A1 Birtley to Coal House

Scheme Number: TR010031

6.3 Environmental Statement – Appendix 9.2d Ground Investigation Factual Report

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

August 2019

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedures) Regulations 2009

A1 Birtley to Coal House

Development Consent Order 20[xx]

Environmental Statement - Appendix

Regulation Reference:	APFP Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010031
Application Document Reference	TR010031/APP/6.3
Author:	A1 Birtley to Coal House Project Team, Highways England

Version	Date	Status of Version
Rev 0	14 August 2019	Application Issue

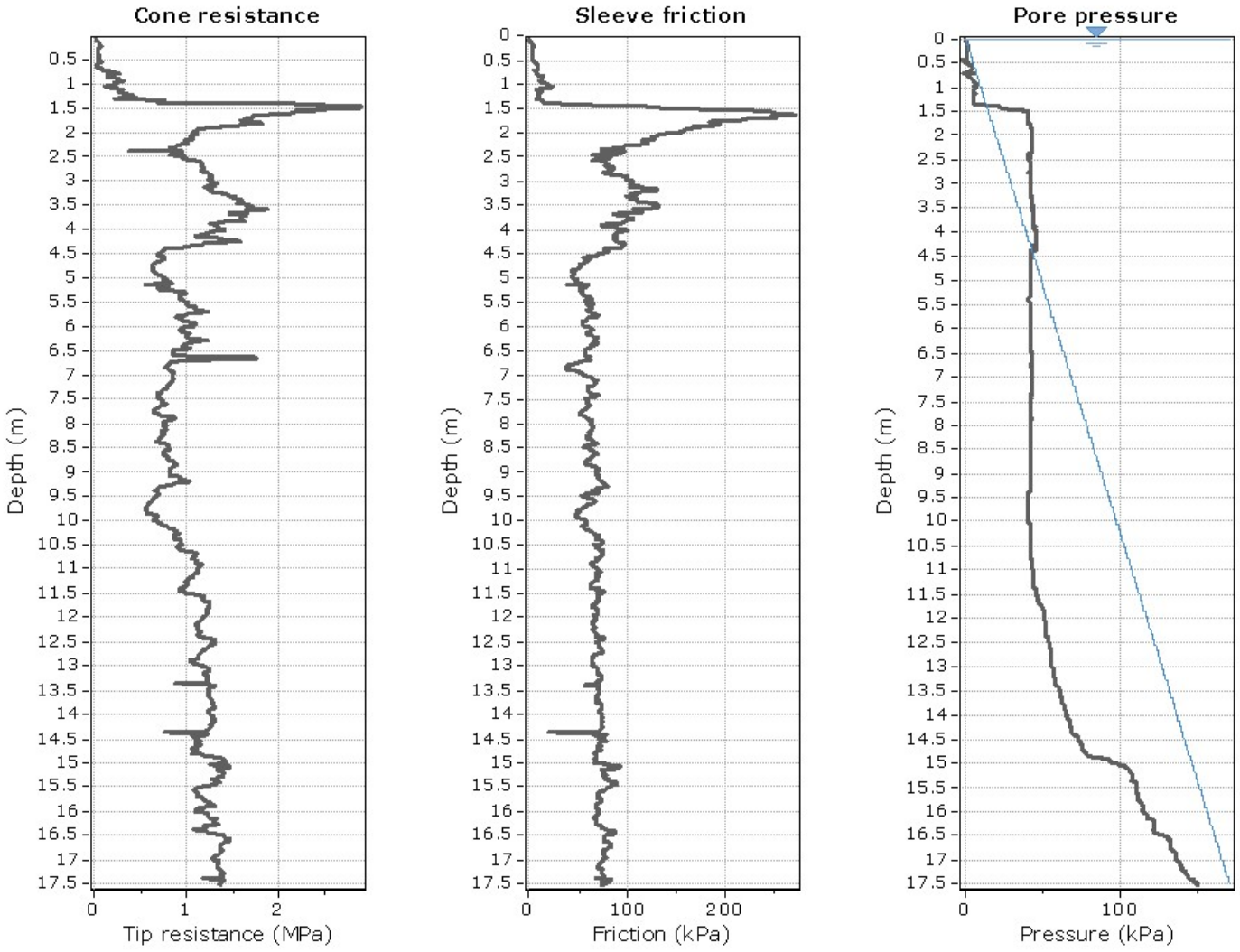
APPENDIX C
CPT REPORTS

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

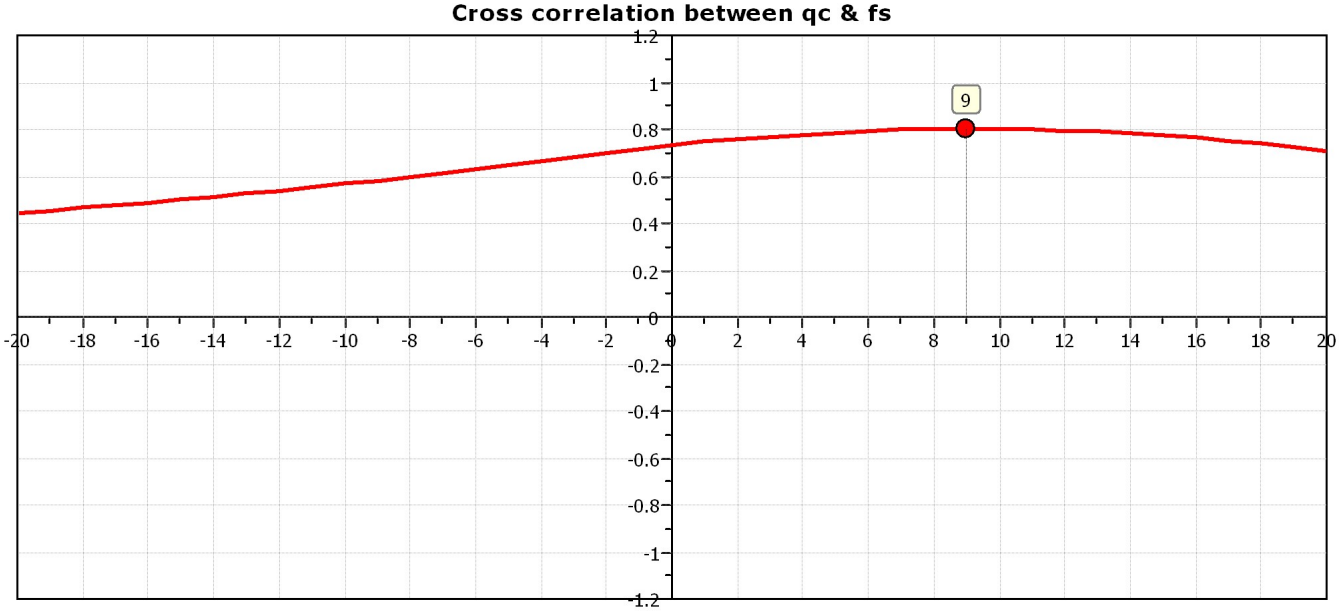
CPT: CPT17-01

Project: **CA3043**
Location: **A1B2CH**

Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

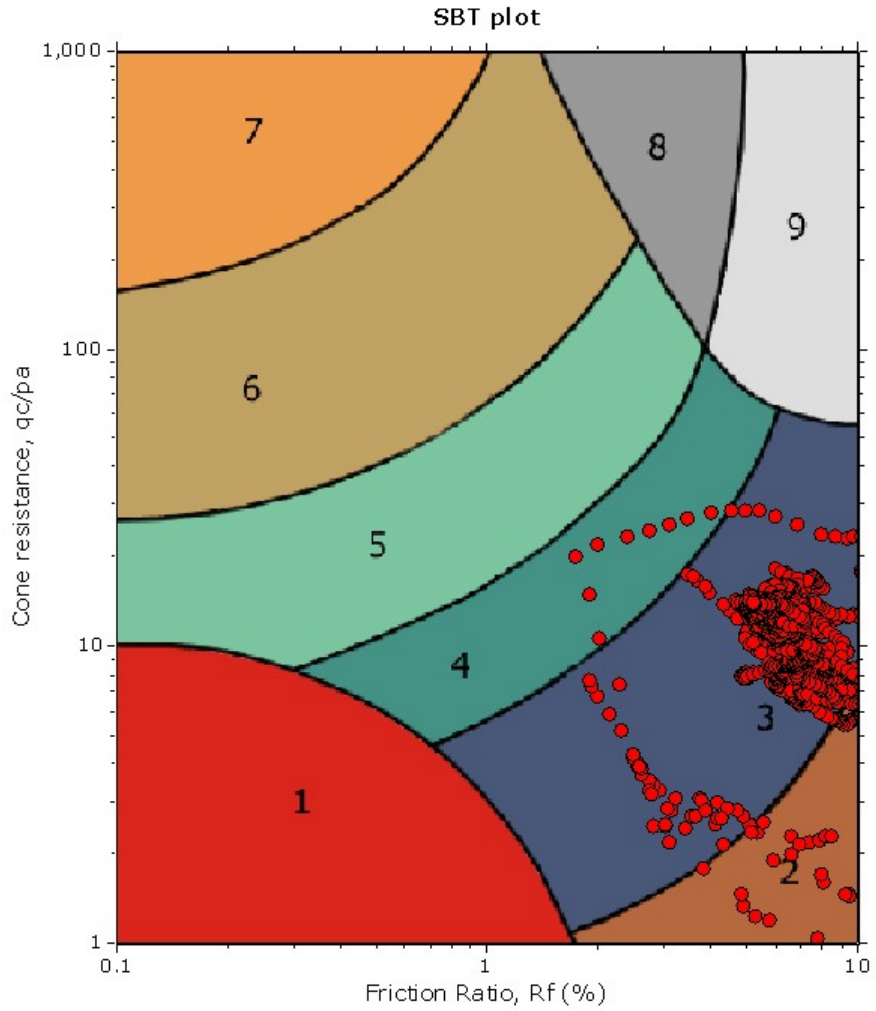


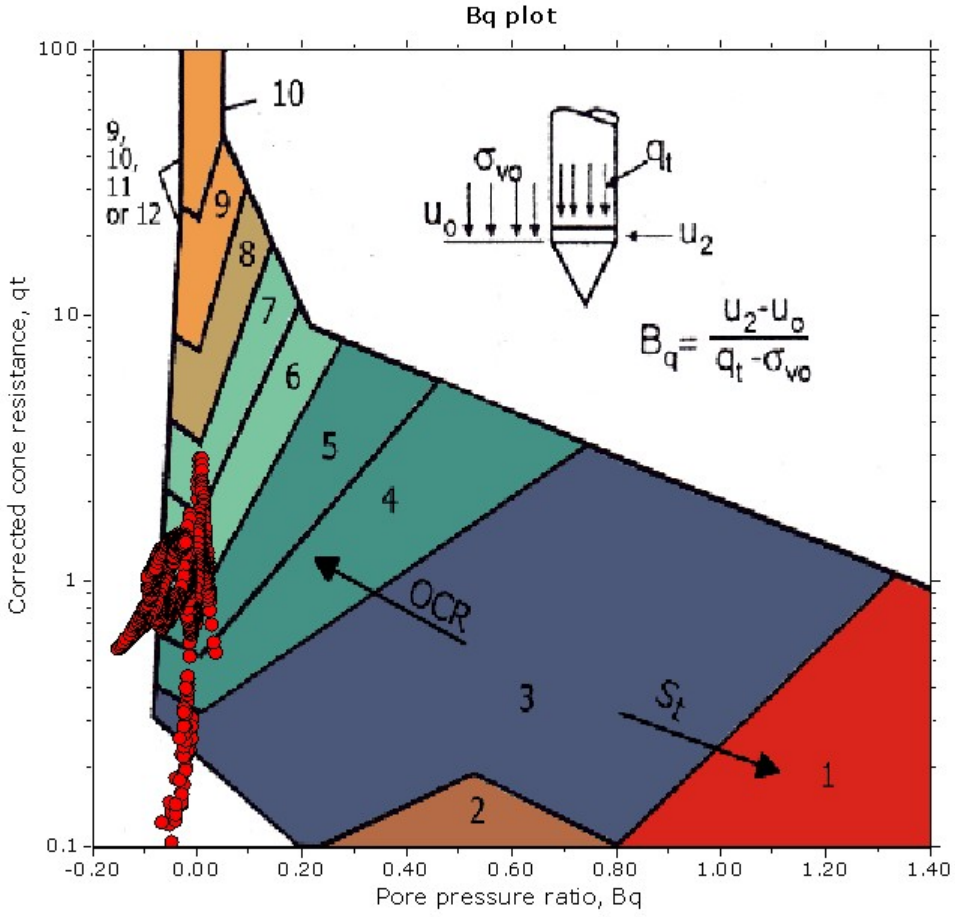
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

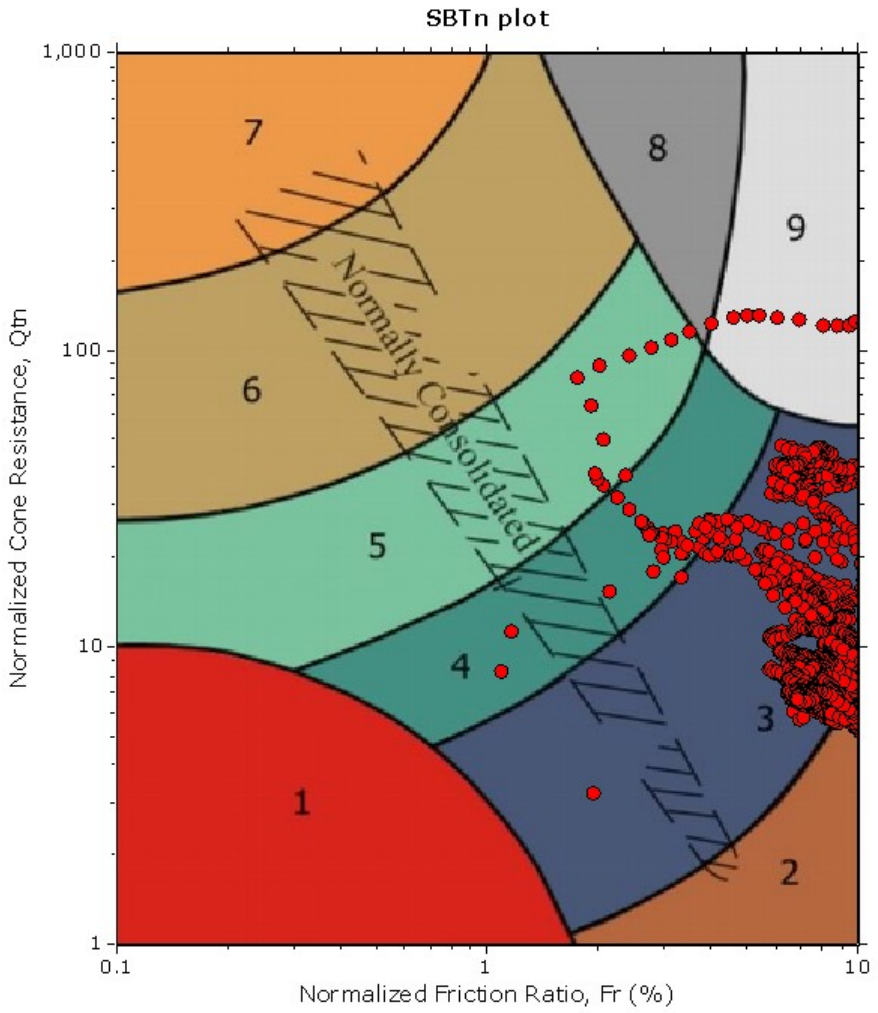
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

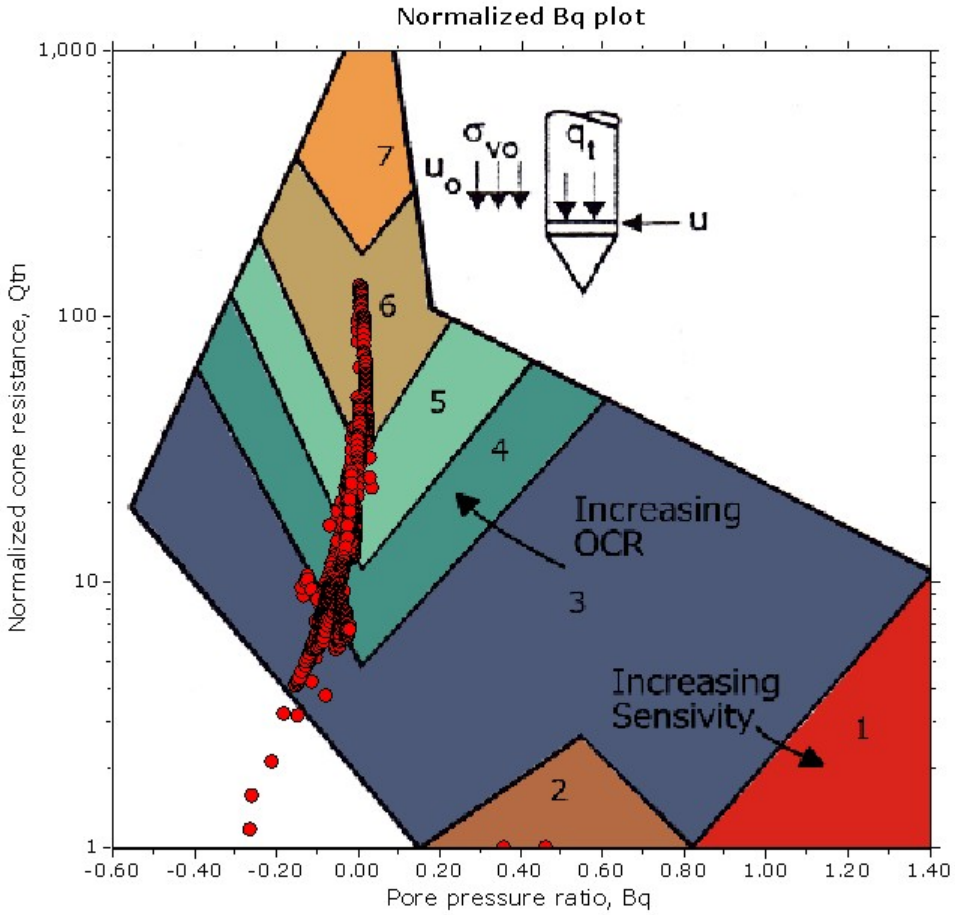
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

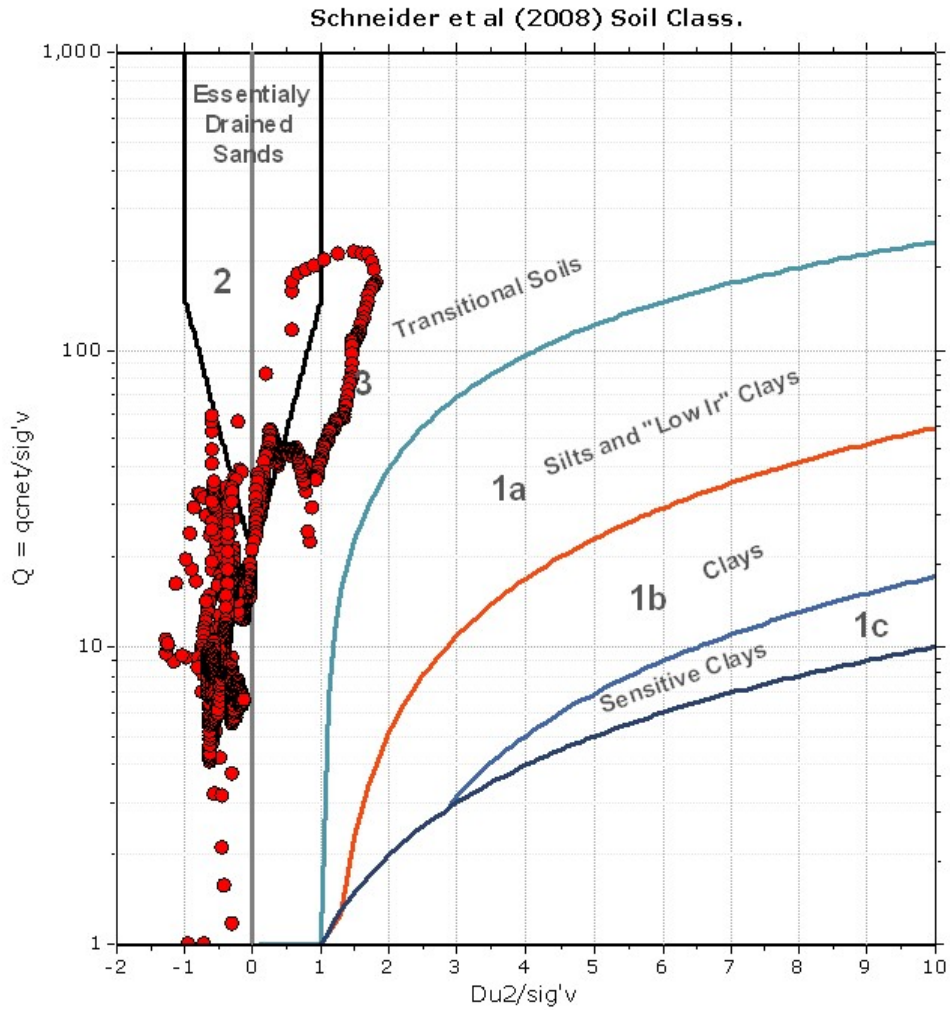
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

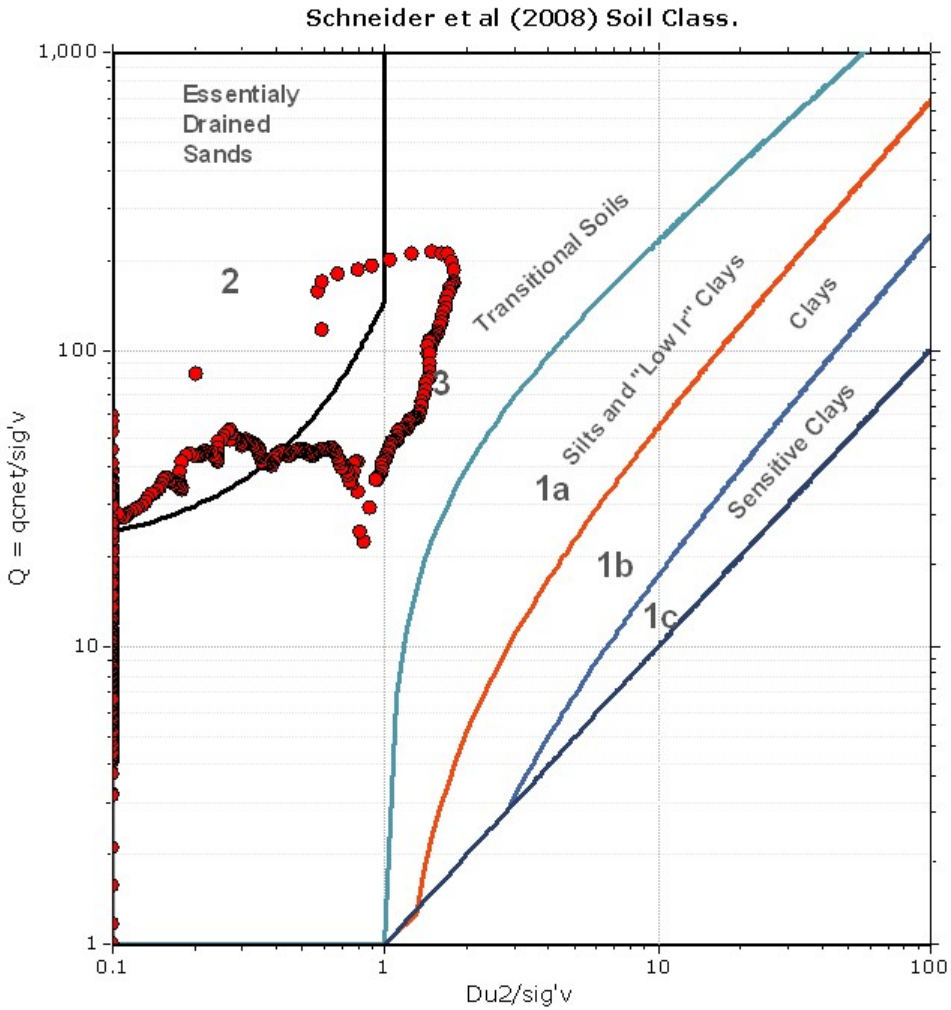
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



