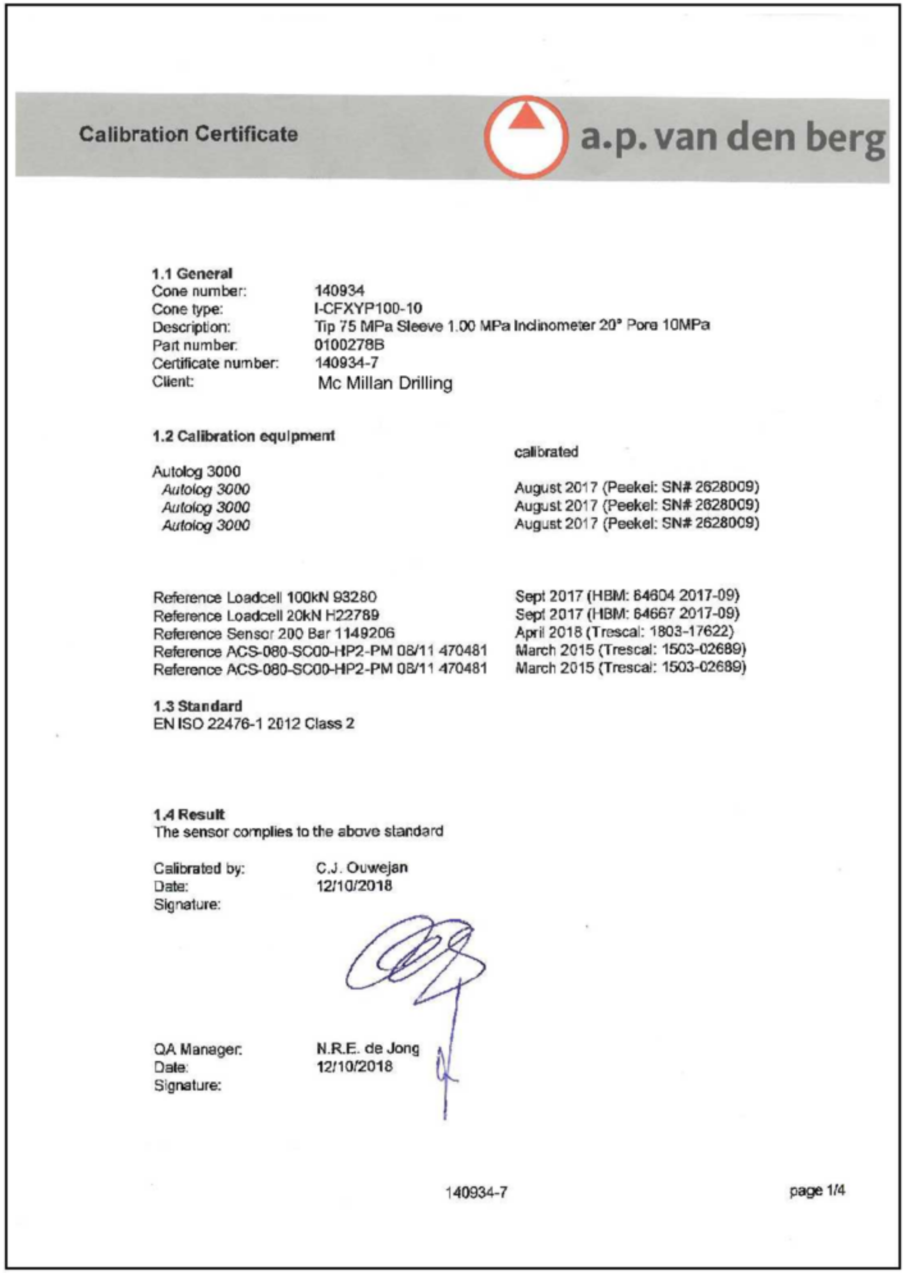
Zero Value			Max. Deviation from Zero Value		
Cone	-0,015	[MPa]	Cone	3.75	[MPa]
Sleeve	0,04	[MPa]	Sleeve	0.05	[MPa]
Pore(u2)	-3,1	[kPa]	Pore(u2)	500.0	[kPa]

Ref [MPa]	Cone [MPa]	Cone-Ref [kPa]
-0.018	-0.013	5
1.000	1.015	15
2.104	2.095	-9
4.022	4.023	1
8.491	8.494	3
12.349	12.331	-18
20.978	20.975	-3
30.487	30.531	44
41.759	41.798	39
49.899	49.955	56
61.619	61.687	68
75.456	75.470	14