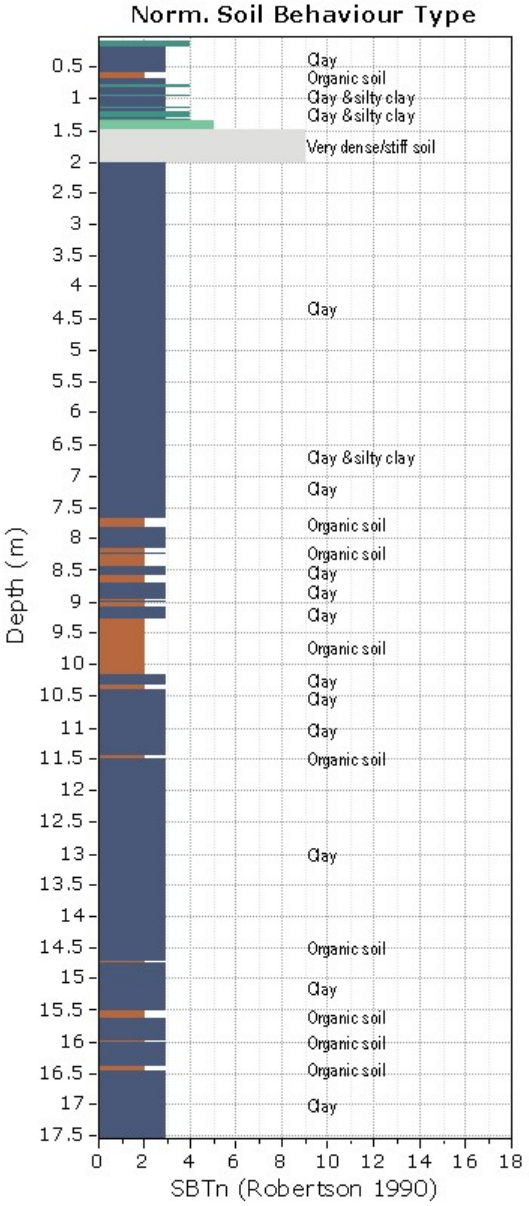


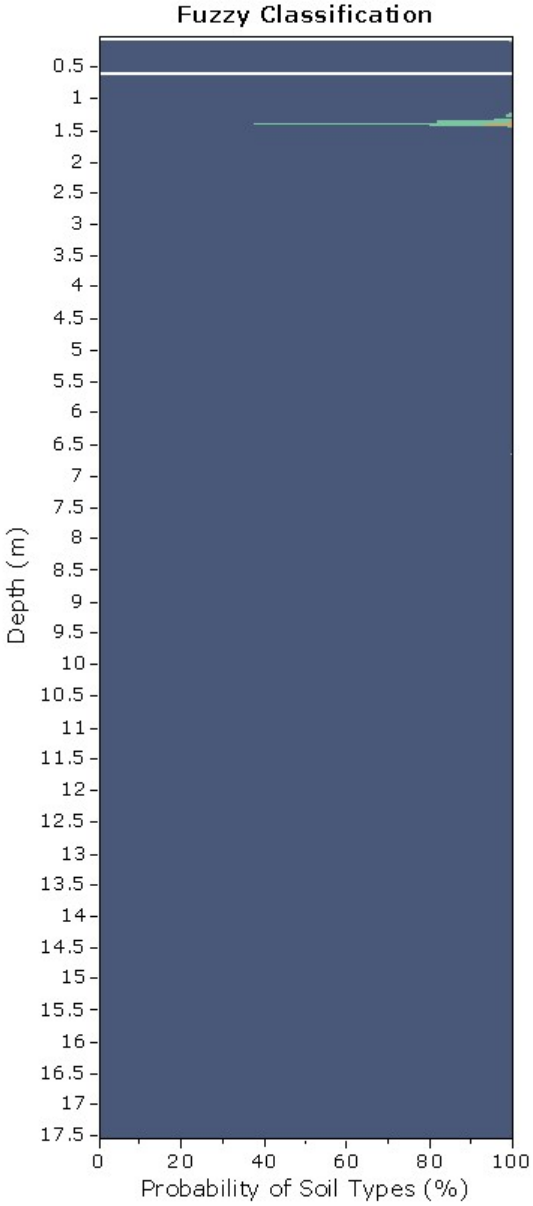
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-01

Project: **CA3043**
Location: **A1B2CH**

Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

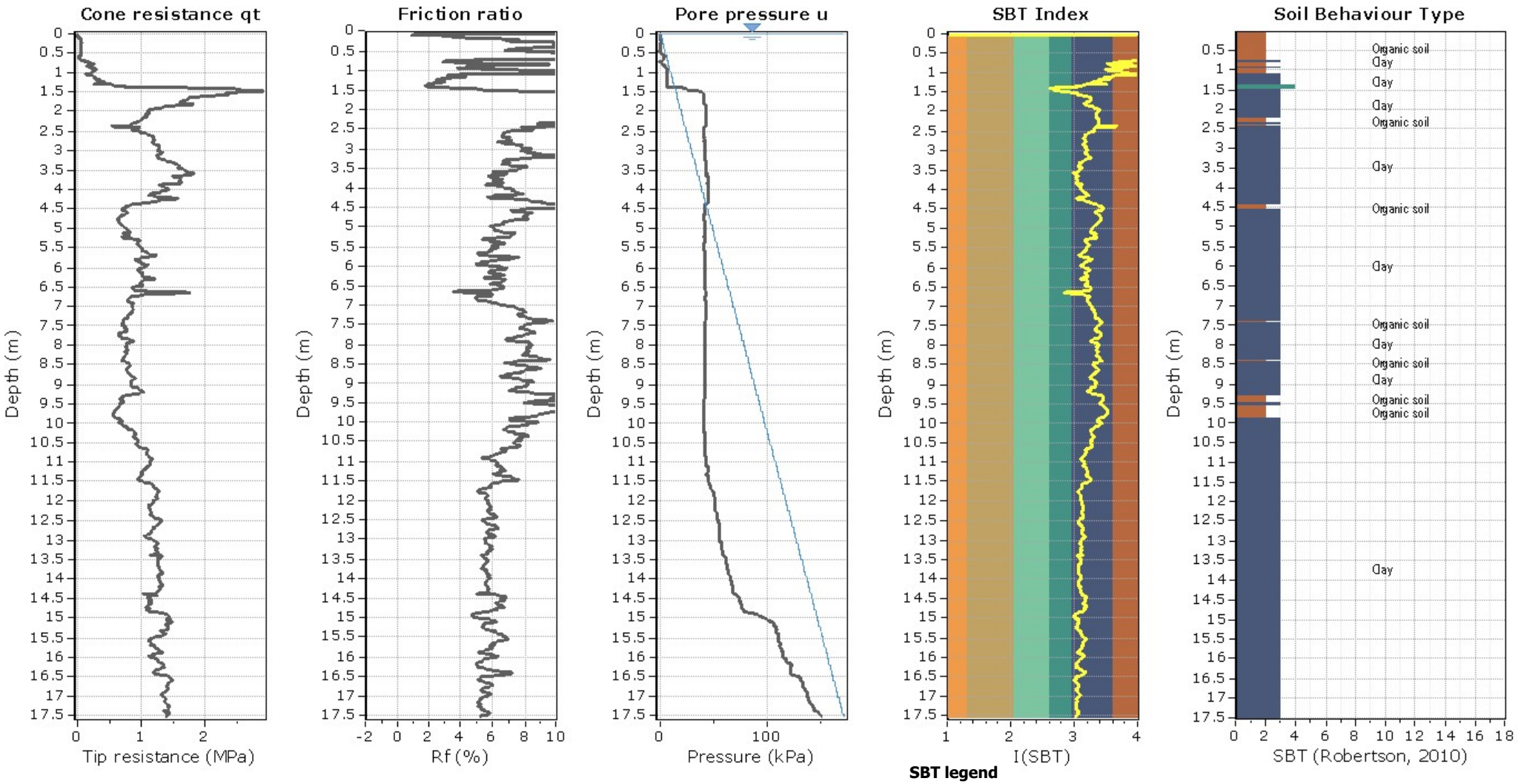




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

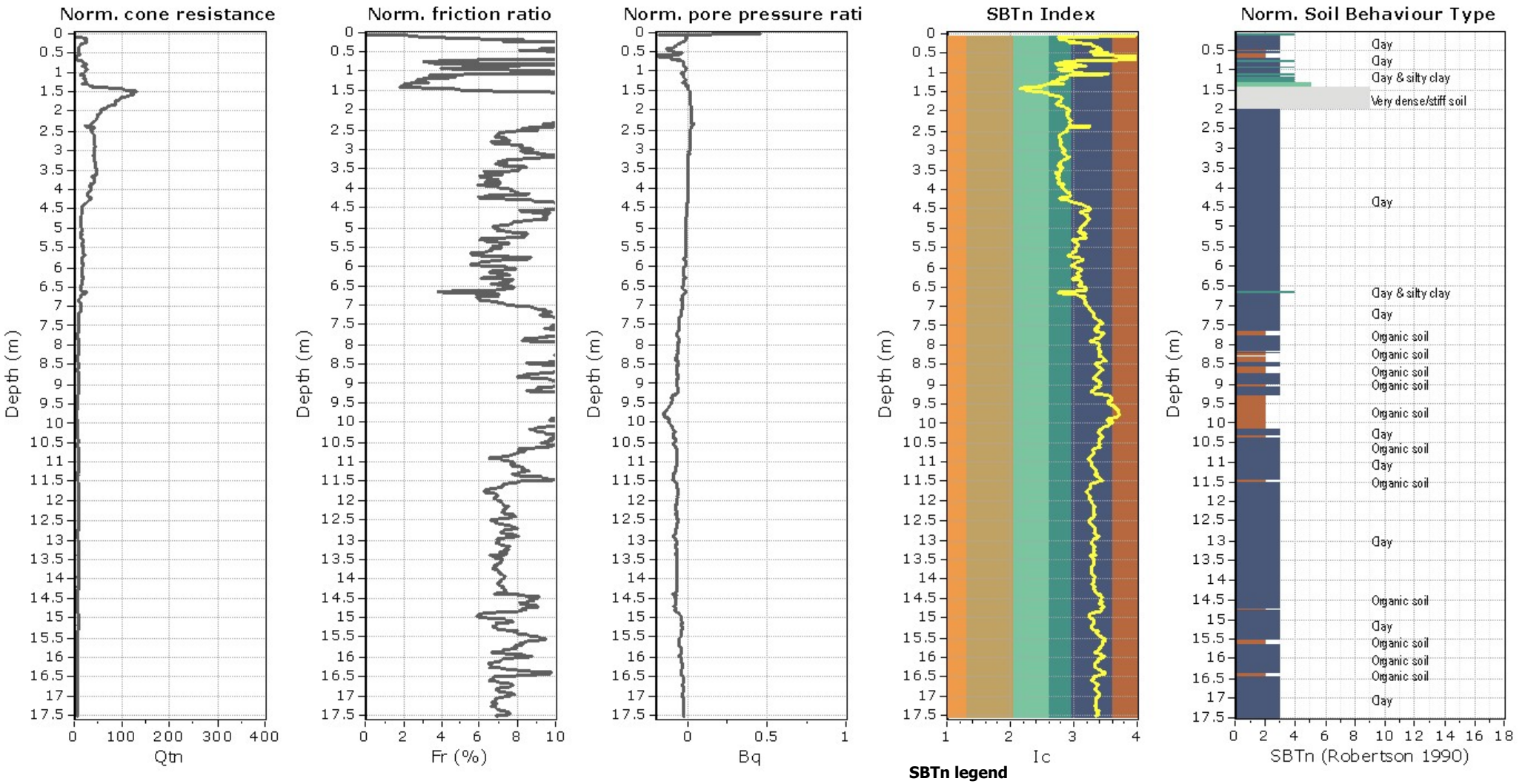
CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

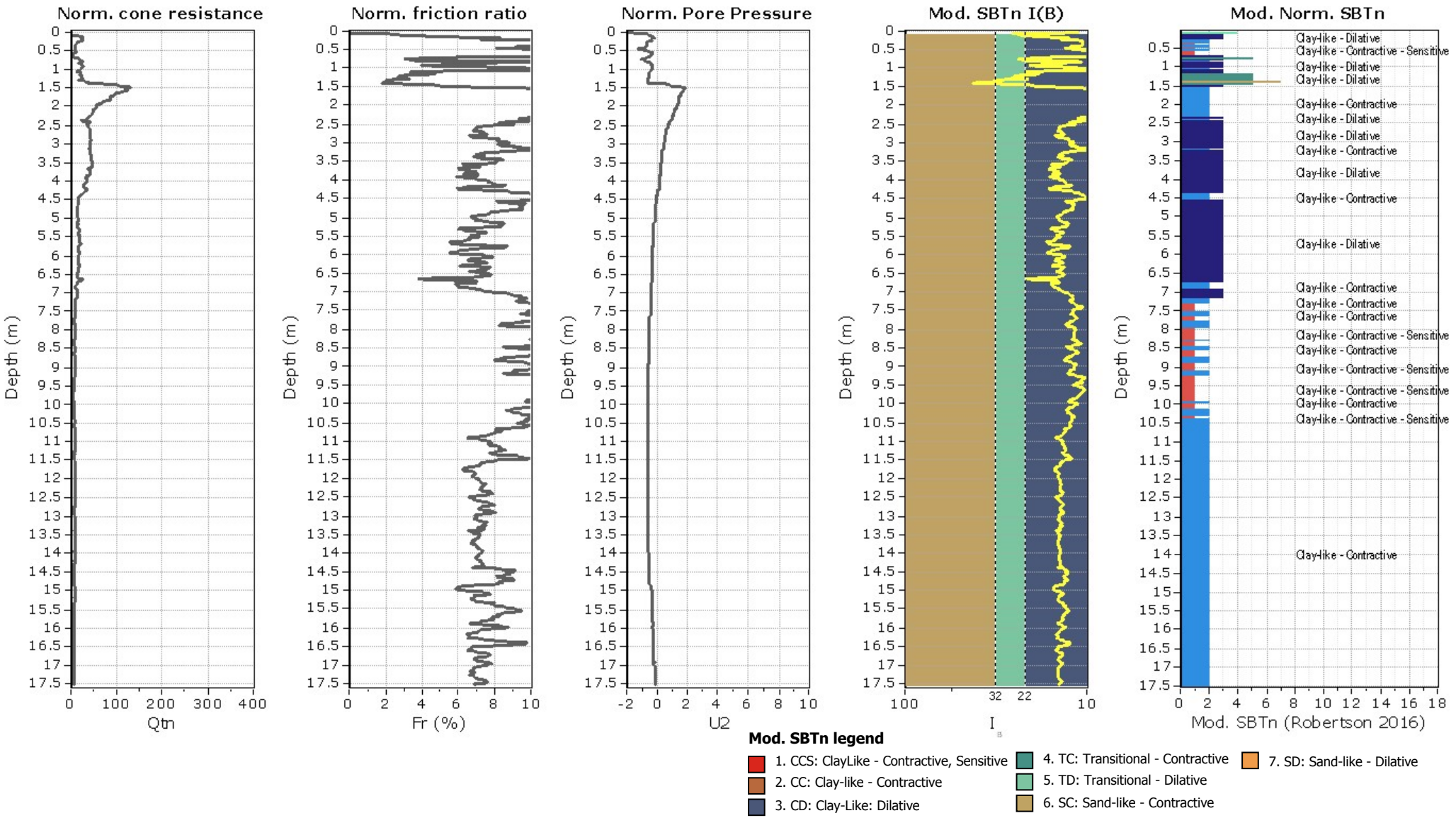
CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

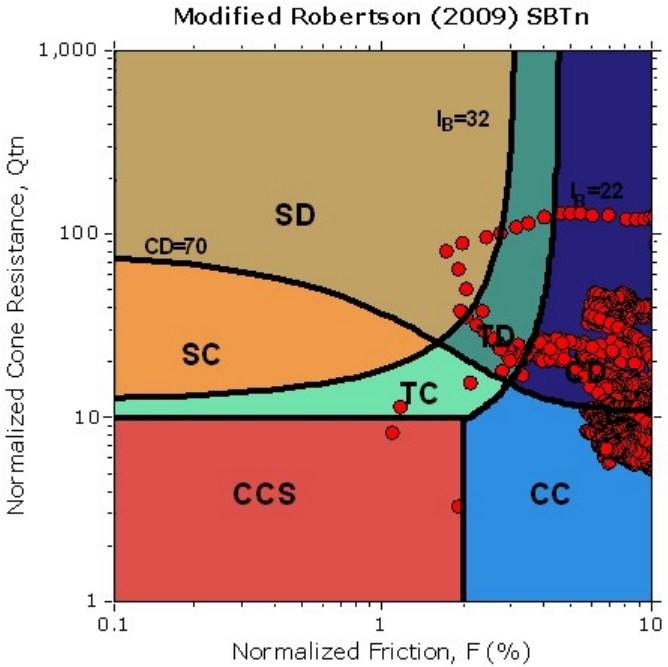


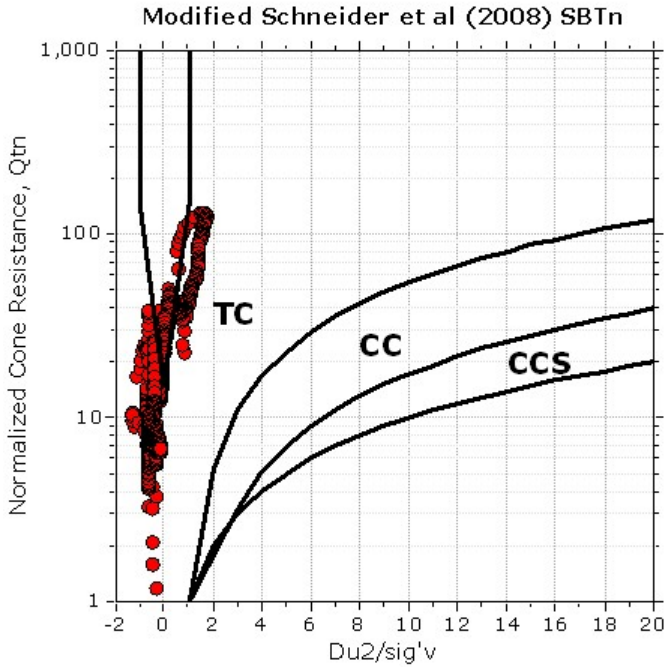
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

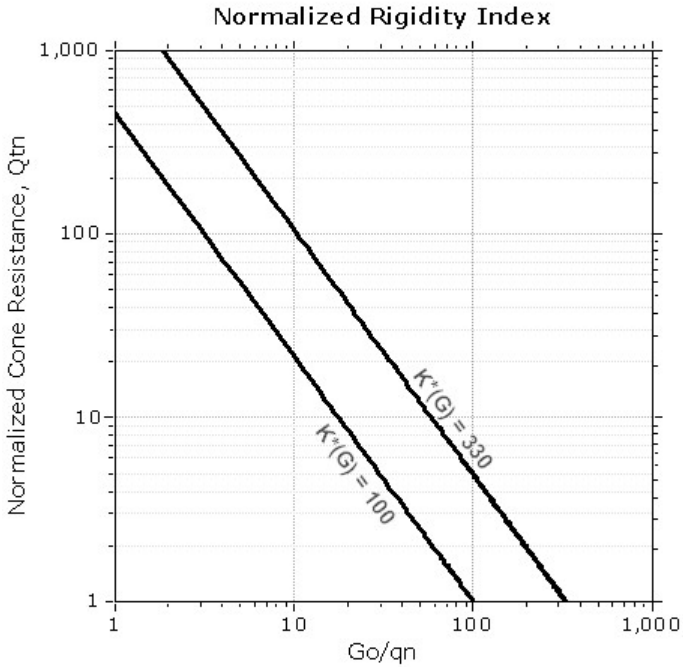
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







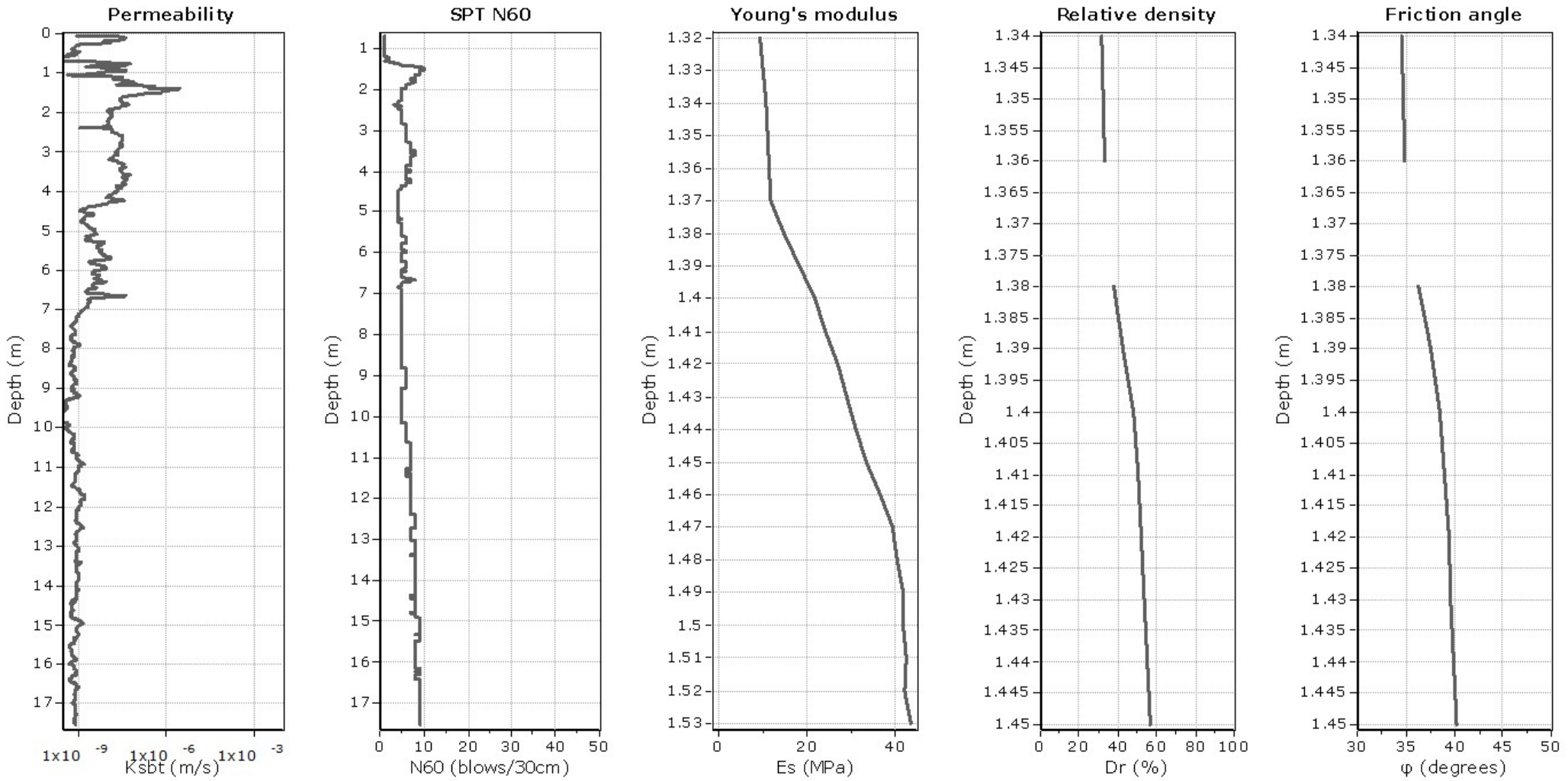
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



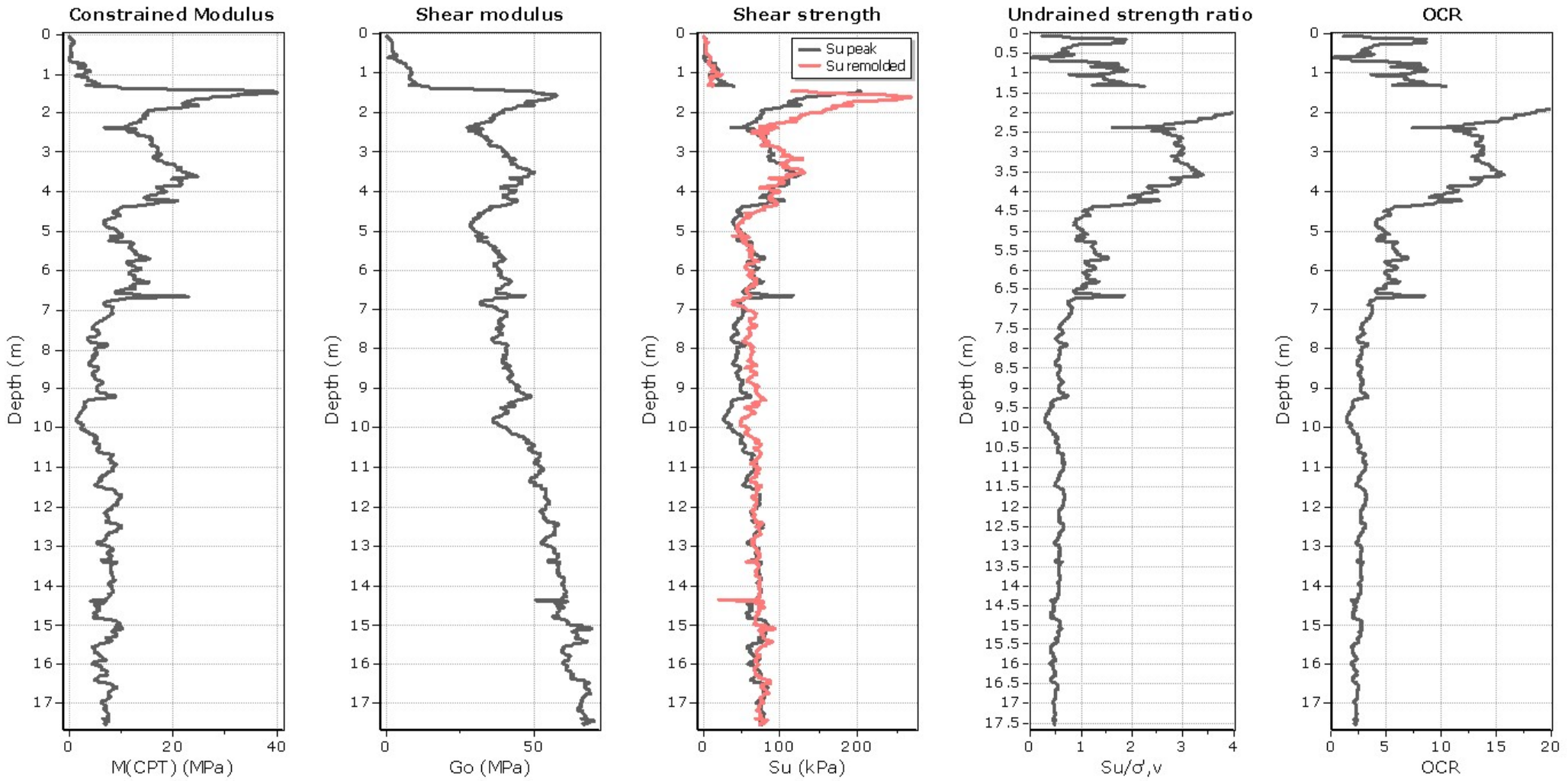
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



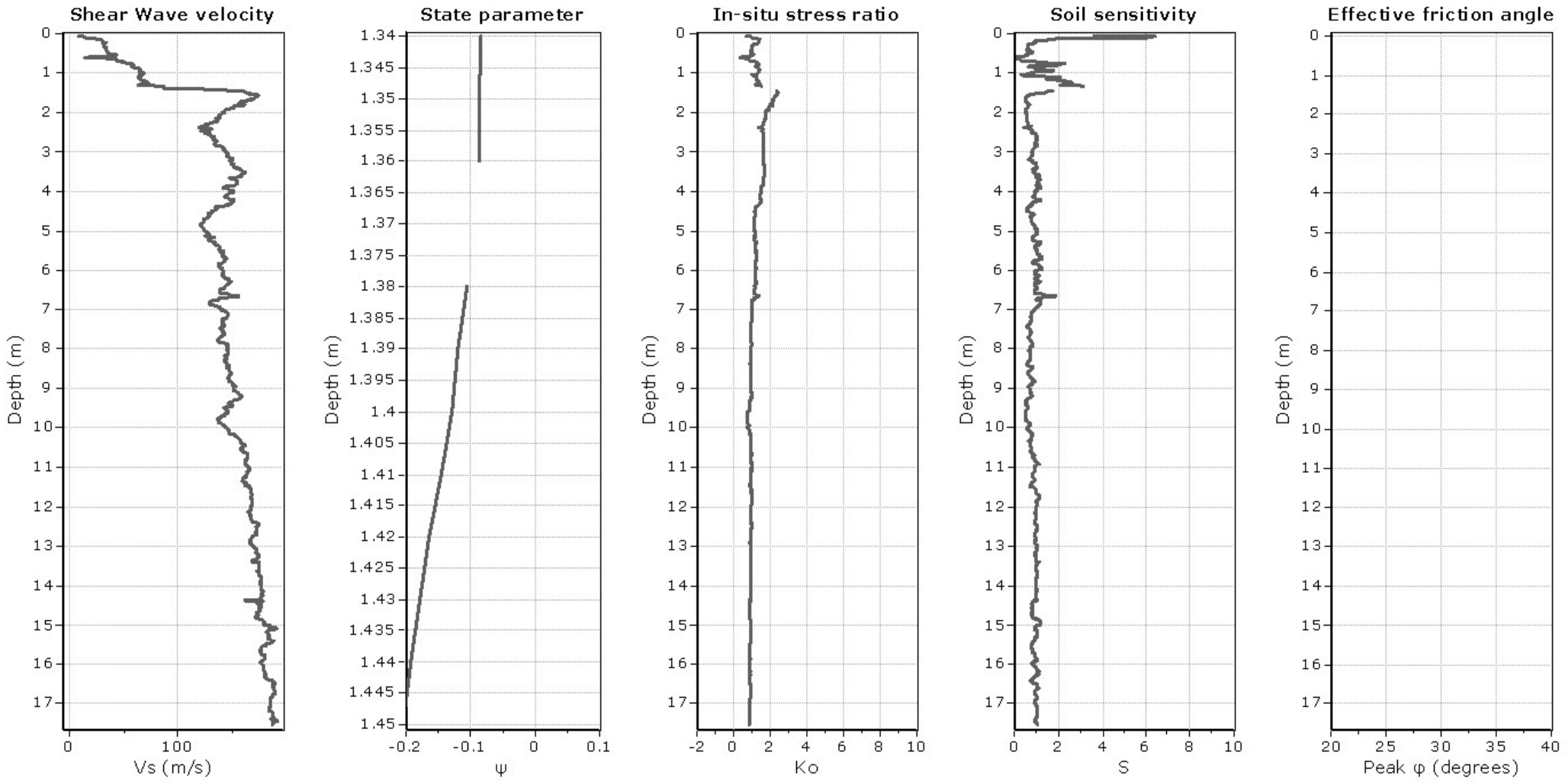
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01
Total depth: 17.53 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

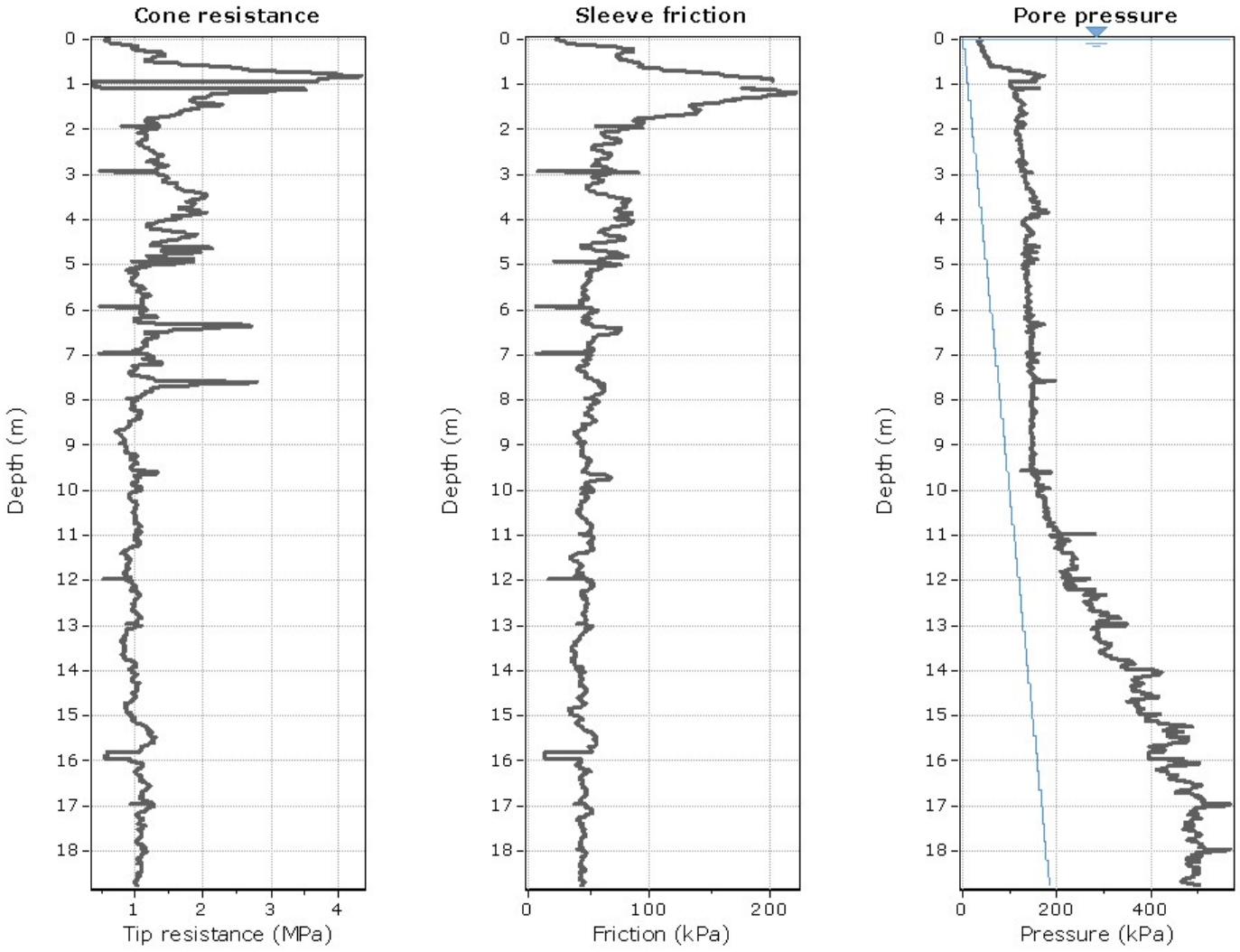
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

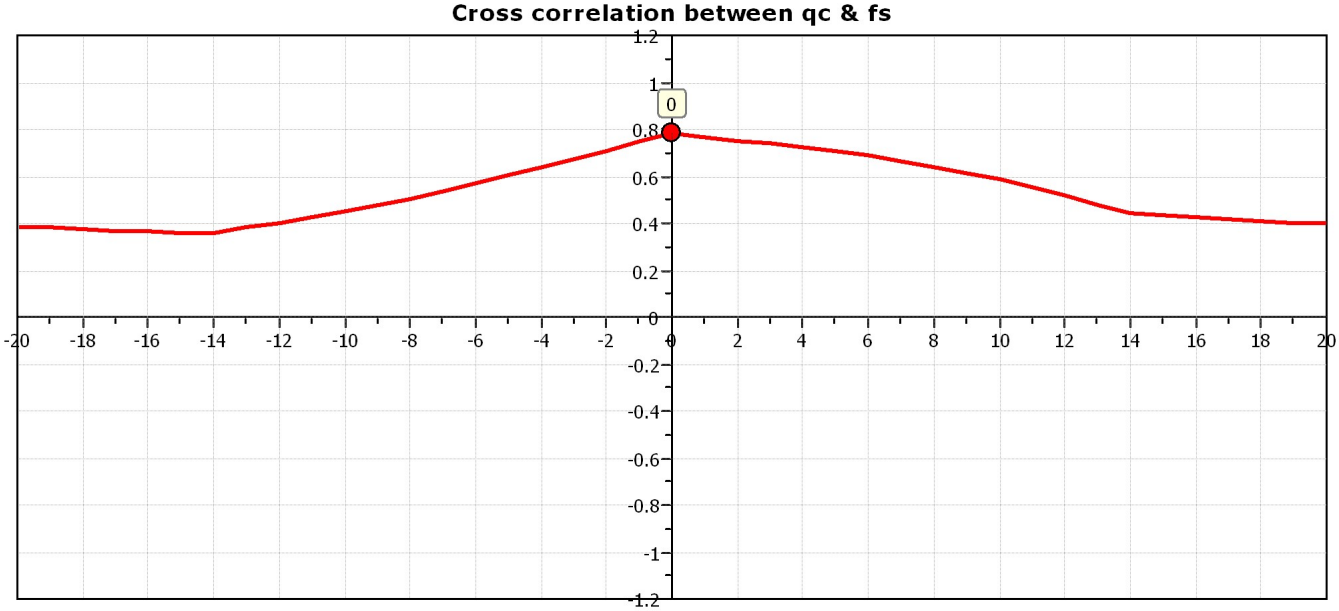
CPT: CPT17-01A

Project: **CA3043**
Location: **A1B2CH**

Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

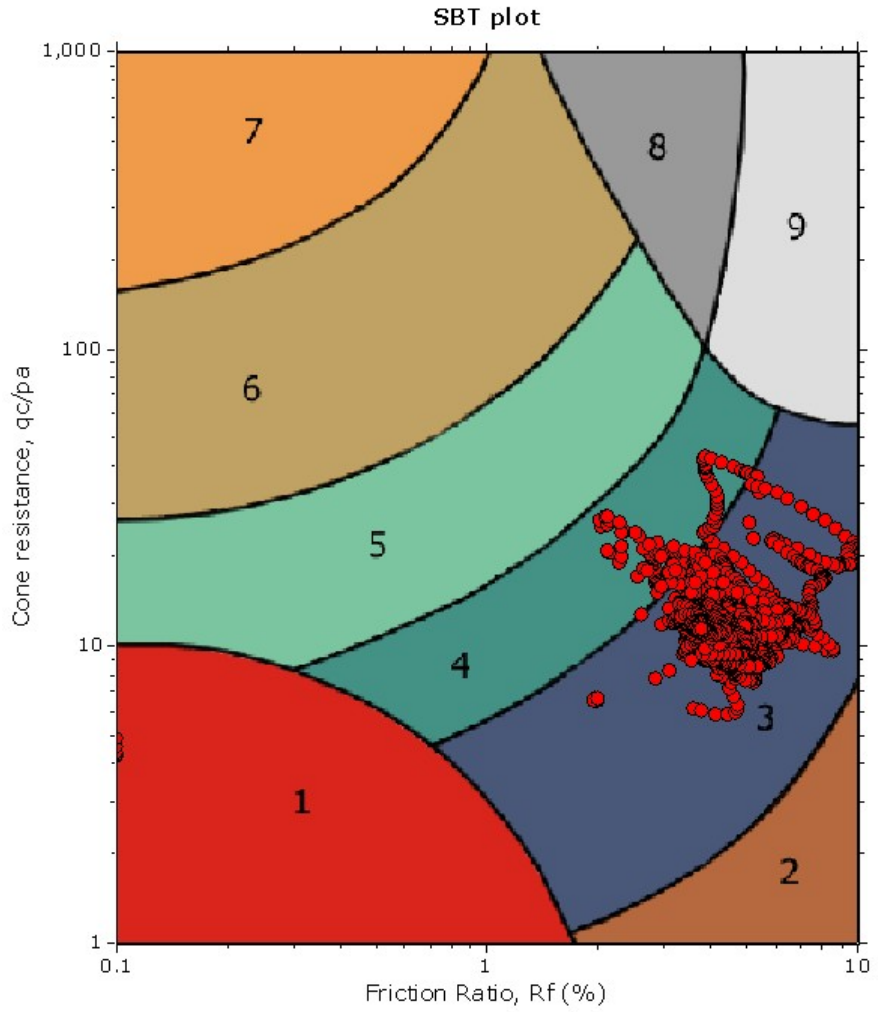


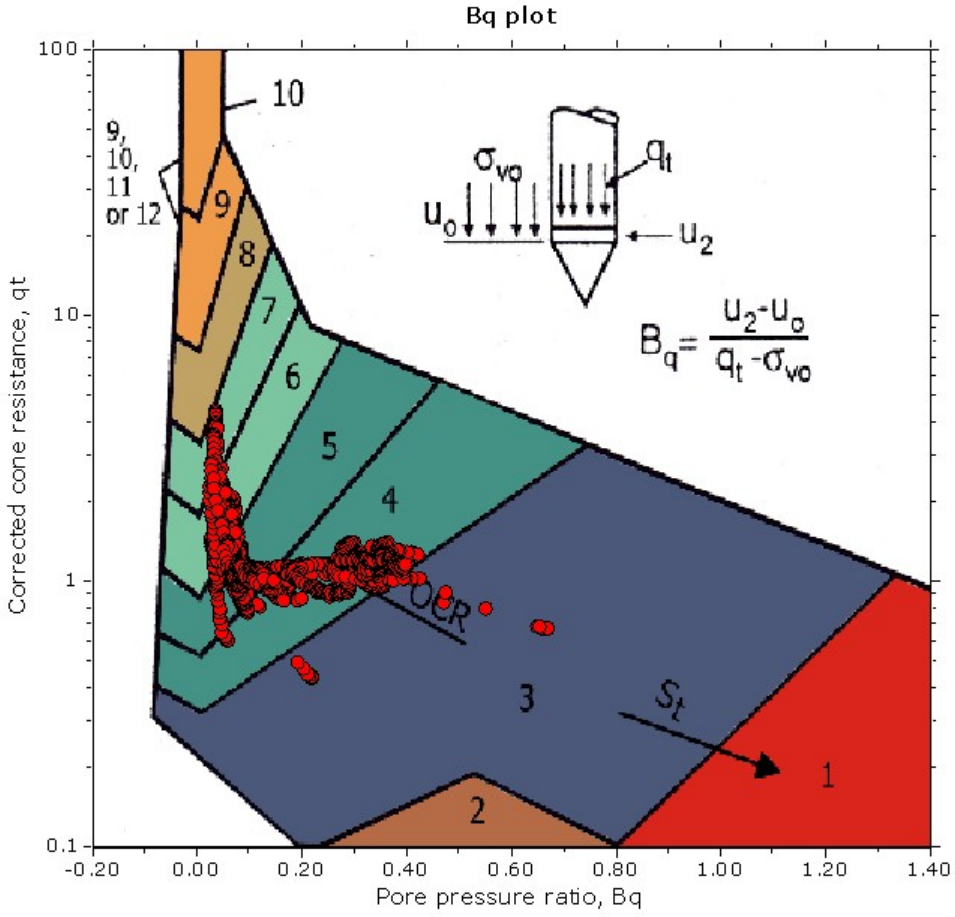
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

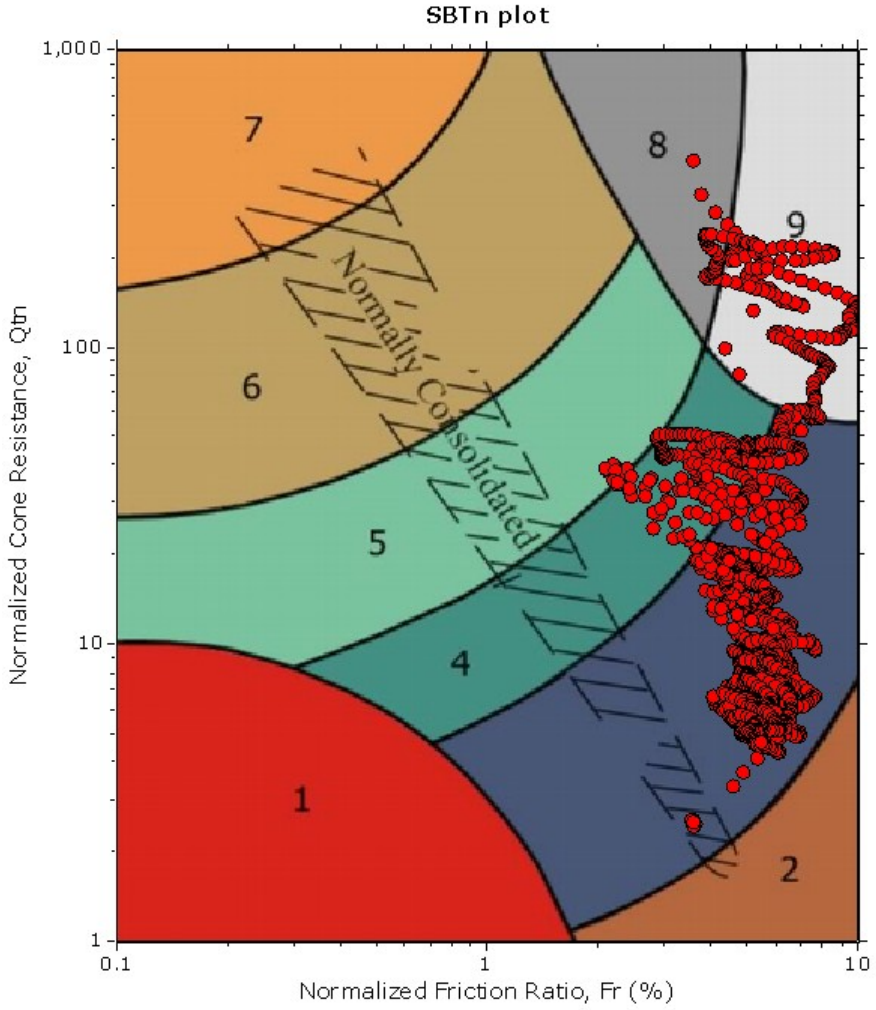
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

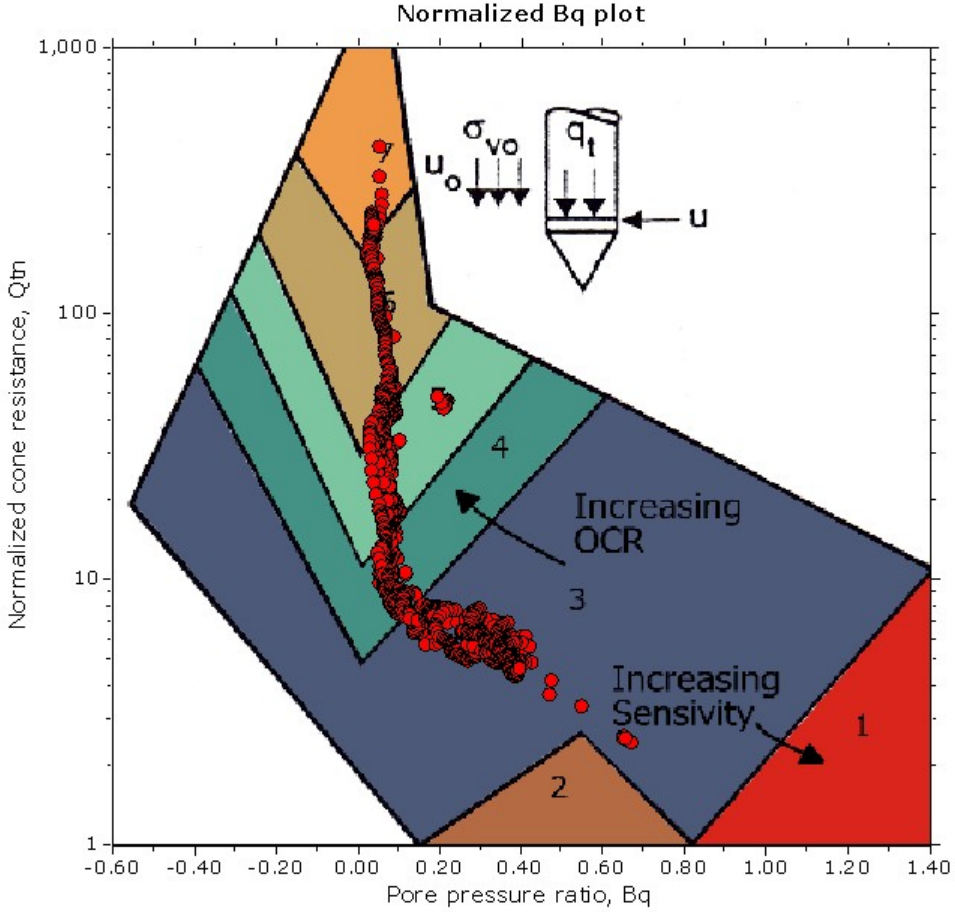
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