Ref [MPa]	Sleeve [MPa]	Sleeve-Ref [kPa]
0.000	0.000	0
0.036	0.036	0
0.067	0.067	0
0.104	0.105	1
0.130	0.131	1
0.198	0.200	2
0.296	0.299	3
0.421	0.424	3
0.568	0.571	3
0.675	0.678	3
0.752	0.755	3
1.023	1.023	0

Ref [MPa]	Pore(u2) [MPa]	Pore(u2)-Ref [kPa]
0.001	-0.002	-3
0.211	0.209	-2
0.402	0.400	-2
0.740	0.739	-1
1.202	1.203	1
2.013	2.020	7
2.652	2.659	7
3.972	3.979	7
4.813	4.827	14
5.762	5.787	25
7.858	7.867	9
9.819	9.810	-9

140912-6 page 3/4



Calibration Certificate

a.p. van den berg

1.1 General

Cone number:	140934
Cone type:	I-CFXYP100-10
Description:	Tip 75 MPa Sleeve 1.00 MPa Inclinometer 20° Pore 10MPa
Part number:	0100278B
Certificate number:	140934-7
Client:	Mc Millan Drilling

1.2 Calibration equipment

	calibrated
Autolog 3000	
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Reference Loadcell 100kN 93280	Sept 2017 (HBM: 64604 2017-09)
Reference Loadcell 20kN H22789	Sept 2017 (HBM: 64667 2017-09)
Reference Sensor 200 Bar 1149206	April 2018 (Trescal: 1803-17622)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)