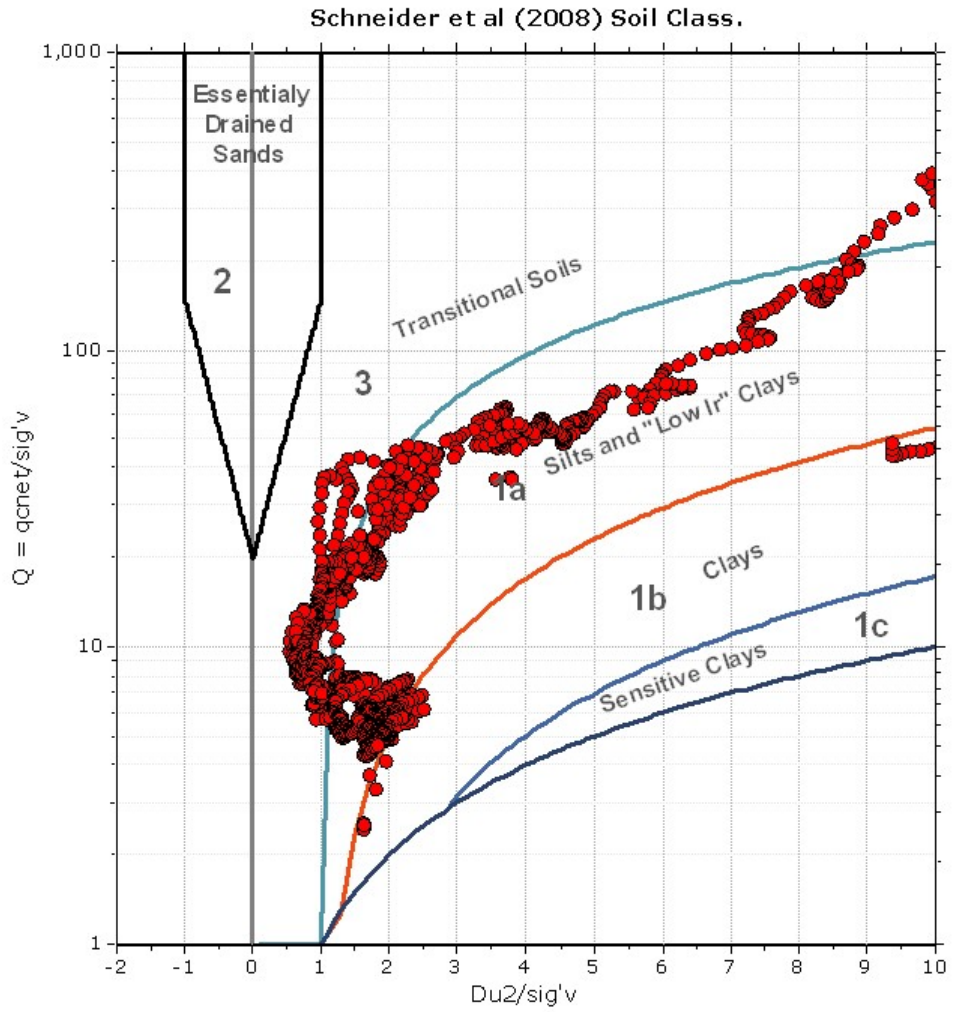
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

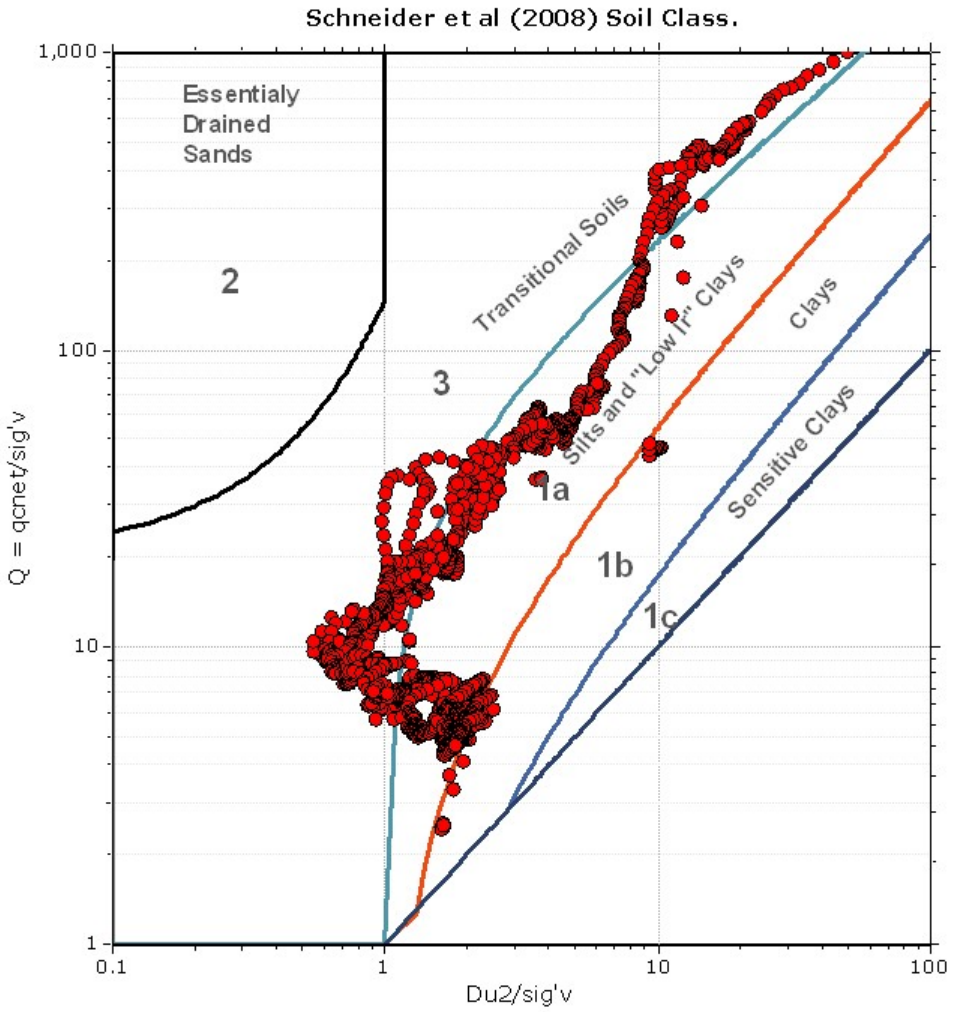
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



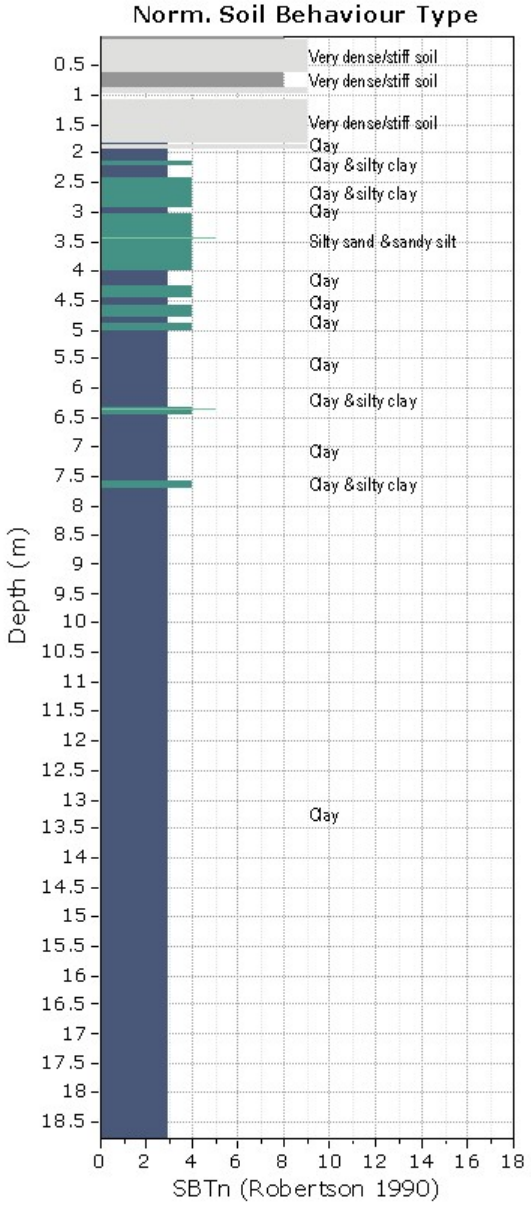


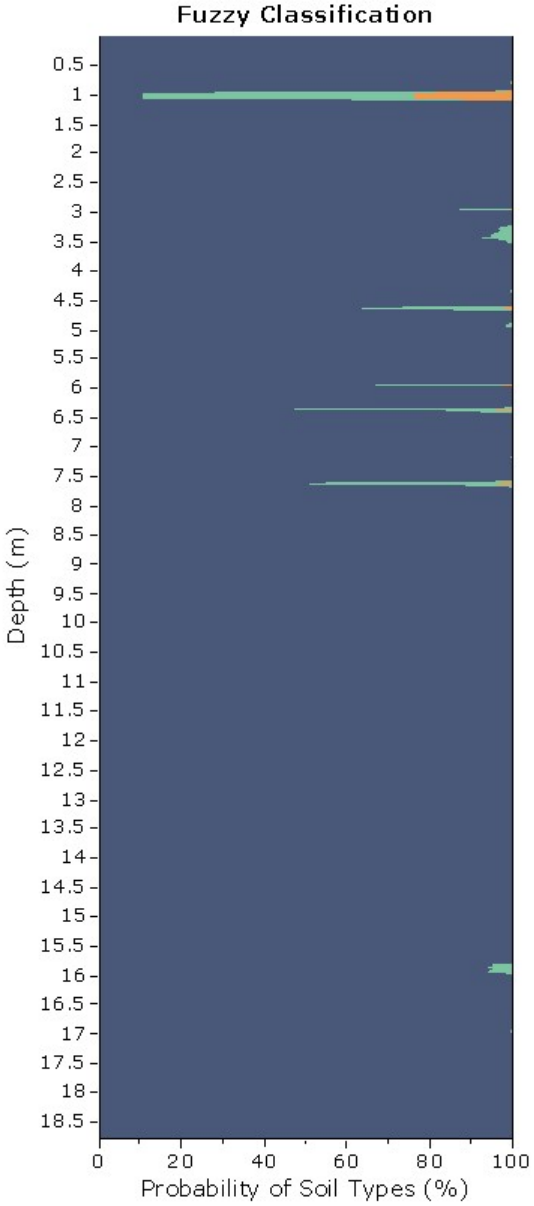
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-01A

Project: CA3043
Location: A1B2CH

Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

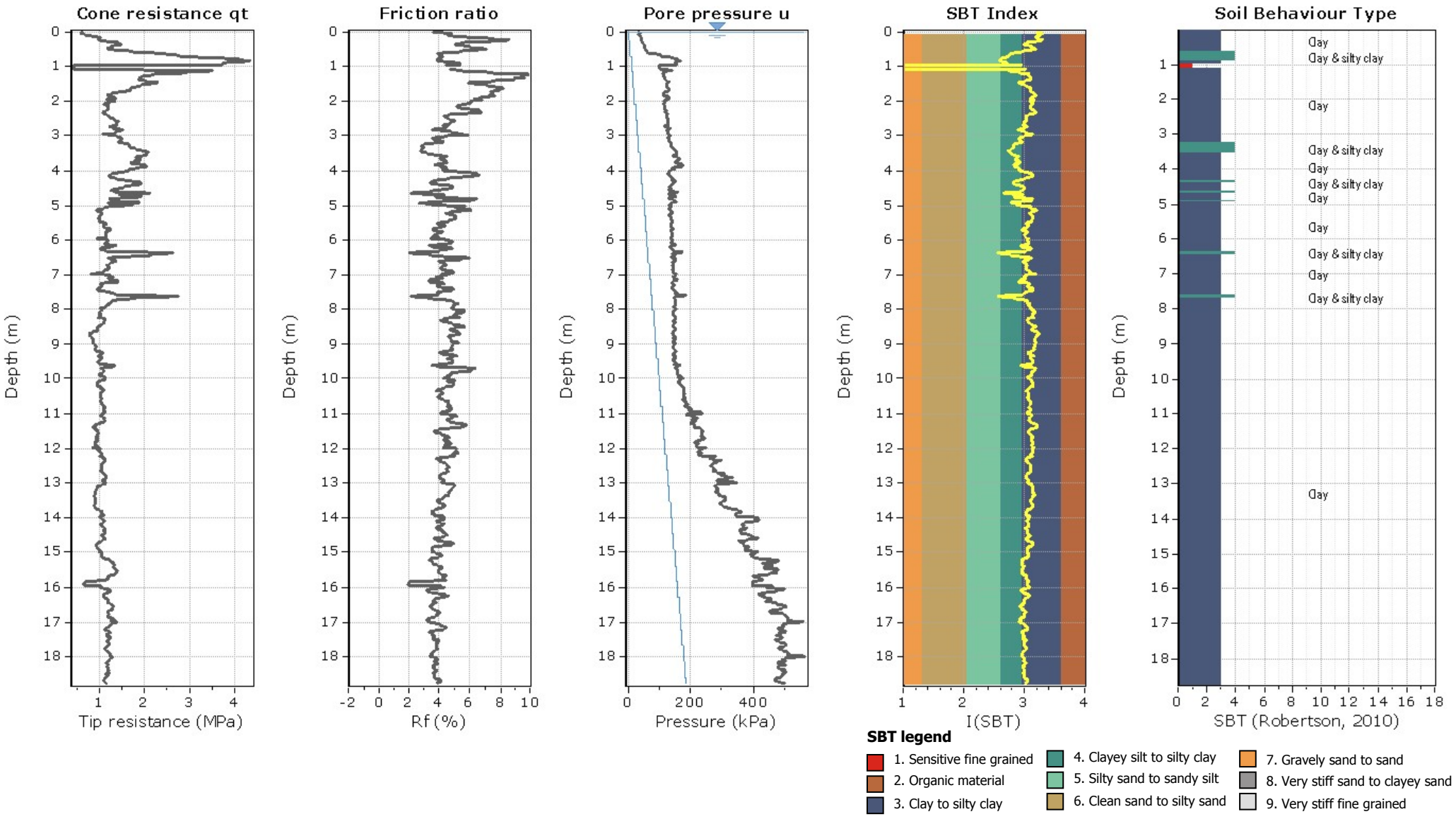




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

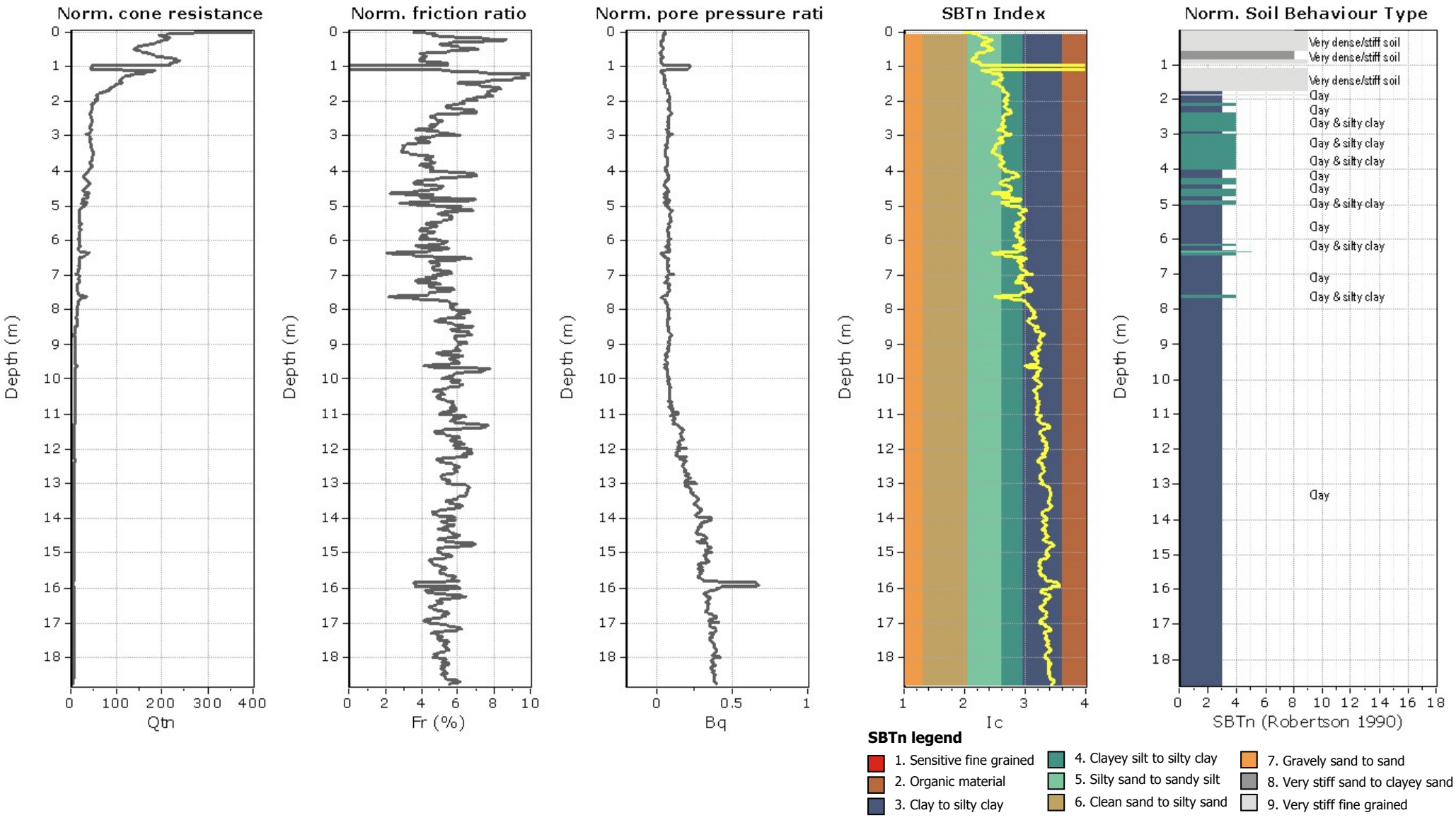
CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

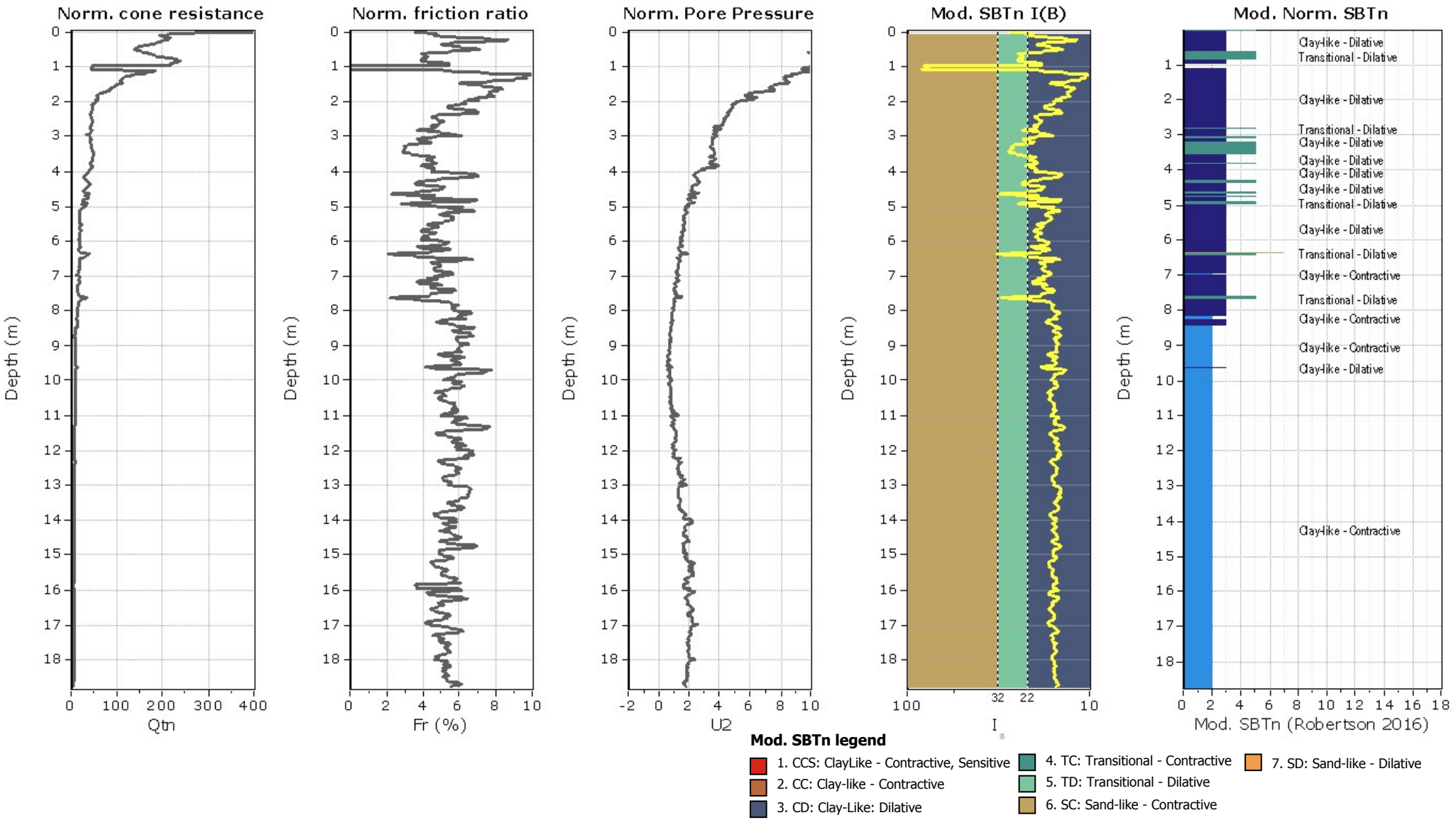
CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