1.3 Standard

EN ISO 22476-1 2012 Class 2

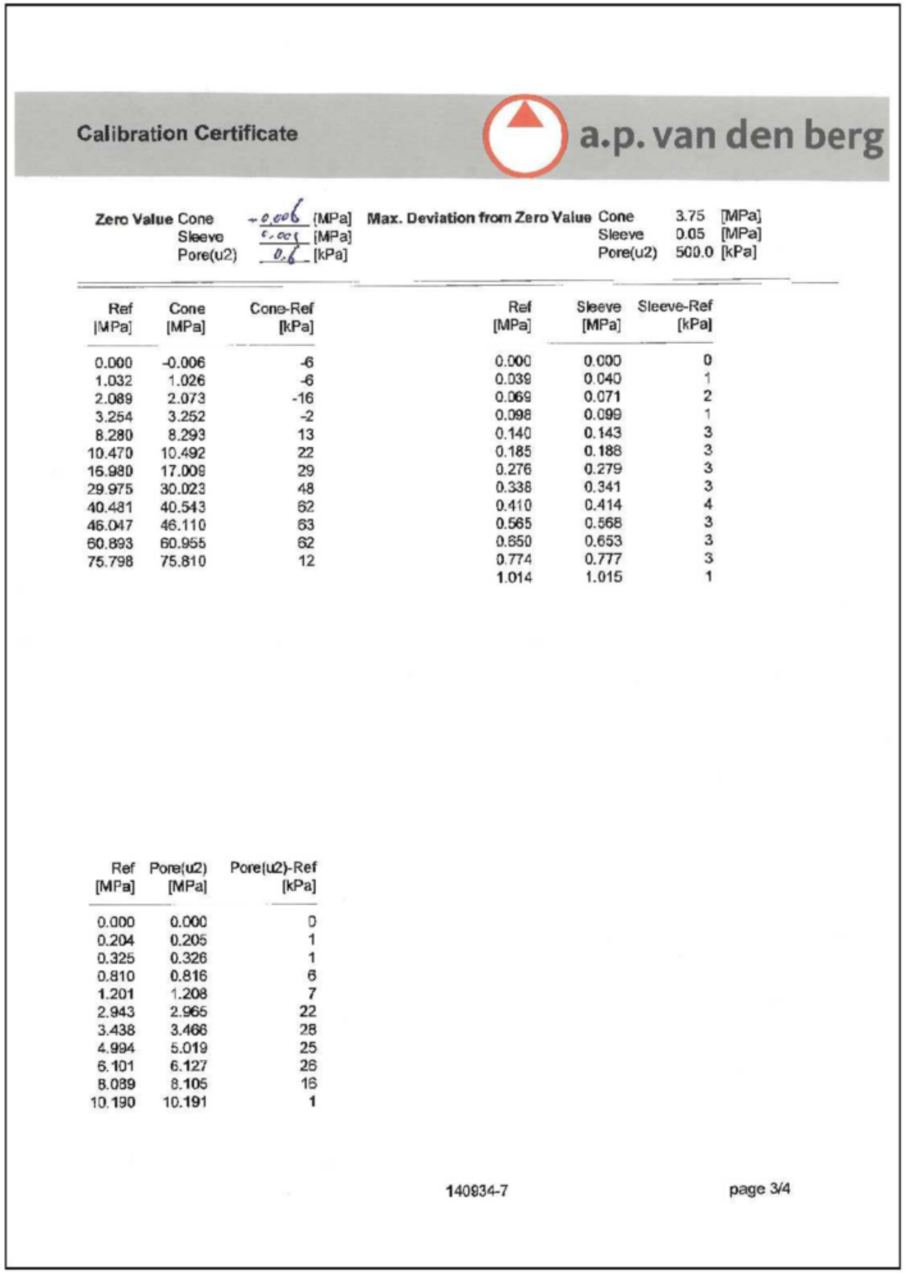
1.4 Result

The sensor complies to the above standard

Calibrated by:	C.J. Ouwejan
Date:	12/10/2018
Signature:	

QA Manager:	N.R.E. de Jong
Date:	12/10/2018
Signature:	

140934-7 page 1/4



Calibration Certificate

a.p. van den berg

Zero Value Cone -0,006 [MPa]
Sleeve 0,001 [MPa]
Pore(u2) 0,6 [kPa]

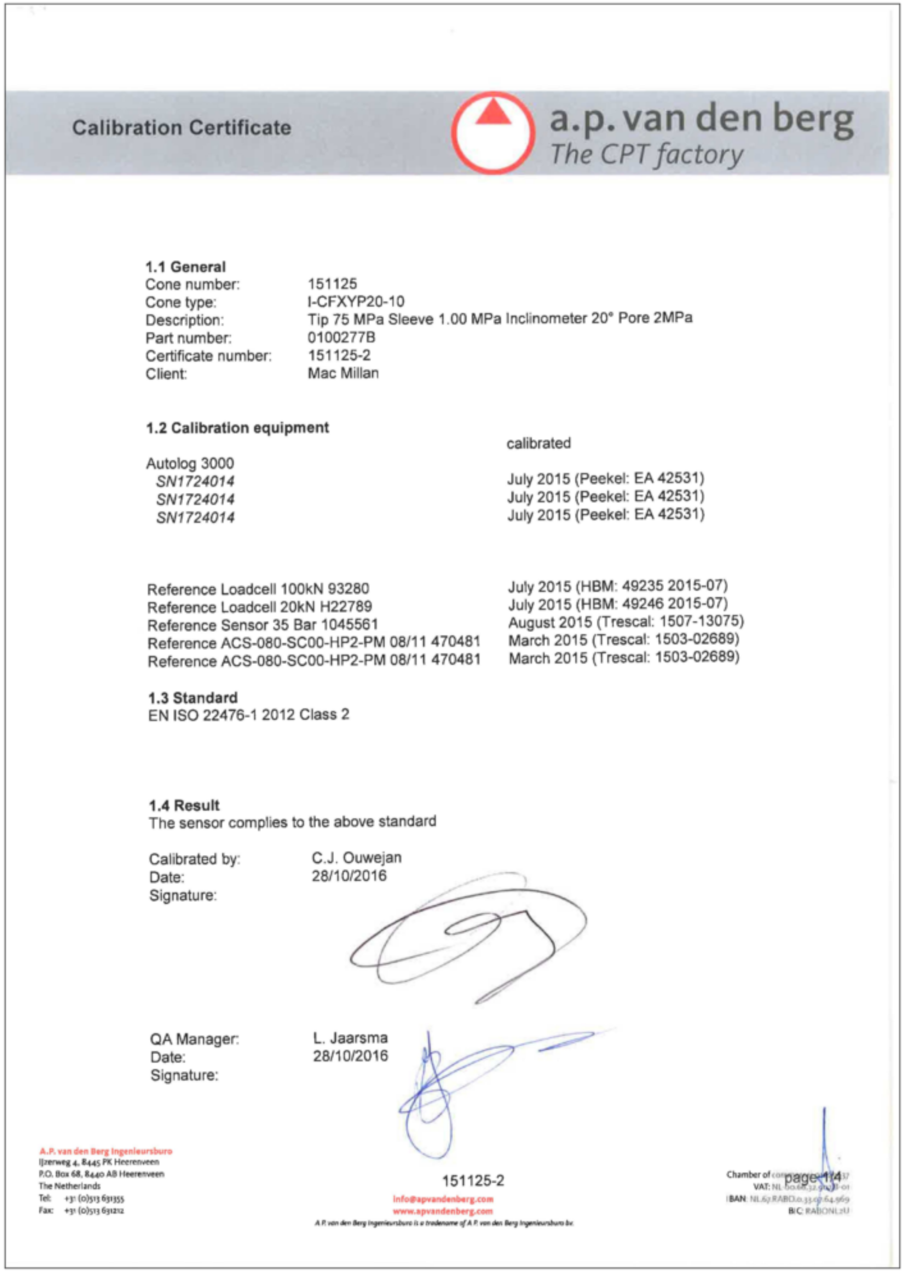
Max. Deviation from Zero Value Cone 3.75 [MPa]
Sleeve 0.05 [MPa]
Pore(u2) 500.0 [kPa]