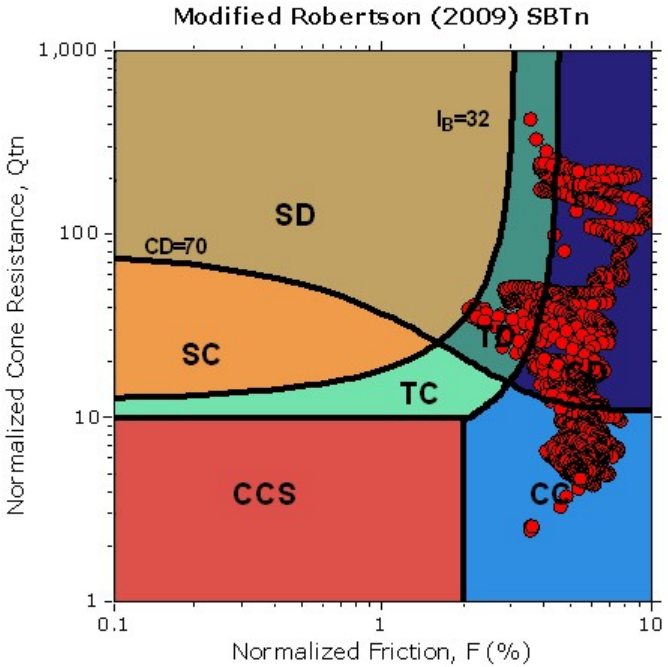


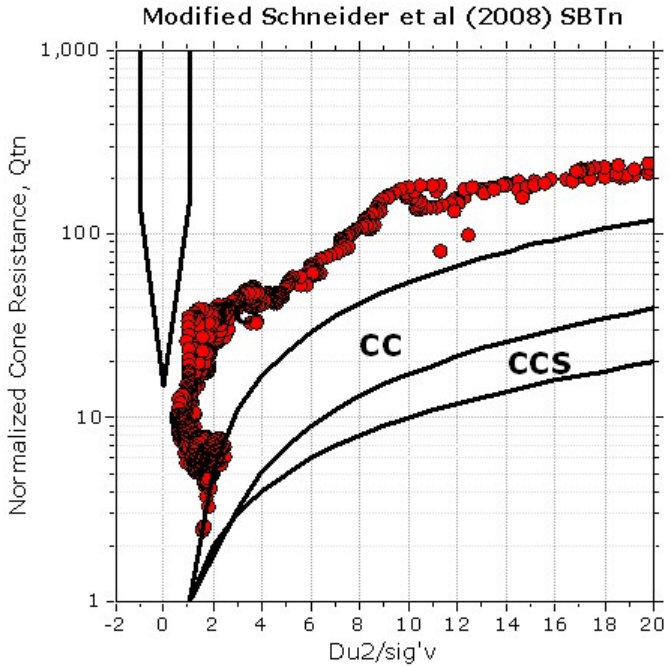
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

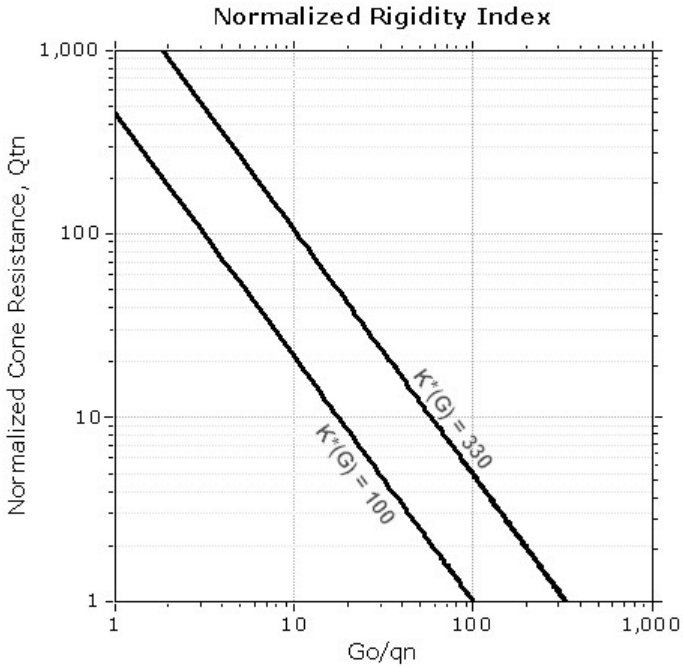
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







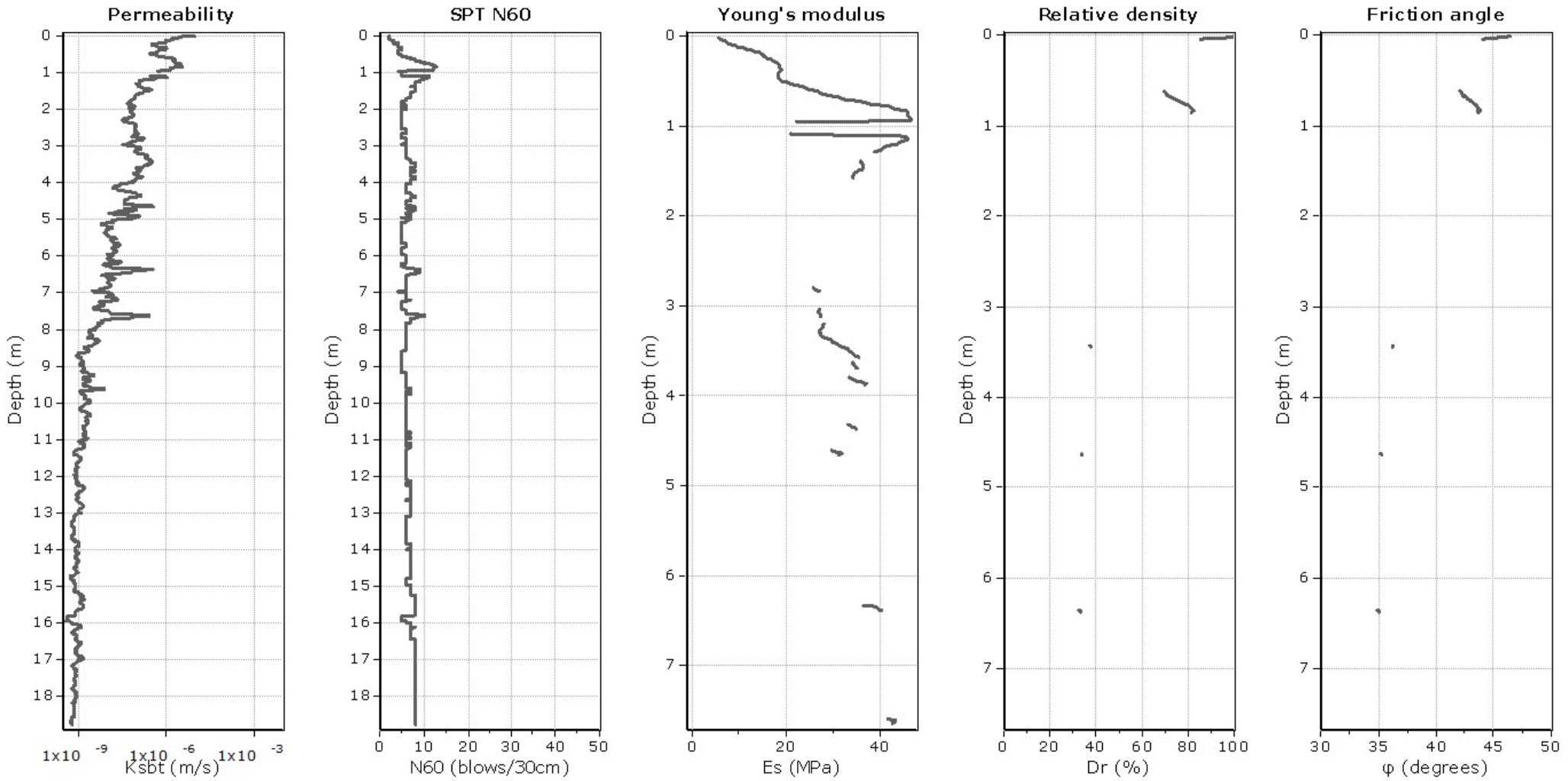
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



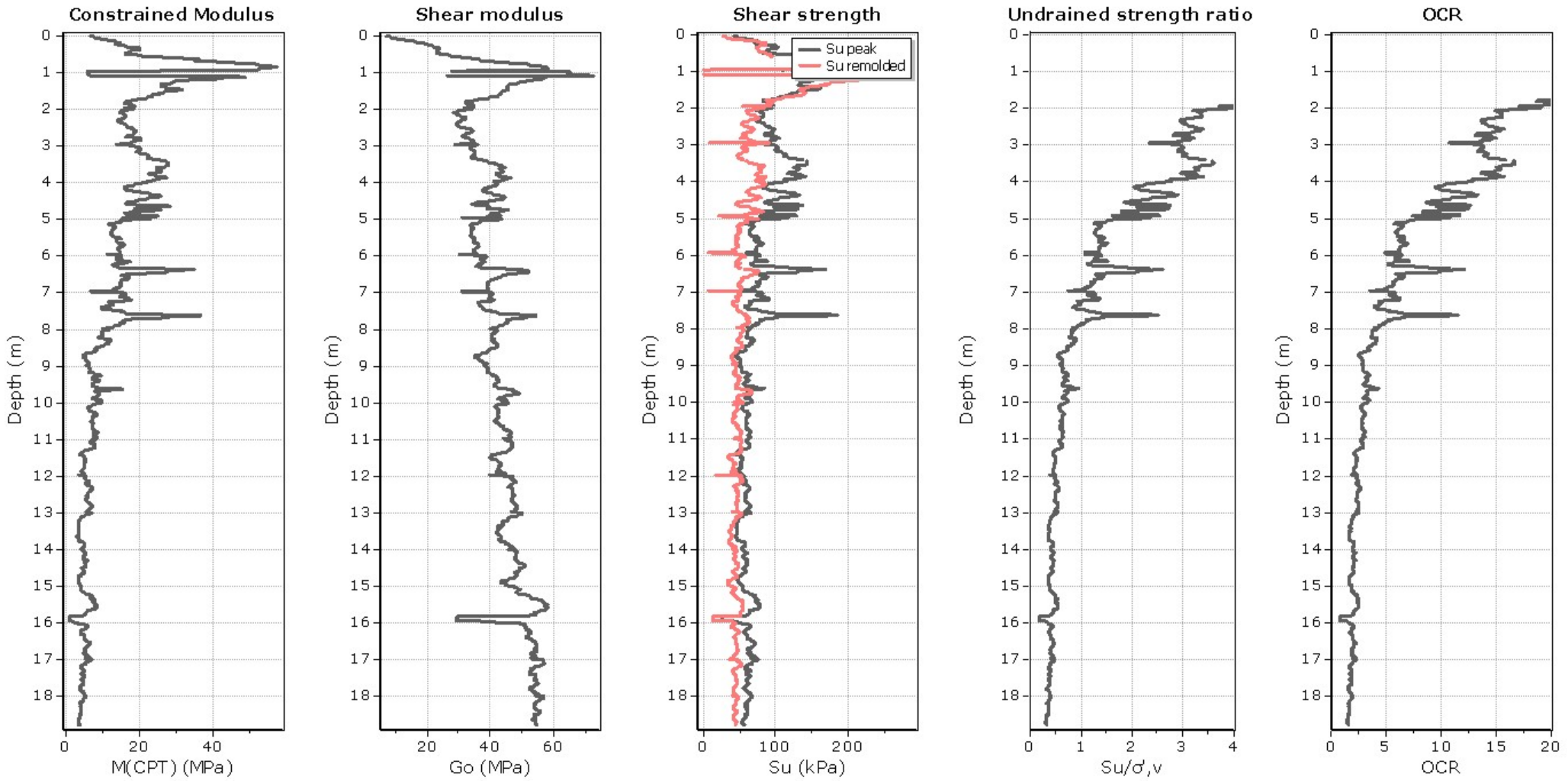
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



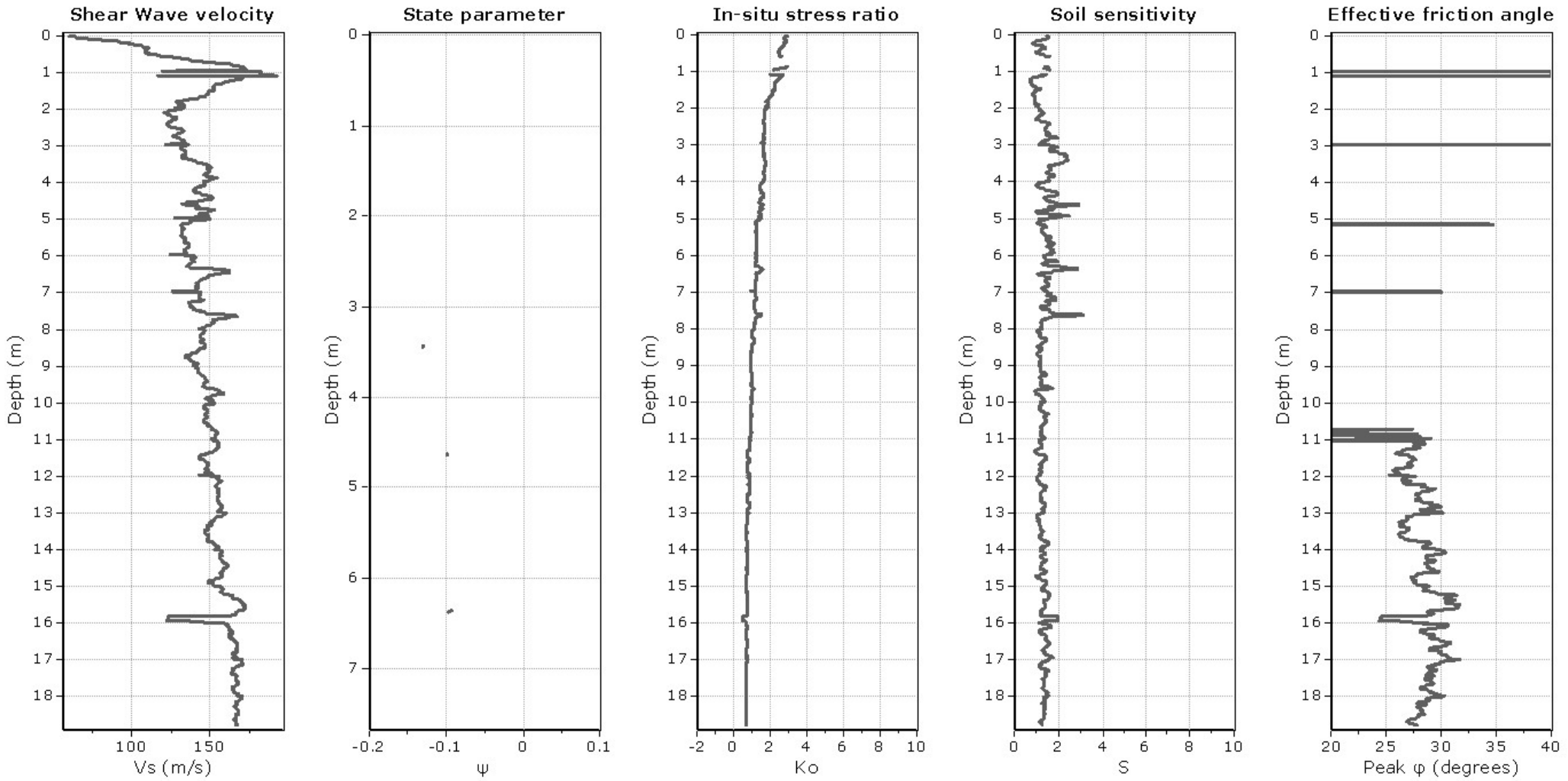
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-01A
Total depth: 18.77 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

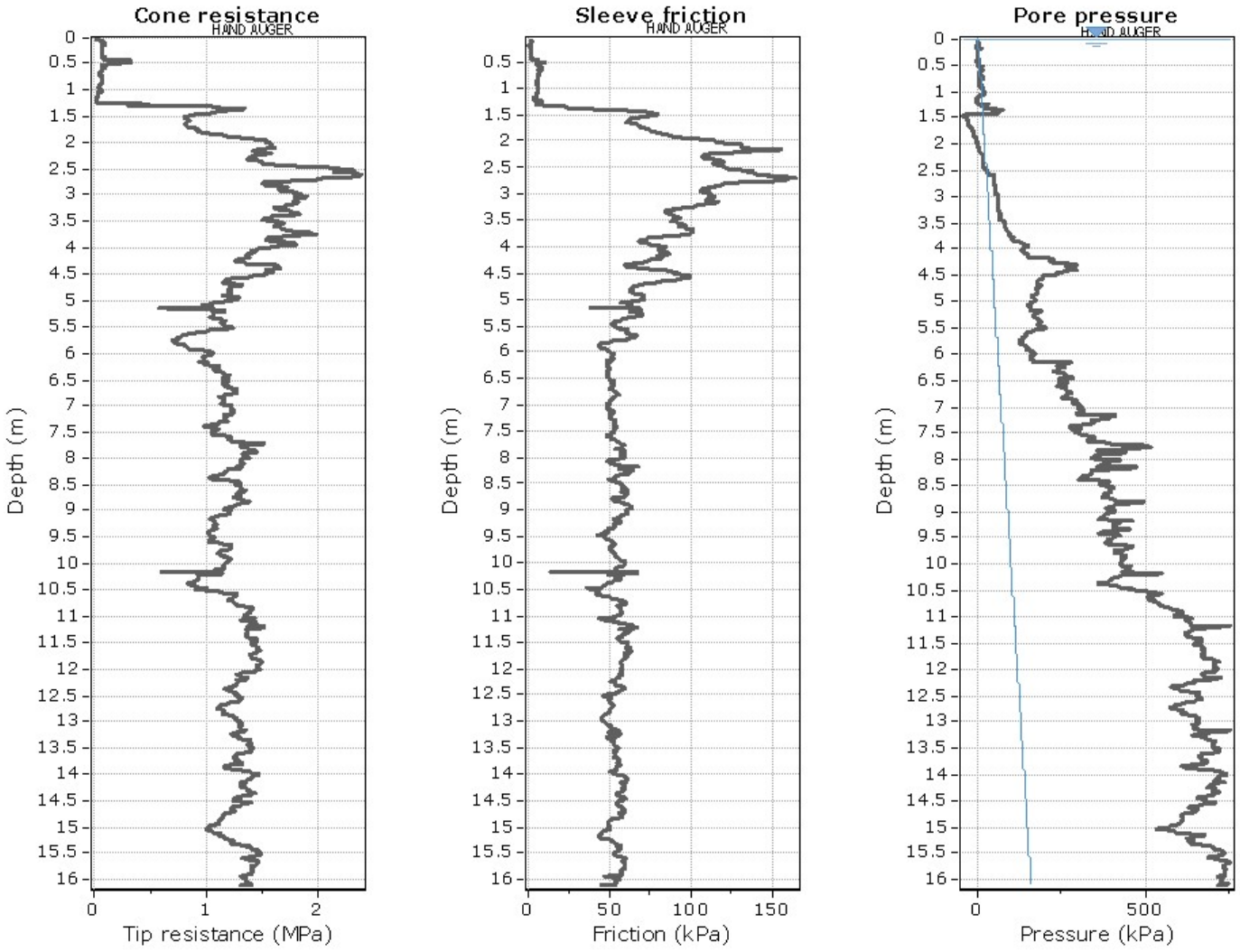
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-03

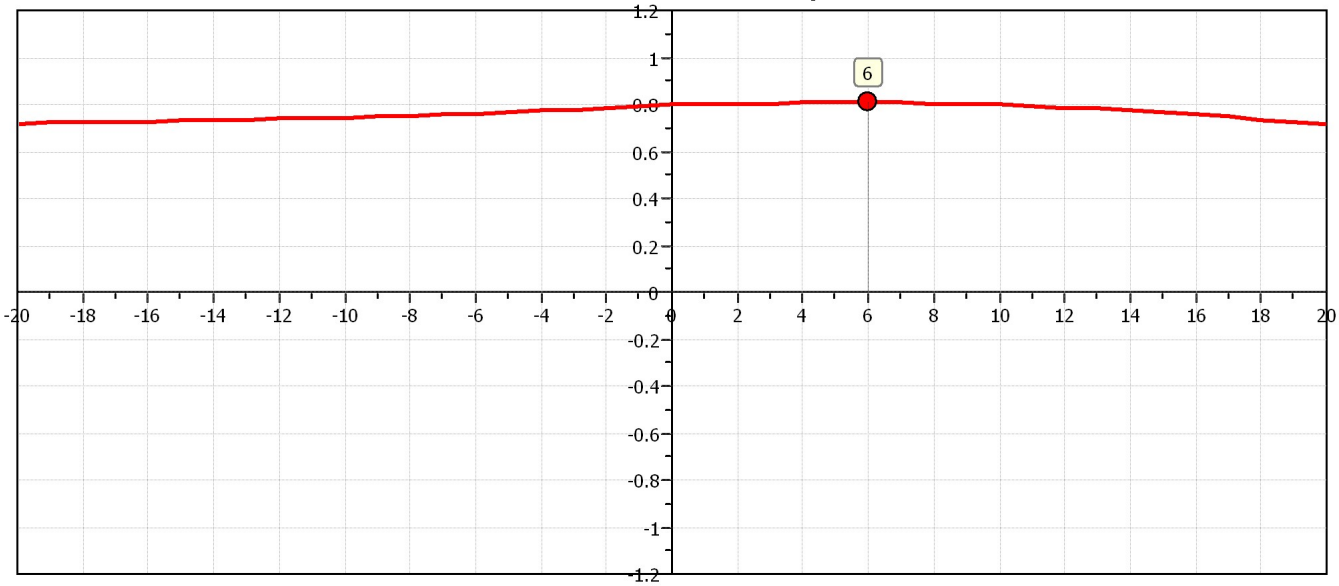
Project: **CA3043**
Location: **A1B2CH**

Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

Cross correlation between qc & fs

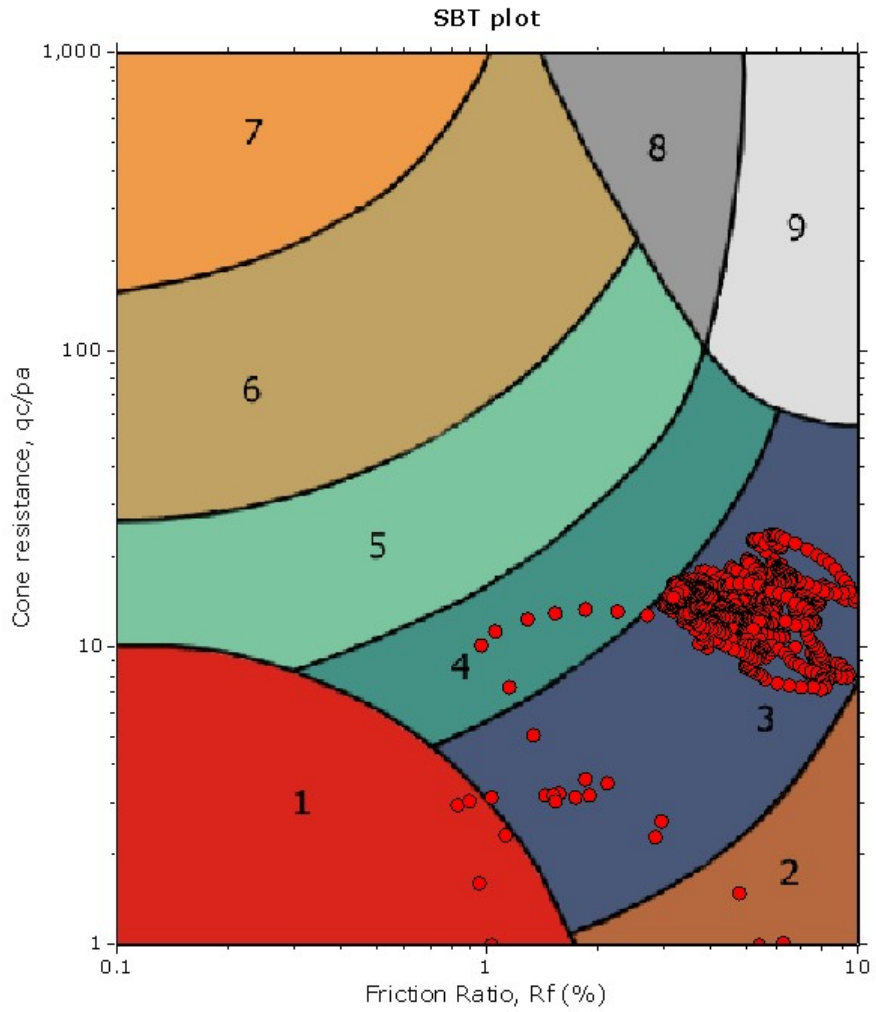


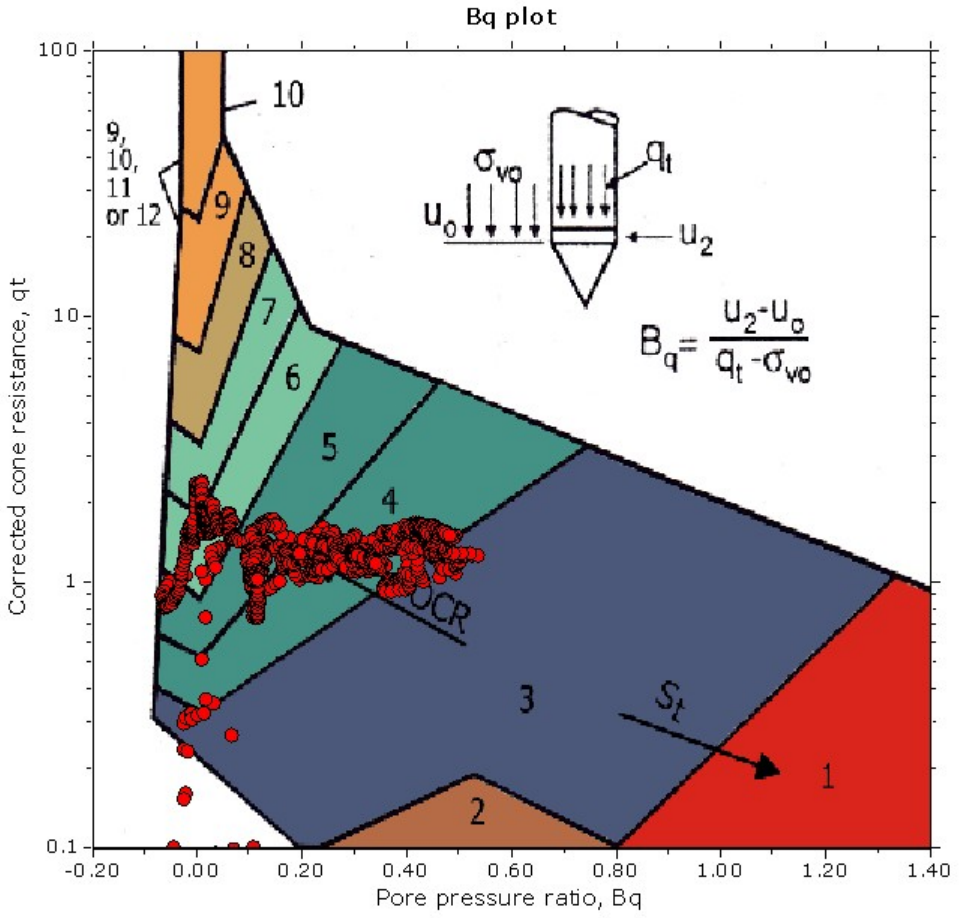
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