Ref [MPa]	Cone [MPa]	Cone-Ref [kPa]
0.000	-0.006	-6
1.032	1.026	-6
2.089	2.073	-16
3.254	3.252	-2
8.280	8.293	13
10.470	10.492	22
16.980	17.009	29
29.975	30.023	48
40.481	40.543	62
46.047	46.110	63
60.893	60.955	62
75.798	75.810	12

Ref [MPa]	Sleeve [MPa]	Sleeve-Ref [kPa]
0.000	0.000	0
0.039	0.040	1
0.069	0.071	2
0.098	0.099	1
0.140	0.143	3
0.185	0.188	3
0.276	0.279	3
0.338	0.341	3
0.410	0.414	4
0.565	0.568	3
0.650	0.653	3
0.774	0.777	3
1.014	1.015	1

Ref [MPa]	Pore(u2) [MPa]	Pore(u2)-Ref [kPa]
0.000	0.000	0
0.204	0.205	1
0.325	0.326	1
0.810	0.816	6
1.201	1.208	7
2.943	2.965	22
3.438	3.466	28
4.994	5.019	25
6.101	6.127	26
8.089	8.105	16
10.190	10.191	1

140934-7 page 3/4



Calibration Certificate

a.p. van den berg
The CPT factory

1.1 General

Cone number:	151125
Cone type:	I-CFXYP20-10
Description:	Tip 75 MPa Sleeve 1.00 MPa Inclinometer 20° Pore 2MPa
Part number:	0100277B
Certificate number:	151125-2
Client:	Mac Millan

1.2 Calibration equipment

	calibrated
Autolog 3000	
SN1724014	July 2015 (Peekel: EA 42531)
SN1724014	July 2015 (Peekel: EA 42531)
SN1724014	July 2015 (Peekel: EA 42531)
Reference Loadcell 100kN 93280	July 2015 (HBM: 49235 2015-07)
Reference Loadcell 20kN H22789	July 2015 (HBM: 49246 2015-07)
Reference Sensor 35 Bar 1045561	August 2015 (Trescal: 1507-13075)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)

1.3 Standard

EN ISO 22476-1 2012 Class 2

1.4 Result

The sensor complies to the above standard

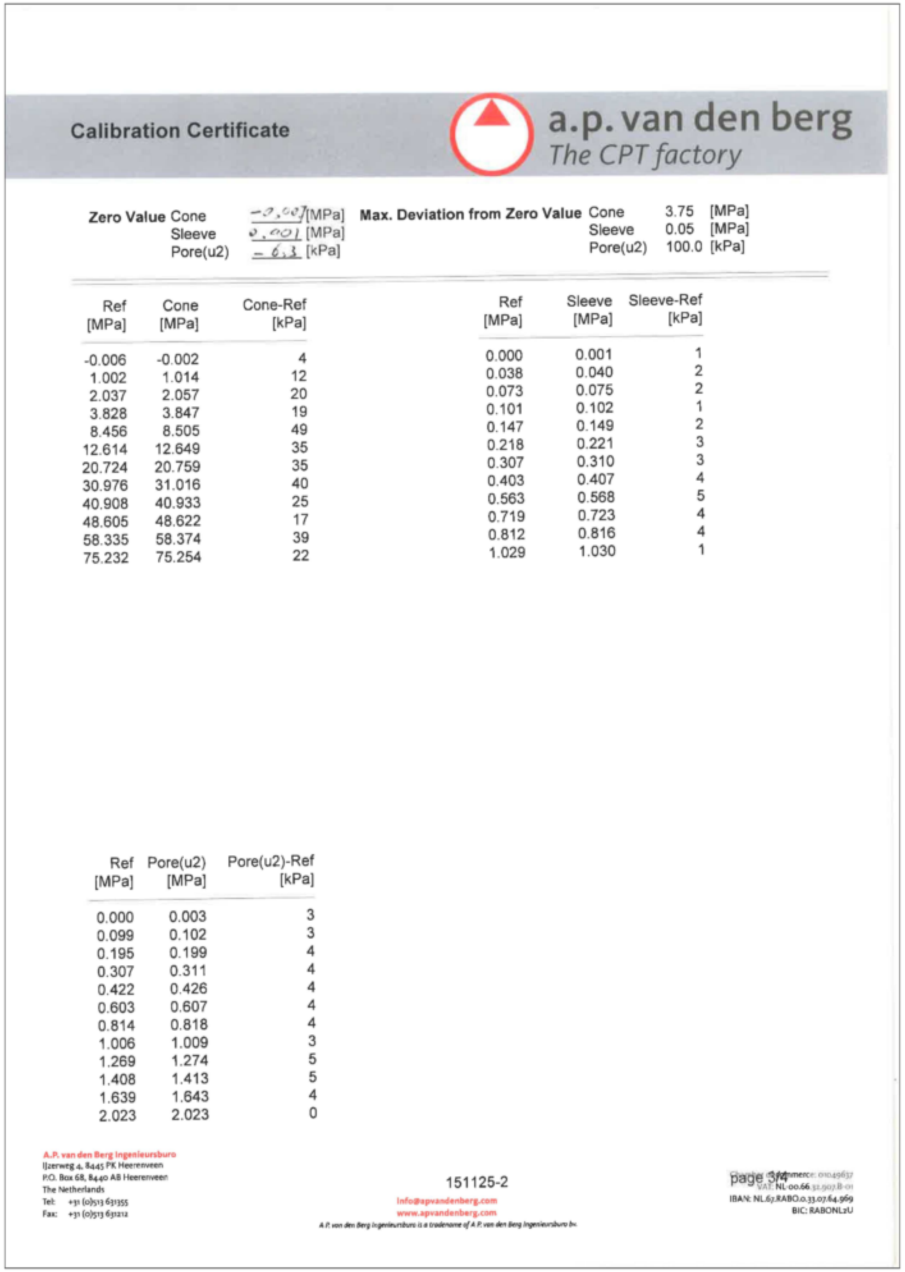
Calibrated by: C.J. Ouwejan
Date: 28/10/2016
Signature:

QA Manager: L. Jaarsma
Date: 28/10/2016
Signature:

A.P. van den Berg Ingenieursburo
IJzerweg 4, 8445 PK Heerenveen
P.O. Box 68, 8440 AB Heerenveen
The Netherlands
Tel: +31 (0)513 631355
Fax: +31 (0)513 631212

151125-2
info@apvandenberg.com
www.apvandenberg.com
A.P. van den Berg Ingenieursburo is a tradename of A.P. van den Berg Ingenieursburo bv.

Chamber of commerce: 01049637
VAT: NL-00.66.32.907.B-01
IBAN: NL.67.RABO.0.33.07.64.969
BIC: RABONL2U
page 1/4



Calibration Certificate

a.p. van den berg
The CPT factory

Zero Value Cone -0,007 [MPa]
Sleeve 0,001 [MPa]
Pore(u2) - 6,3 [kPa]

Max. Deviation from Zero Value Cone 3.75 [MPa]
Sleeve 0.05 [MPa]
Pore(u2) 100.0 [kPa]

Ref [MPa]	Cone [MPa]	Cone-Ref [kPa]
-0.006	-0.002	4
1.002	1.014	12
2.037	2.057	20
3.828	3.847	19
8.456	8.505	49
12.614	12.649	35
20.724	20.759	35
30.976	31.016	40
40.908	40.933	25
48.605	48.622	17
58.335	58.374	39
75.232	75.254	22