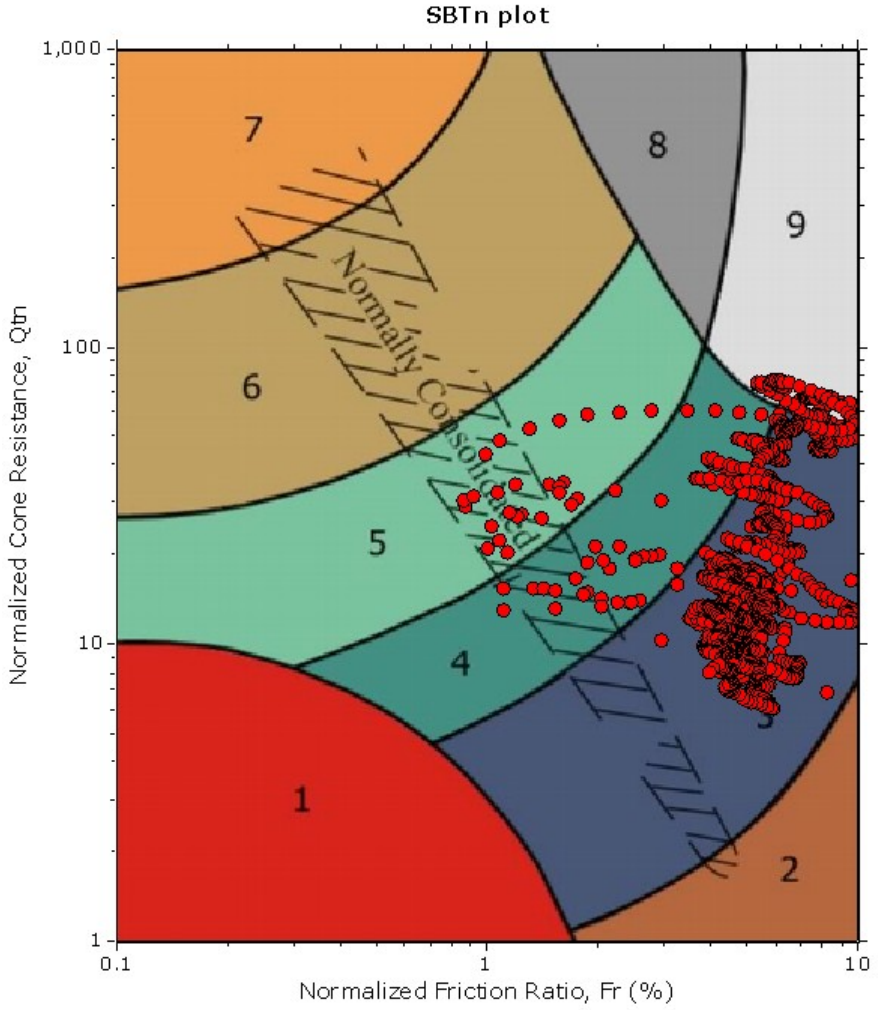
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

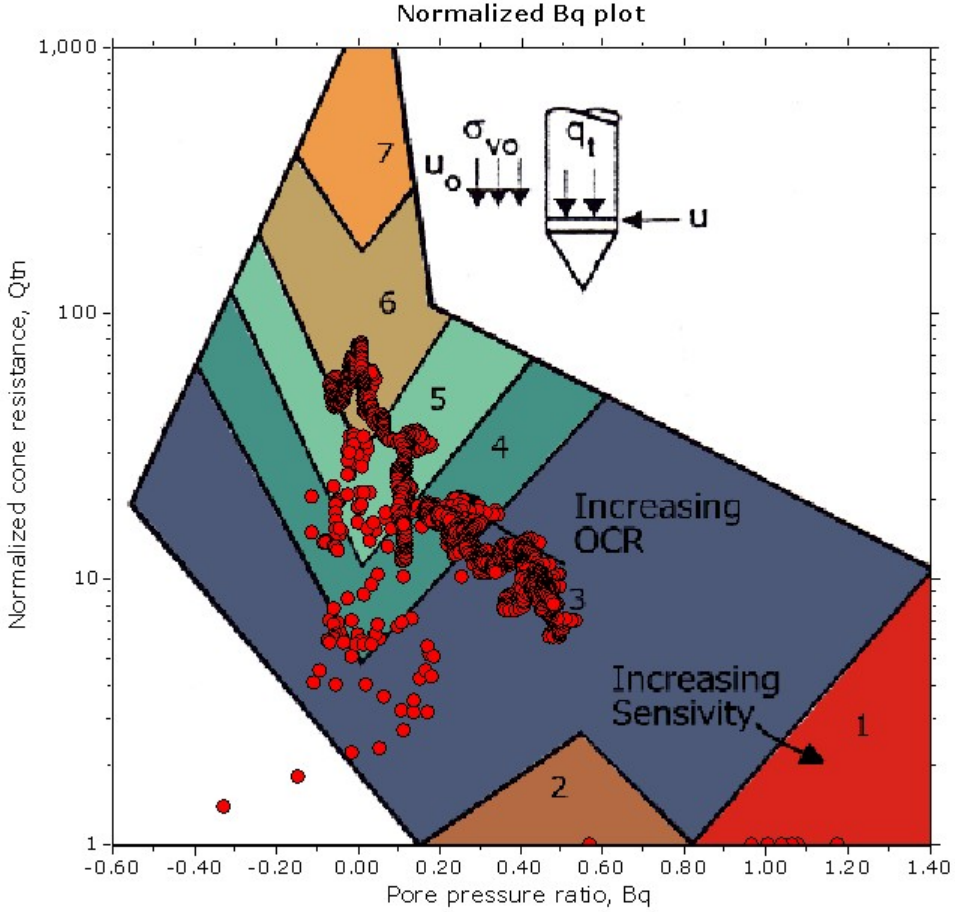
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

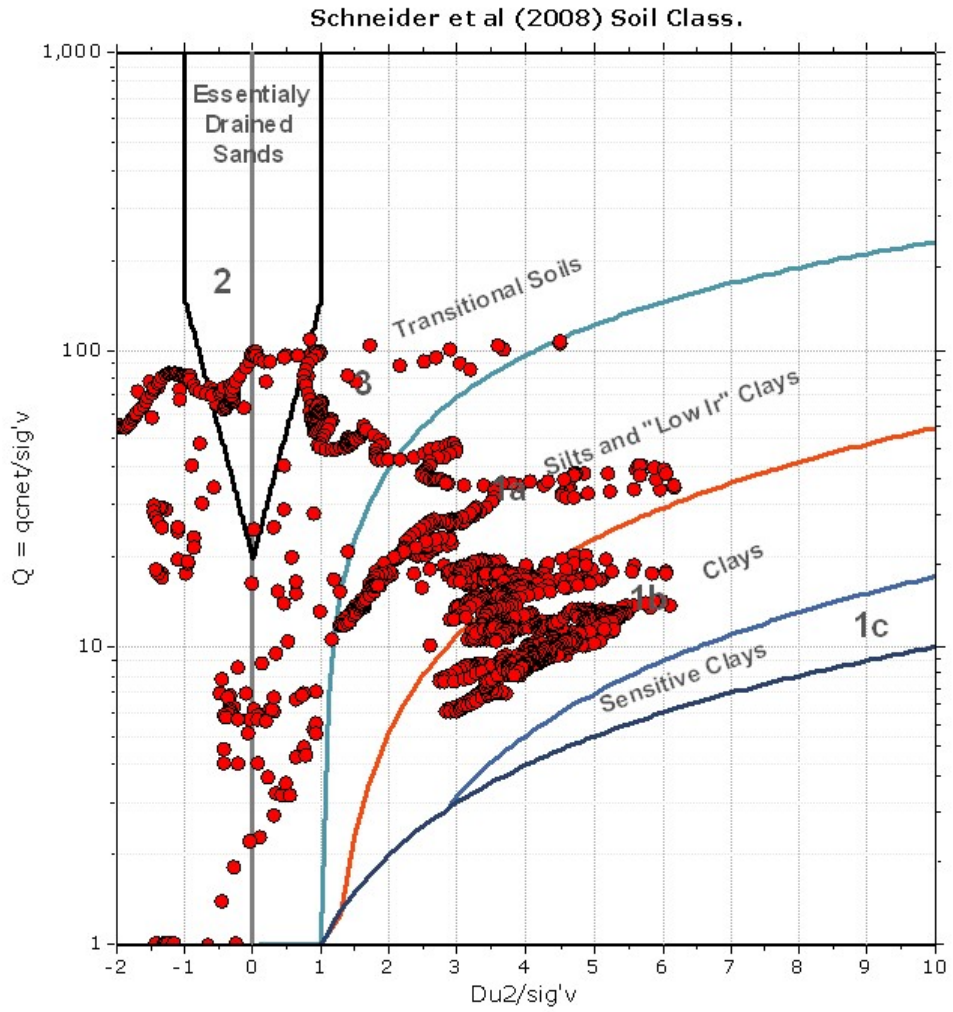
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

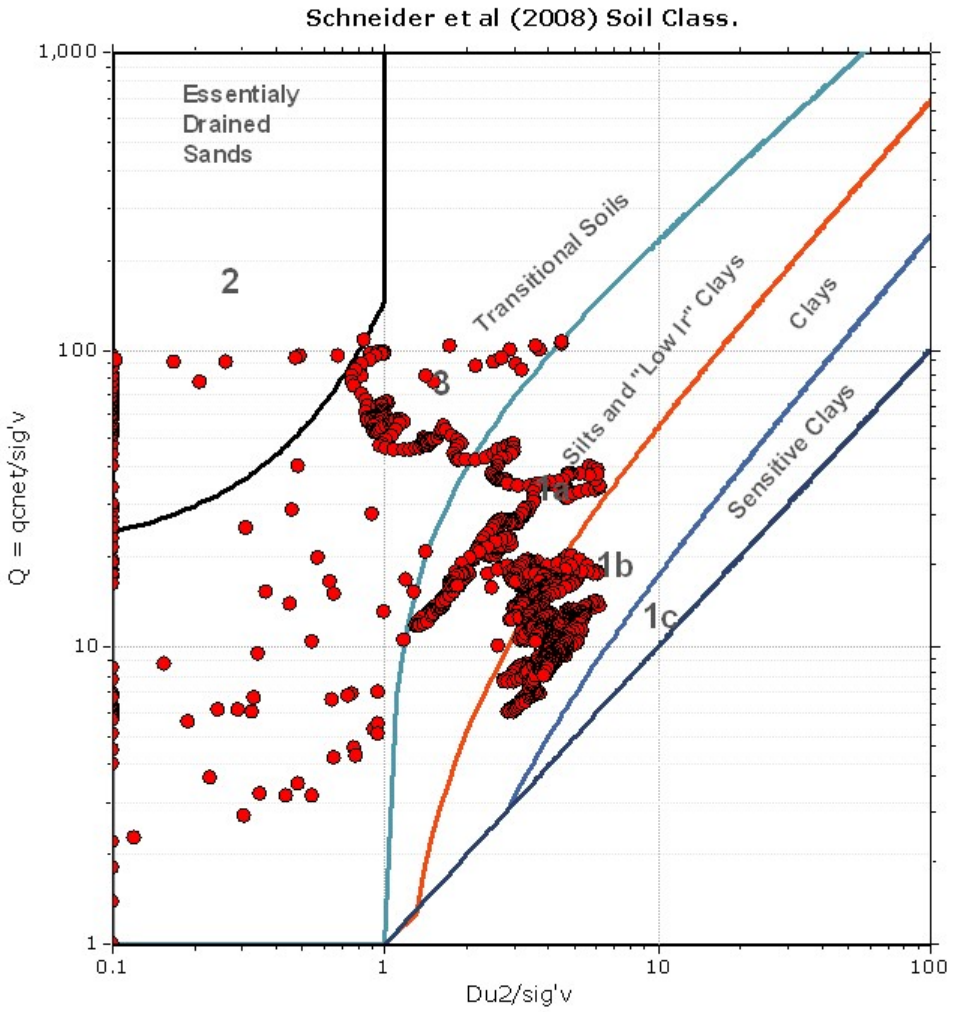
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



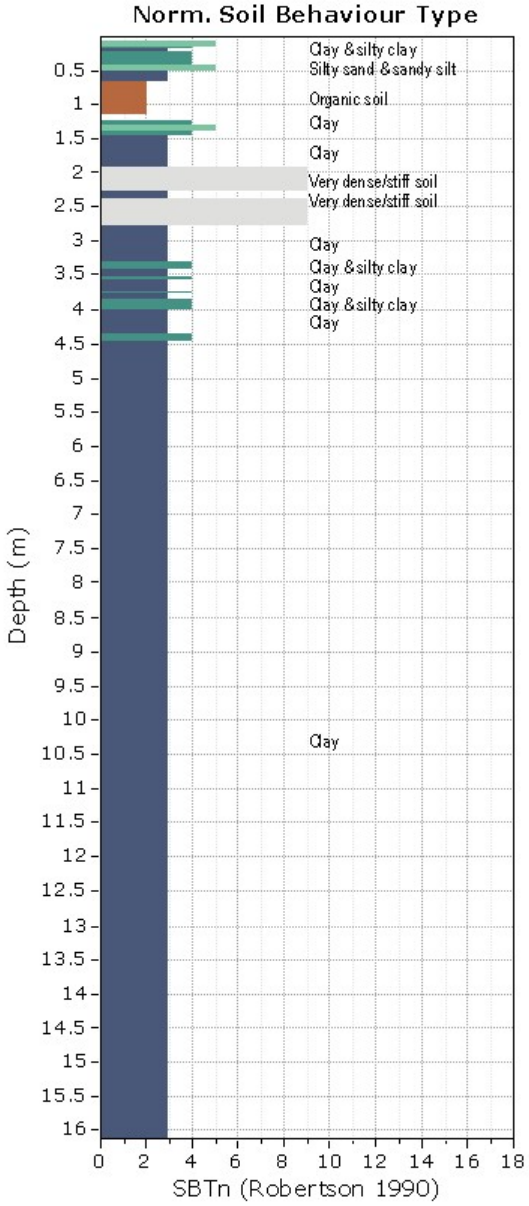


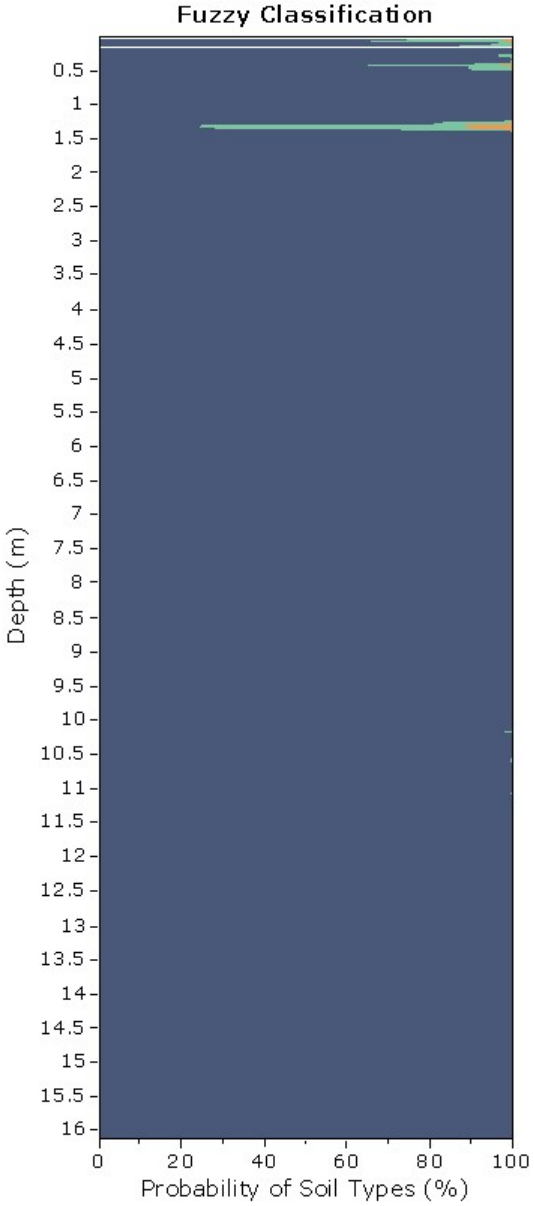
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-03

Project: **CA3043**
Location: **A1B2CH**

Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

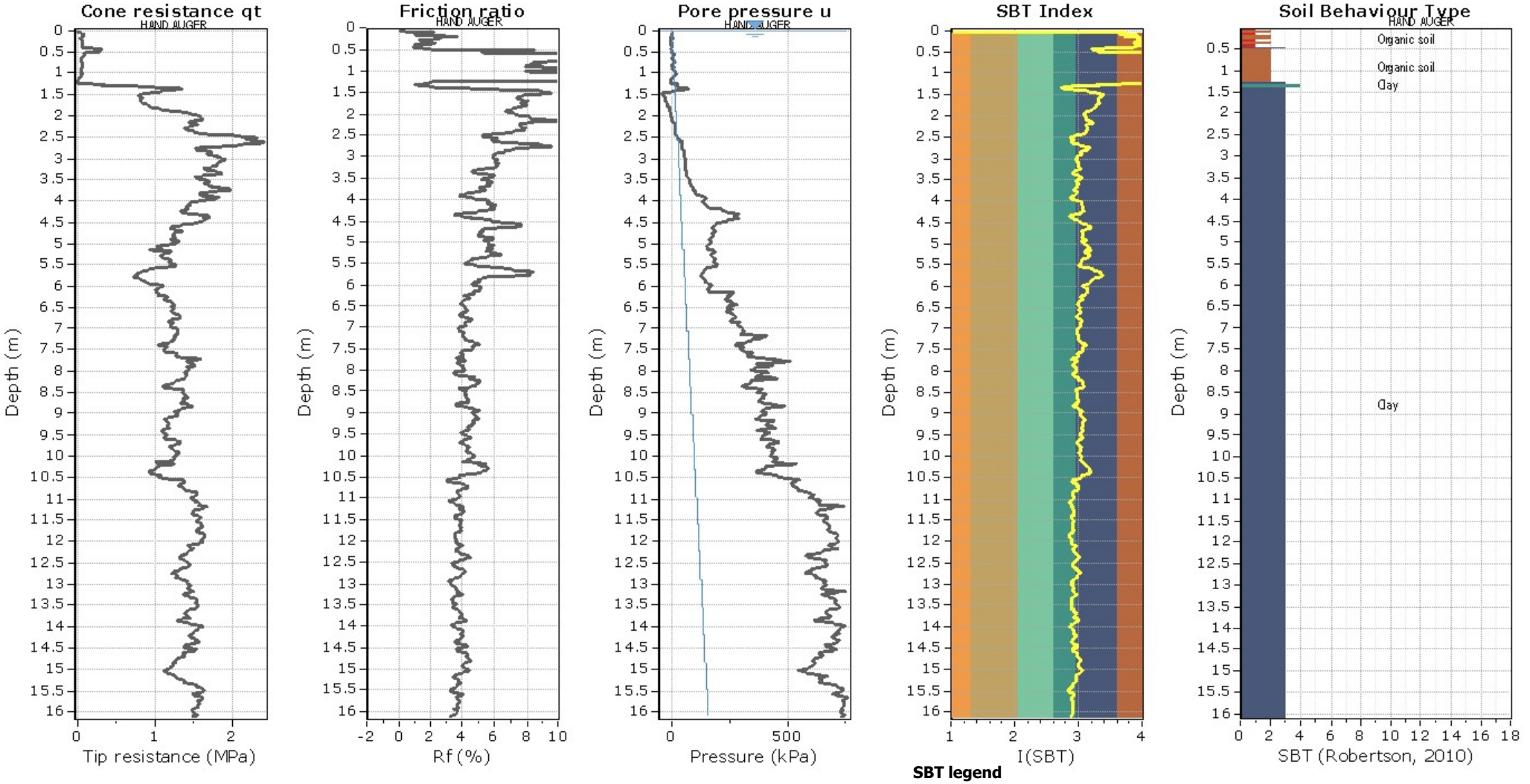




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

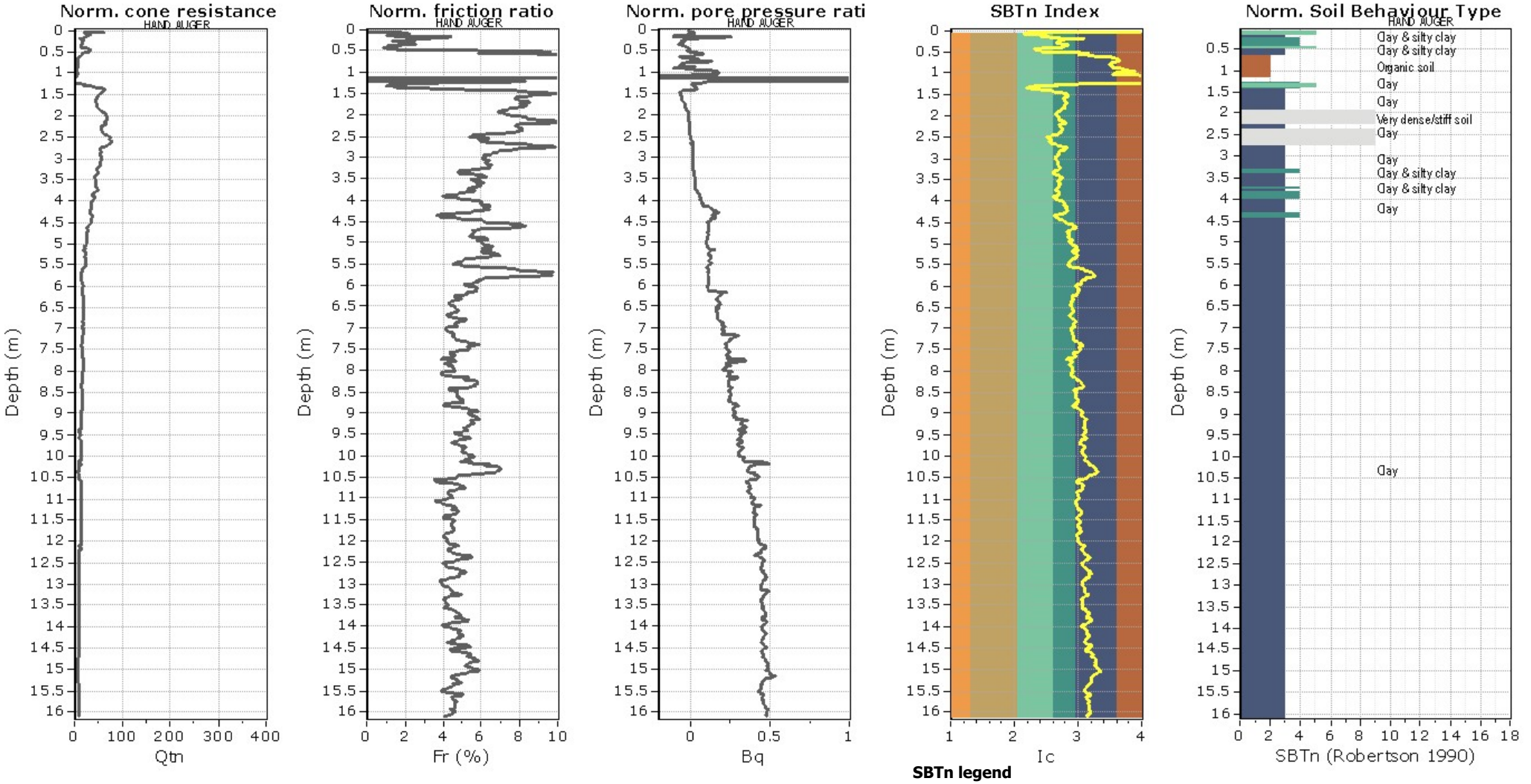
CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