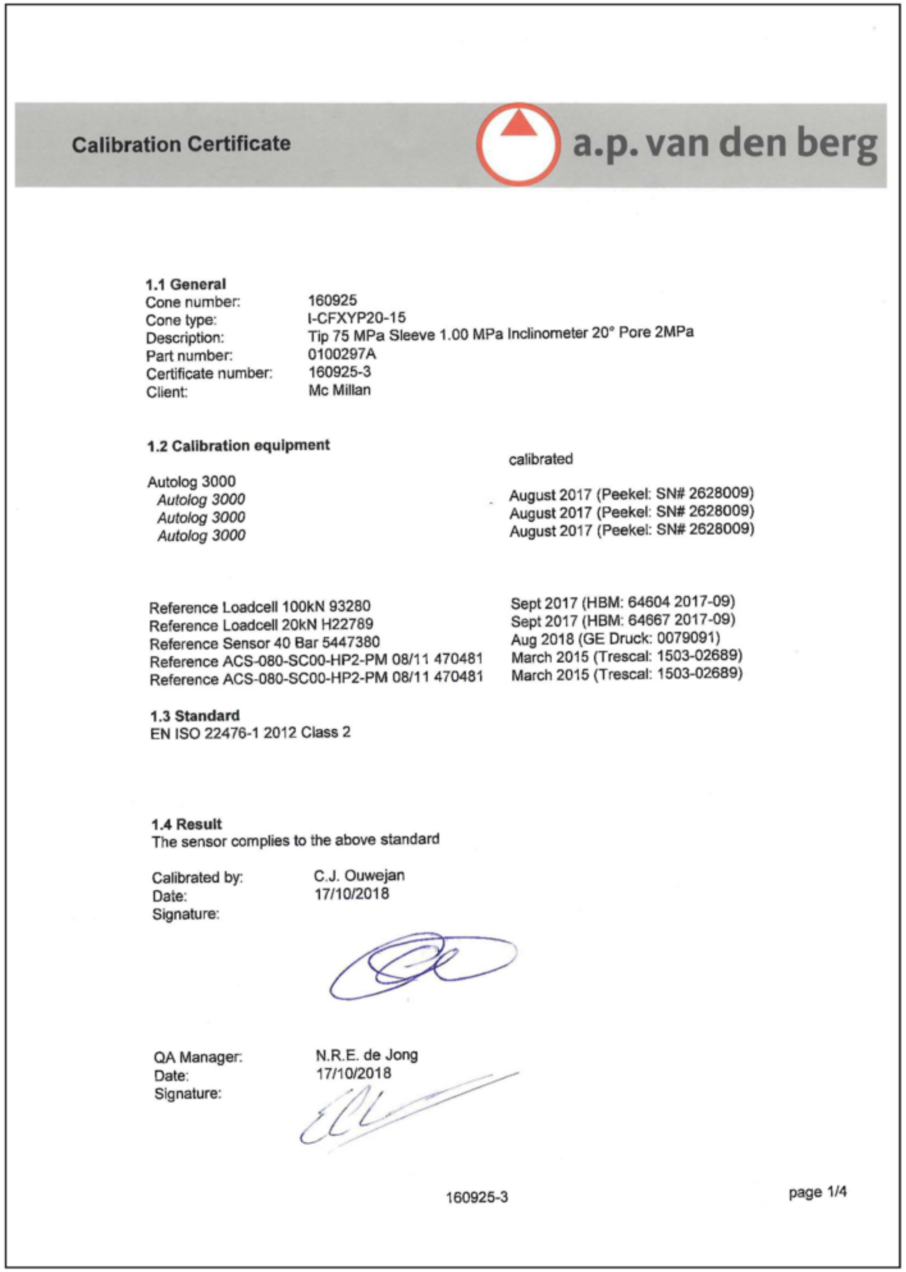
Ref [MPa]	Sleeve [MPa]	Sleeve-Ref [kPa]
0.000	0.001	1
0.038	0.040	2
0.073	0.075	2
0.101	0.102	1
0.147	0.149	2
0.218	0.221	3
0.307	0.310	3
0.403	0.407	4
0.563	0.568	5
0.719	0.723	4
0.812	0.816	4
1.029	1.030	1

Ref [MPa]	Pore(u2) [MPa]	Pore(u2)-Ref [kPa]
0.000	0.003	3
0.099	0.102	3
0.195	0.199	4
0.307	0.311	4
0.422	0.426	4
0.603	0.607	4
0.814	0.818	4
1.006	1.009	3
1.269	1.274	5
1.408	1.413	5
1.639	1.643	4
2.023	2.023	0

A.P. van den Berg Ingenieursburo
IJzerweg 4, 8445 PK Heerenveen
P.O. Box 68, 8440 AB Heerenveen
The Netherlands
Tel: +31 (0)513 631355
Fax: +31 (0)513 631212

151125-2
info@apvandenberg.com
www.apvandenberg.com
A.P. van den Berg Ingenieursburo is a tradename of A.P. van den Berg Ingenieursburo bv.

Chamber of commerce: 01049637
VAT: NL-00.66.32.907.B-01
IBAN: NL.67.RABO.0.33.07.64.969
BIC: RABONL2U
page 3/4



Calibration Certificate a.p. van den berg

1.1 General

Cone number: 160925
Cone type: I-CFXYP20-15
Description: Tip 75 MPa Sleeve 1.00 MPa Inclinometer 20° Pore 2MPa
Part number: 0100297A
Certificate number: 160925-3
Client: Mc Millan

1.2 Calibration equipment

	calibrated
Autolog 3000	
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Autolog 3000	August 2017 (Peekel: SN# 2628009)
Reference Loadcell 100kN 93280	Sept 2017 (HBM: 64604 2017-09)
Reference Loadcell 20kN H22789	Sept 2017 (HBM: 64667 2017-09)
Reference Sensor 40 Bar 5447380	Aug 2018 (GE Druck: 0079091)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)
Reference ACS-080-SC00-HP2-PM 08/11 470481	March 2015 (Trescal: 1503-02689)