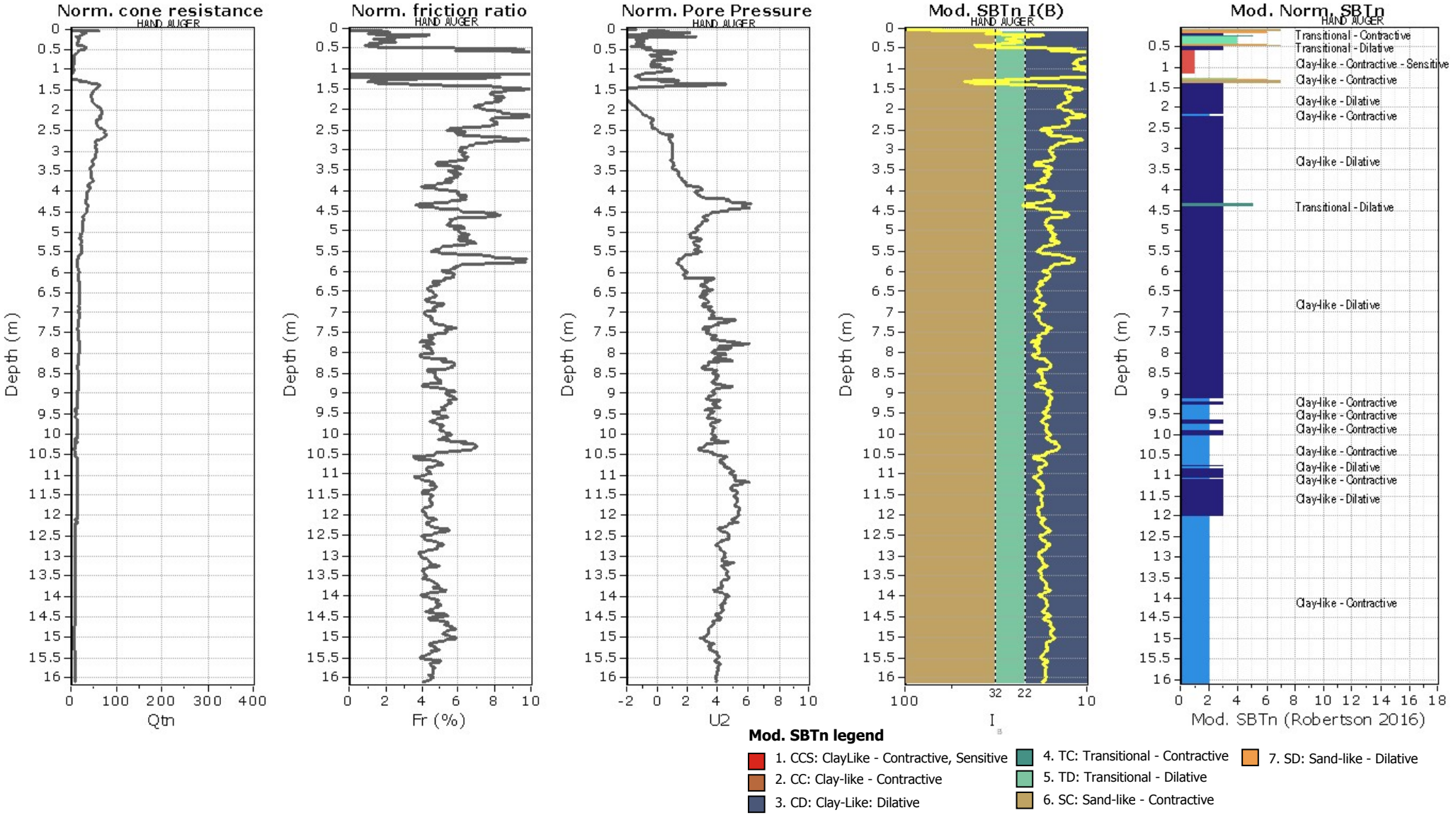
CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

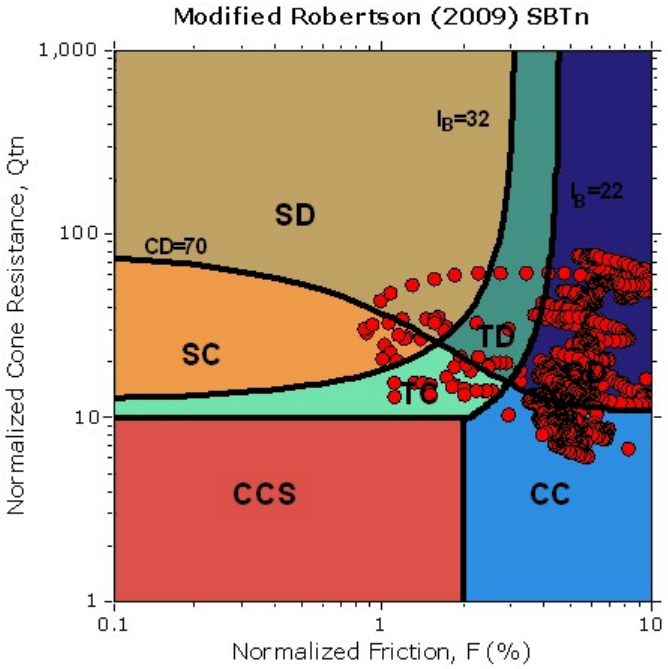


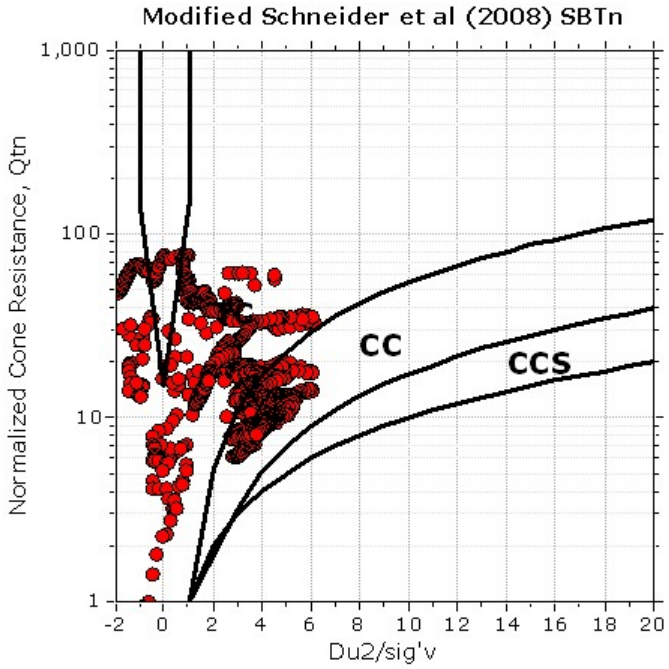
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

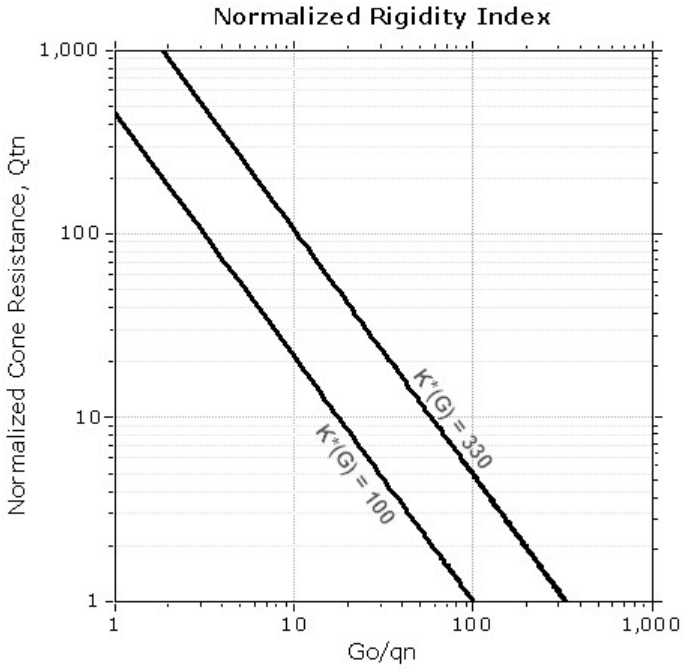
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







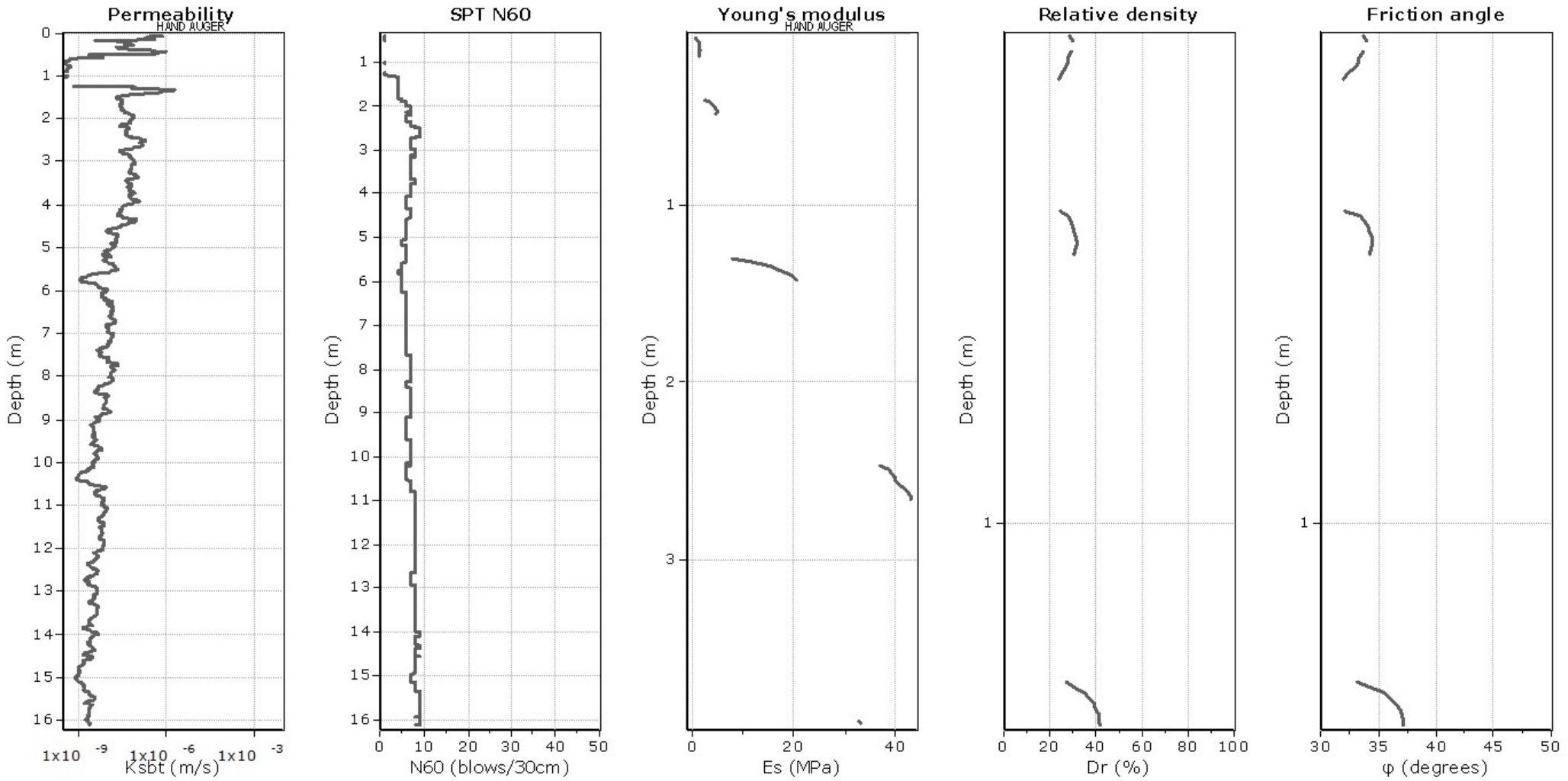
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



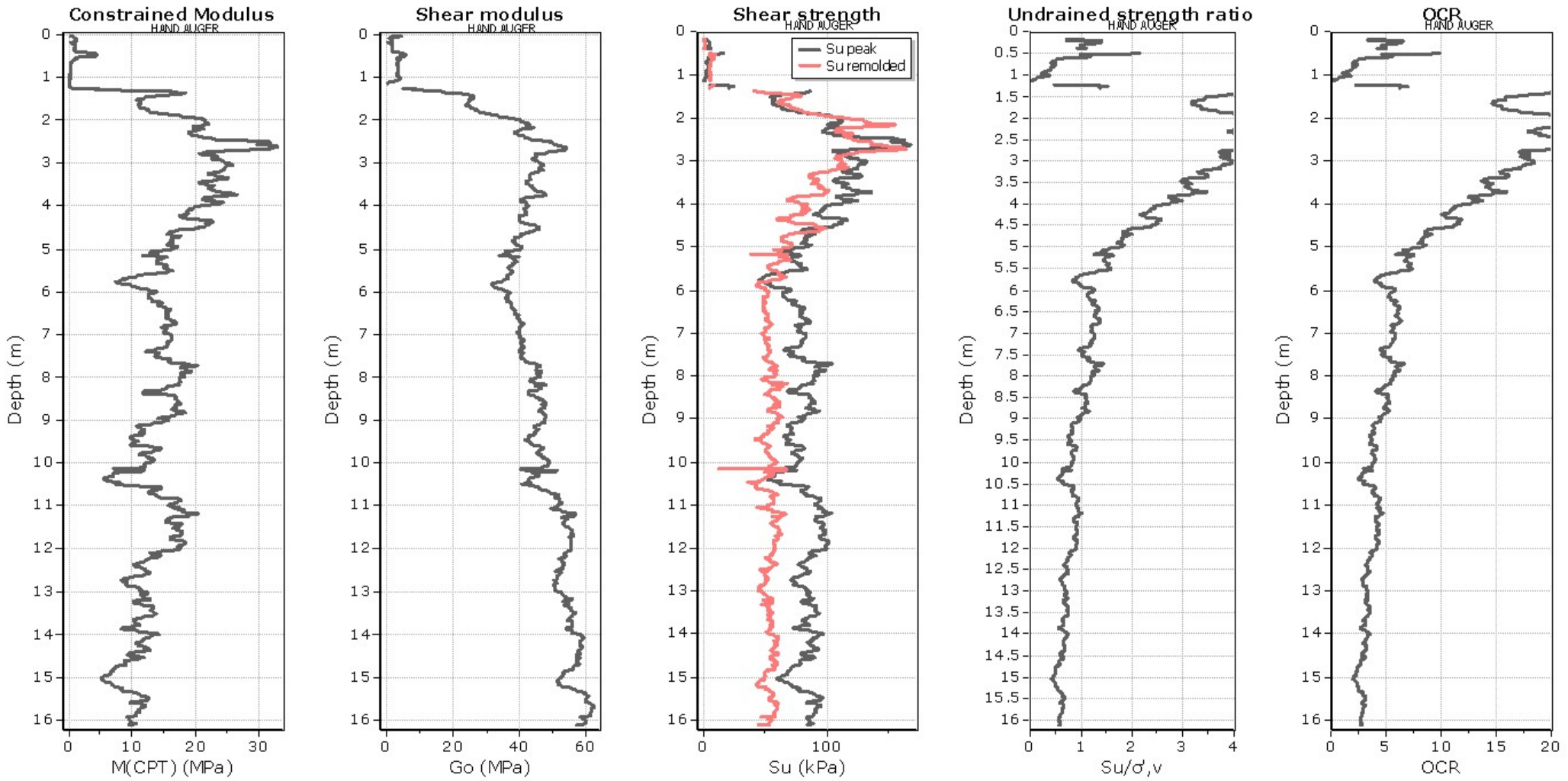
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

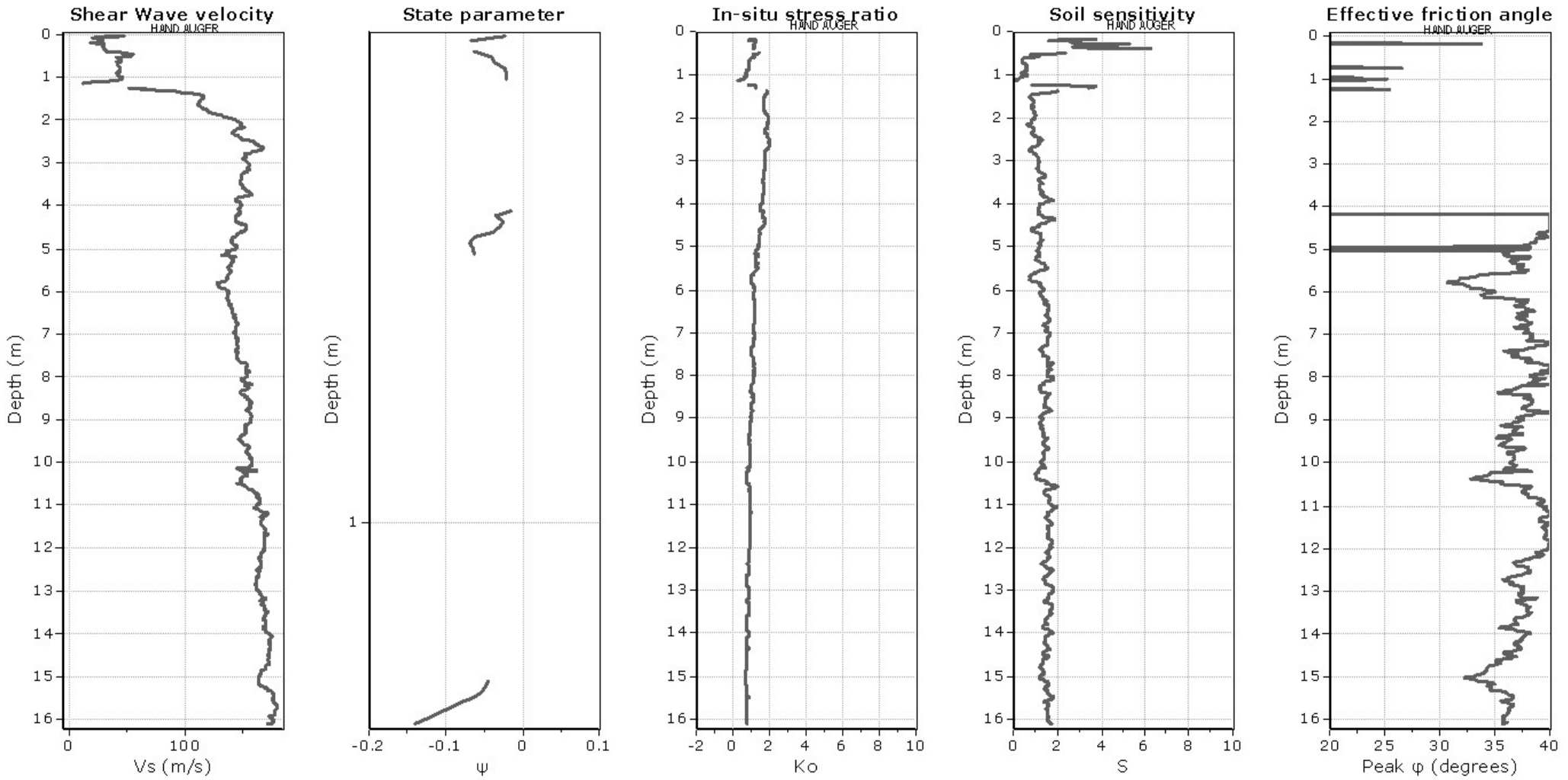
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-03
Total depth: 16.11 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

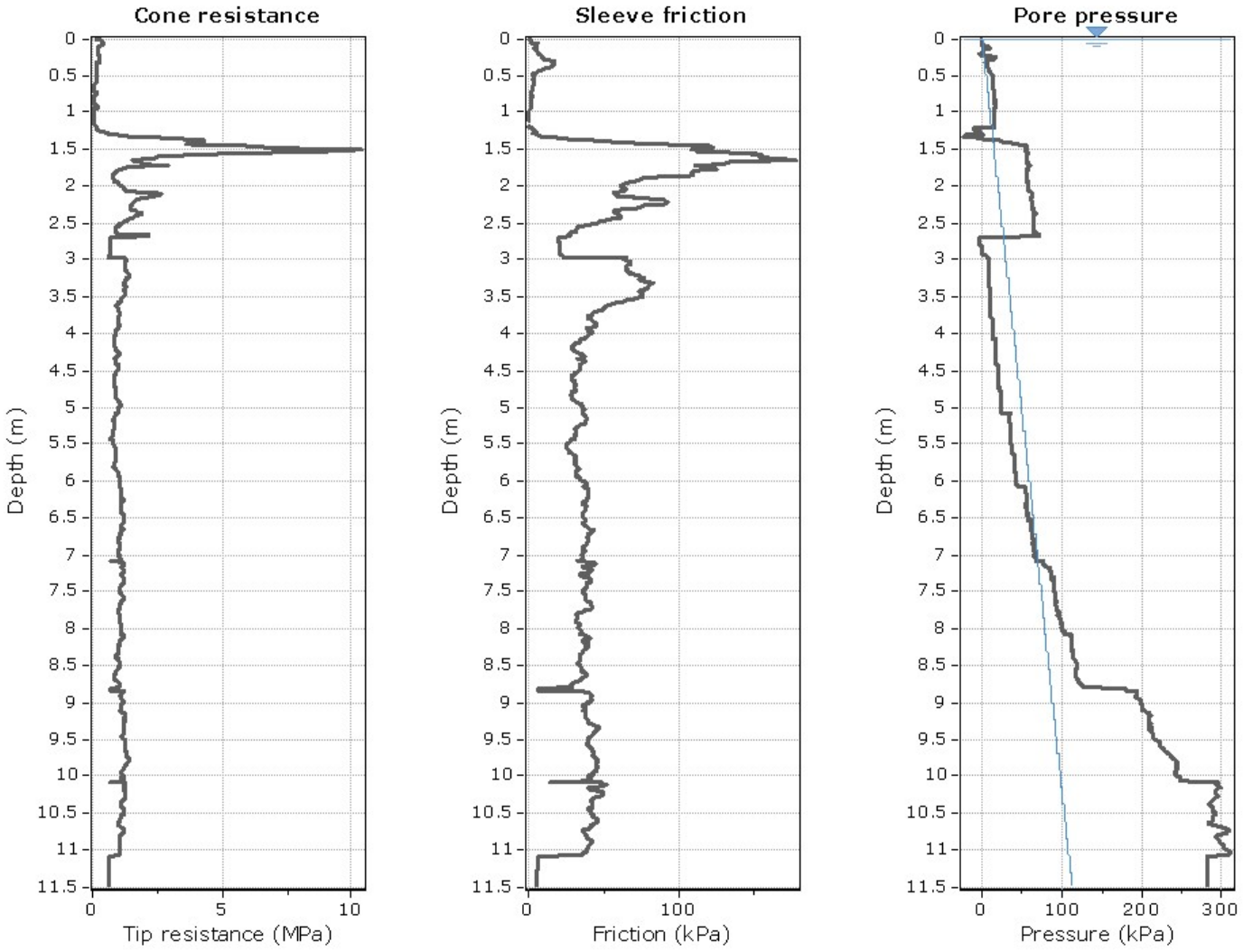
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