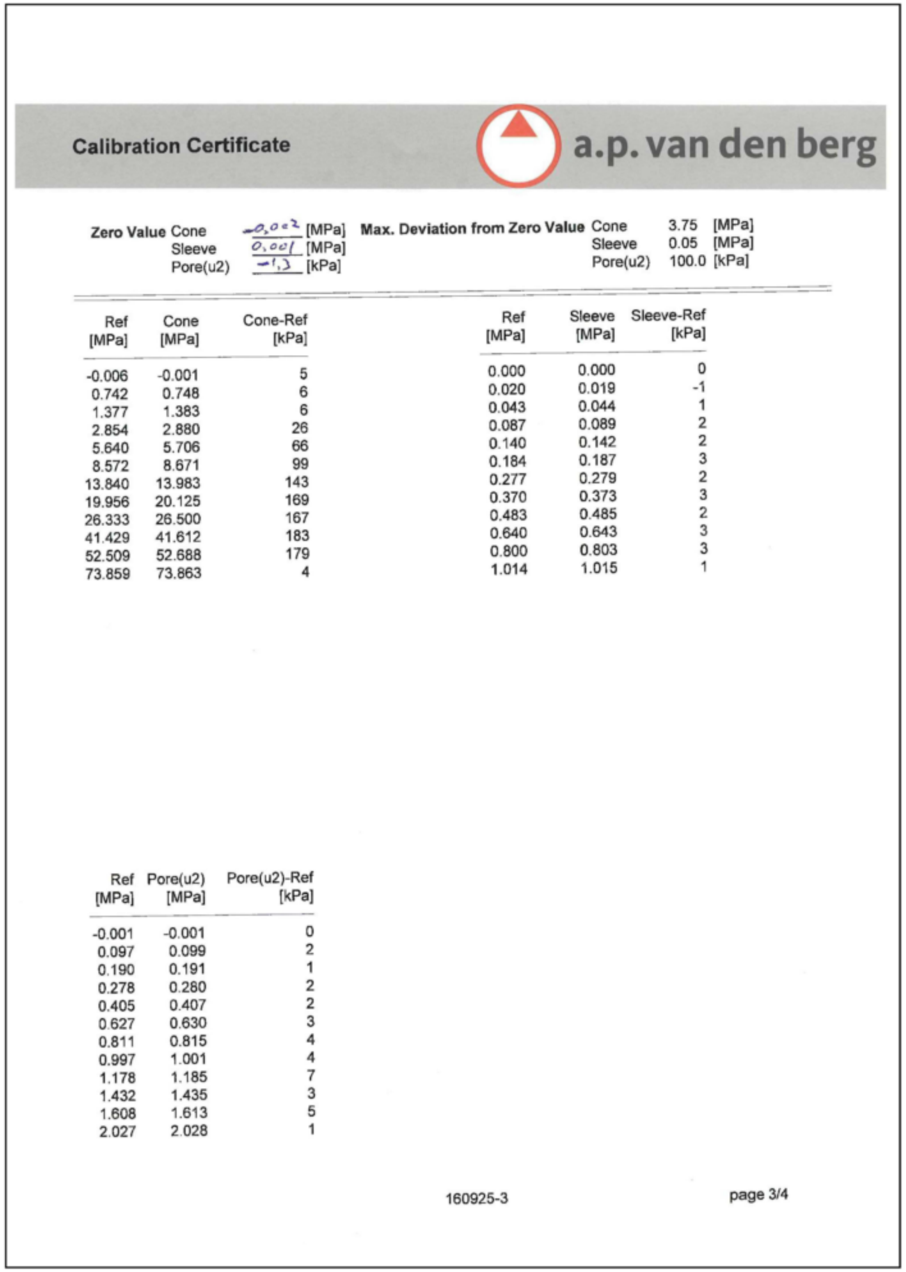
1.3 Standard
EN ISO 22476-1 2012 Class 2

1.4 Result
The sensor complies to the above standard

Calibrated by: C.J. Ouwejan
Date: 17/10/2018
Signature:

QA Manager: N.R.E. de Jong
Date: 17/10/2018
Signature:

160925-3 page 1/4



Calibration Certificate a.p. van den berg

Zero Value Cone -0,002 [MPa]
Sleeve 0,001 [MPa]
Pore(u2) -1,3 [kPa]

Max. Deviation from Zero Value Cone 3.75 [MPa]
Sleeve 0.05 [MPa]
Pore(u2) 100.0 [kPa]

Ref [MPa]	Cone [MPa]	Cone-Ref [kPa]
-0.006	-0.001	5
0.742	0.748	6
1.377	1.383	6
2.854	2.880	26
5.640	5.706	66
8.572	8.671	99
13.840	13.983	143
19.956	20.125	169
26.333	26.500	167
41.429	41.612	183
52.509	52.688	179
73.859	73.863	4

Ref [MPa]	Sleeve [MPa]	Sleeve-Ref [kPa]
0.000	0.000	0
0.020	0.019	-1
0.043	0.044	1
0.087	0.089	2
0.140	0.142	2
0.184	0.187	3
0.277	0.279	2
0.370	0.373	3
0.483	0.485	2
0.640	0.643	3
0.800	0.803	3
1.014	1.015	1

Ref [MPa]	Pore(u2) [MPa]	Pore(u2)-Ref [kPa]
-0.001	-0.001	0
0.097	0.099	2
0.190	0.191	1
0.278	0.280	2
0.405	0.407	2
0.627	0.630	3
0.811	0.815	4
0.997	1.001	4
1.178	1.185	7
1.432	1.435	3
1.608	1.613	5
2.027	2.028	1

160925-3 page 3/4

Appendix C

Liquefaction Assessment Summary

Client Westpark
Project Inch Land - Kippenberger Ave. Rangiora
Subject Liquefaction Assessment Summary

Date 29/07/2019
Job Numbe 506685
By F. Monteith

	CPT	SLSa M = 7.5 PGA = 0.13g			SLSb M = 6.0 PGA = 0.19g			ULS M = 7.5 PGA = 0.35g		
		Total Settlement (mm)	LSN	Liq Layers	Total Settlement (mm)	LSN	Liq Layers	Total Settlement (mm)	LSN	Liq Layers
Northern Block	CPT1	0	0	-	0	0	-	0	0	-
	CPT2	0	0	-	0	0	-	0	0	-
	CPT3	0	0	-	0	0	-	0	0	-
	CPT4	0	0	-	0	0	-	0	0	-
	CPT5	0	0	-	0	0	-	12	3	4.2-4.5 4.7-5.0
	CPT6	0	0	-	0	0	-	0	0	-
	CPT7	0	0	-	0	0	-	0	0	-
	CPT8	0	0	-	0	0	-	4	1	4.4-4.7 5.4-5.5
	CPT9	0	0	-	1	0	4.6-4.7	6	1	4.5-4.8
	CPT10	0	0	-	0	0	-	0	0	-
	CPT11	0	0	-	0	0	-	0	0	-
	CPT12	0	0	-	0	0	-	0	0	-
	CPT13	0	0	-	0	0	-	0	0	-
Southern Block	CPT14	10	5	1.8-2.1 3.3-3.5	28	14	1.6-2.2 3.1 3.5	58	30	1.0-2.5 2.8-3.5
	CPT15	20	4	4.1-5.5	28	7	1.8-1.9 4.1 5.5	43	12	1.8-3.1 4.1-5.5
	CPT16	7	1	4.8-5.1	8	2	4.8-5.2	11	2	4.8-5.3
	CPT17	16	5	2.3-3.1 5.0-5.2	23	8	2.2-3.1 5.0 5.2	34	15	1.1-3.1 5.0-5.2
	CPT18	6	2	3.3-3.4 3.8-4.0	7	2	3.3-3.4 3.8 4.0	8	2	3.3-3.4 3.8-4.0
	CPT19	21	5	2.5-2.6 4.7-5.5	26	7	1.5-1.6 2.1, 2.6 4.7-5.5	30	9	1.4-1.6 2.1, 2.6 4.7-5.5
	CPT20	2	1	2.4-2.5 4.4-4.5	4	1	2.4-2.5 4.2 4.5	7	2	2.4-2.5 4.2-4.5
	CPT21	16	5	2.5-3.0 4.1-4.2 5.5-5.6	19	7	1.2-1.3 2.5 3.0 4.1-4.2 5.5-5.6	23	8	1.2-1.3 2.5-3.0 4.1-4.2 5.5-5.8
	CPT22	2	1	4.1-4.3	5	2	1.3-1.4 4.1 4.3	10	4	1.3-1.5 4.1-4.4
	CPT23	2	1	1.8-1.9 3.6-3.7	4	2	1.8-1.9 3.6 3.7	6	2	1.8-1.9 3.6-3.8
	CPT24	0	0	-	1	0	3.8-3.9	2	1	1.1-1.4 3.8-3.9

Document prepared by

Aurecon New Zealand Limited
Level 2, Iwikau Building
93 Cambridge Terrace
Christchurch 8013
New Zealand

T +64 3 366 0821
F +64 3 379 6955
E christchurch@aurecongroup.com
W aurecongroup.com

Bringing ideas to life

Aurecon offices are located in:
Angola, Australia, Botswana, China,
Ghana, Hong Kong, Indonesia, Kenya,
Lesotho, Macau, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.