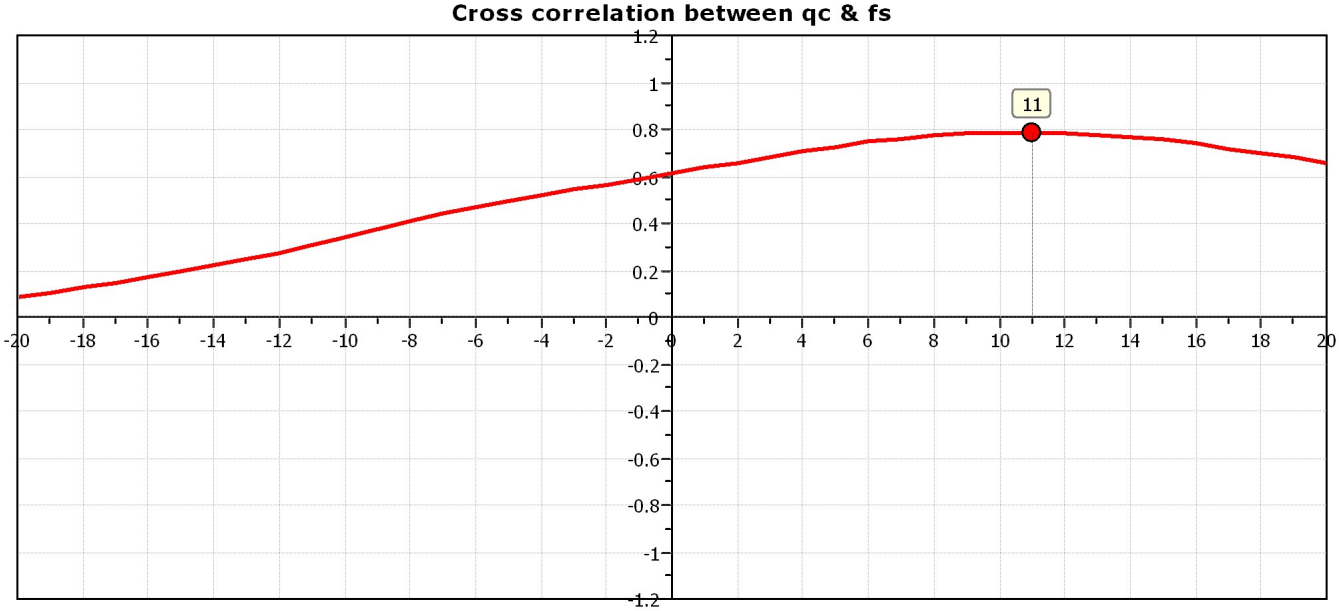
CPT: CPT17-06

Project: **CA3043**
Location: **A1B2CH**

Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

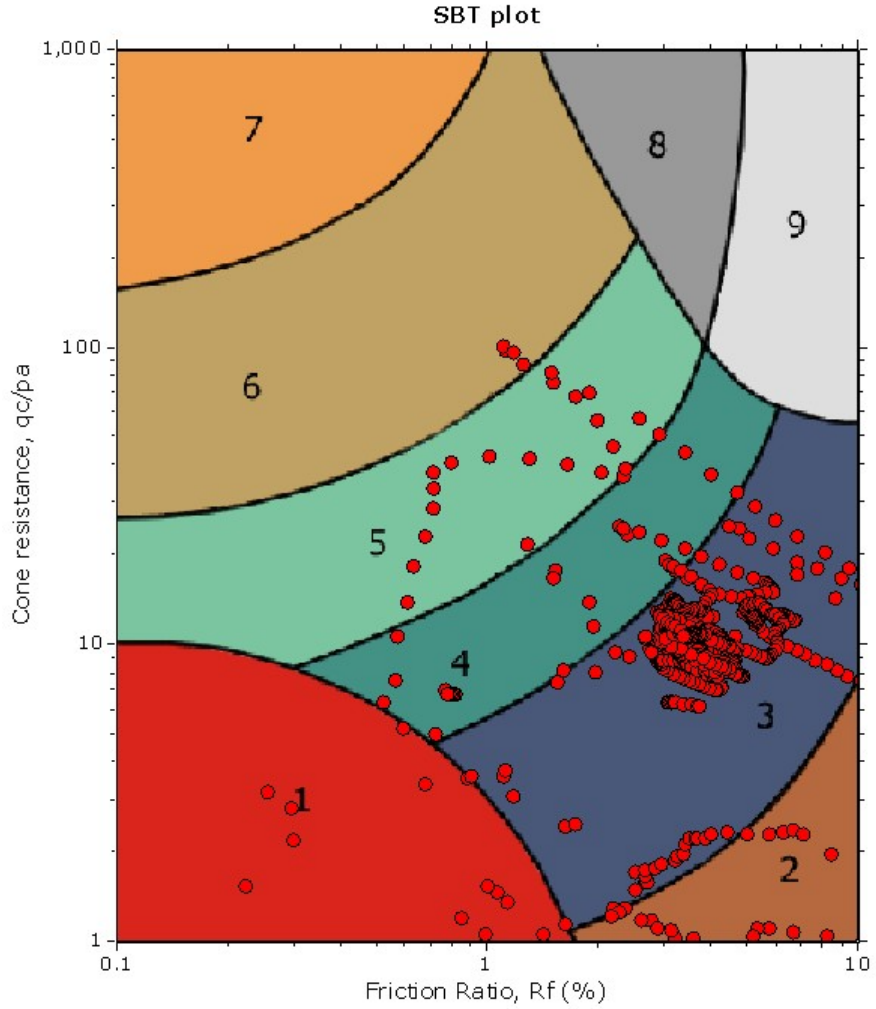


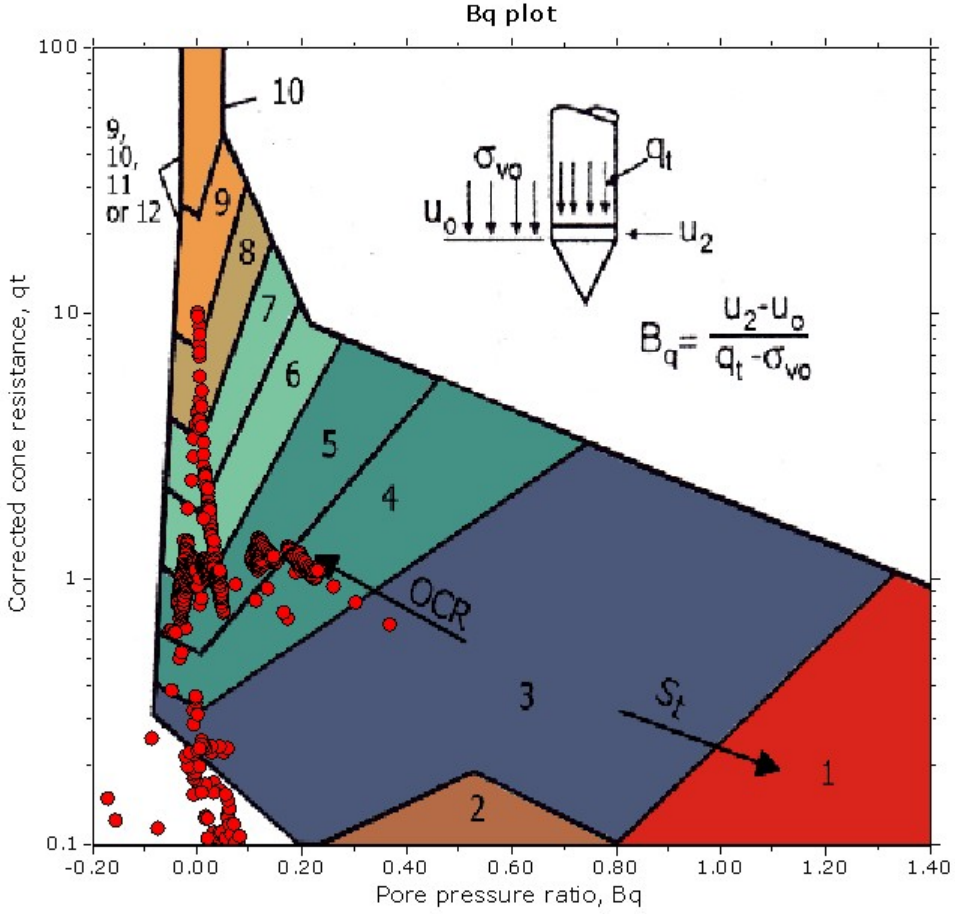
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

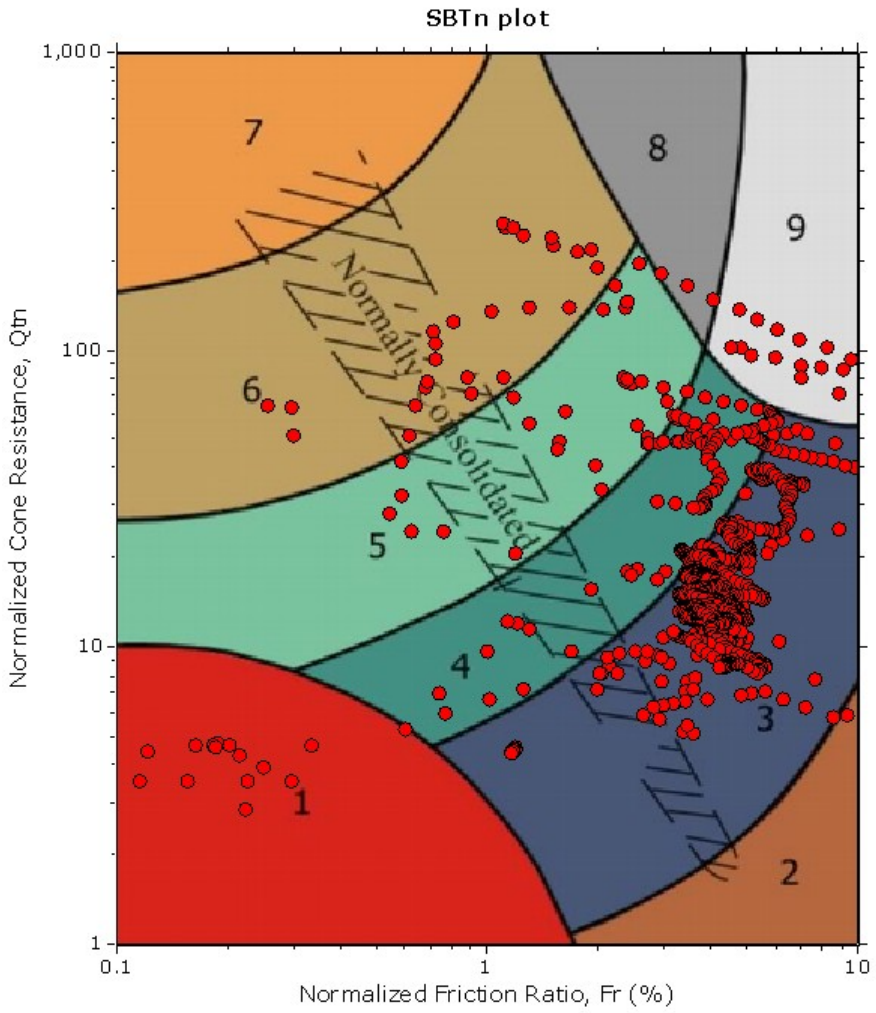
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

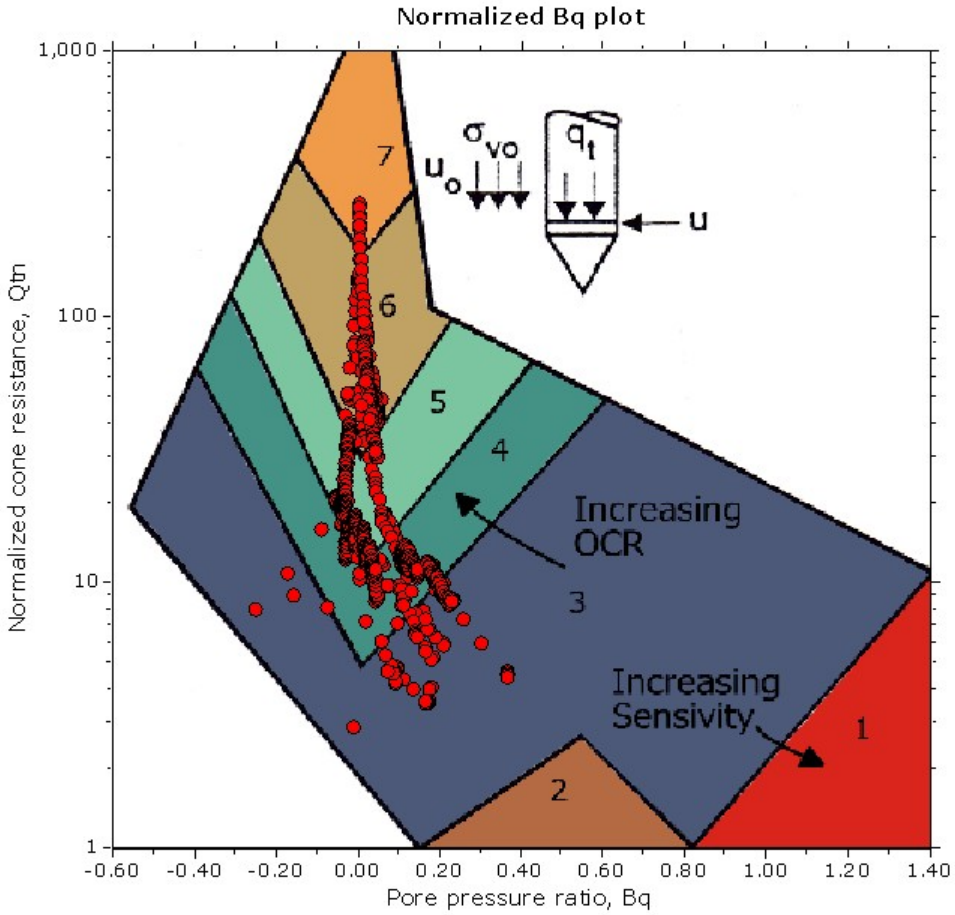
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

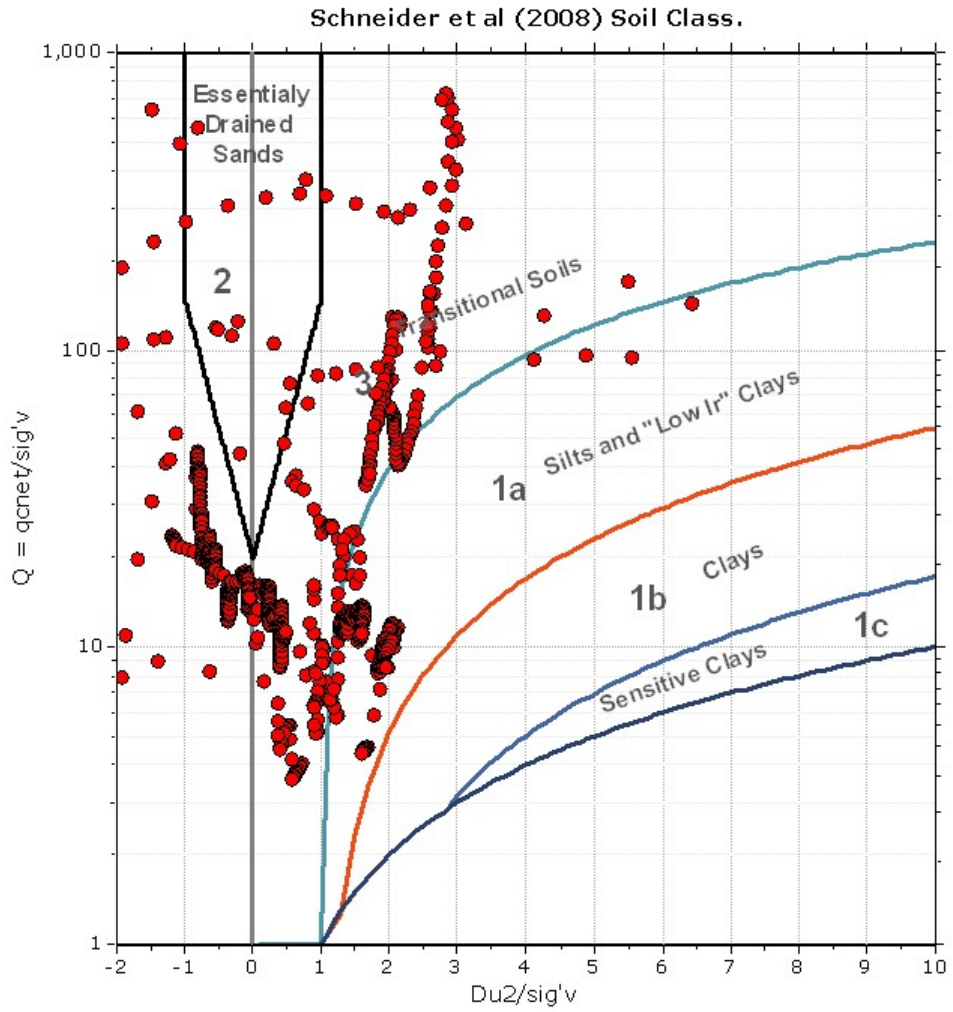
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

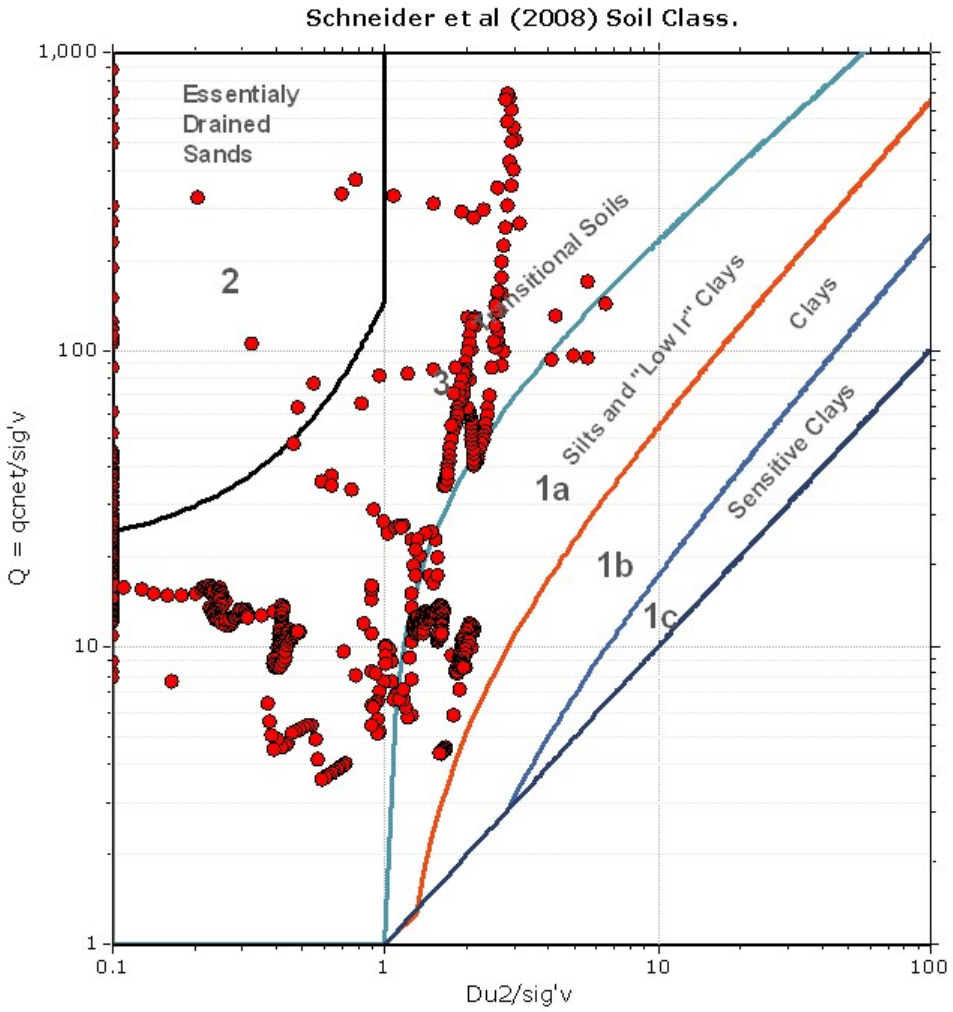
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



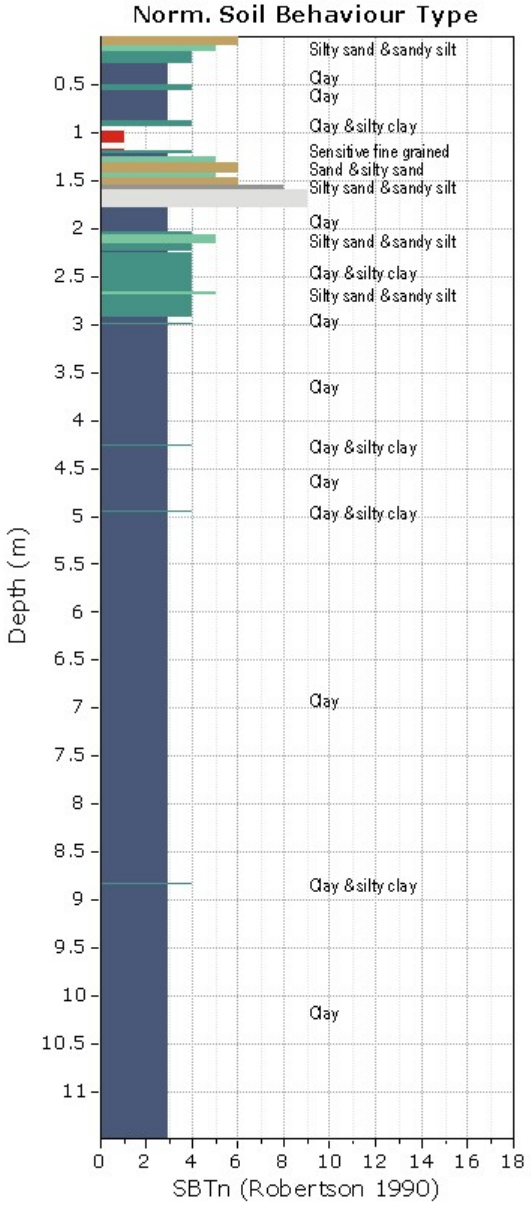


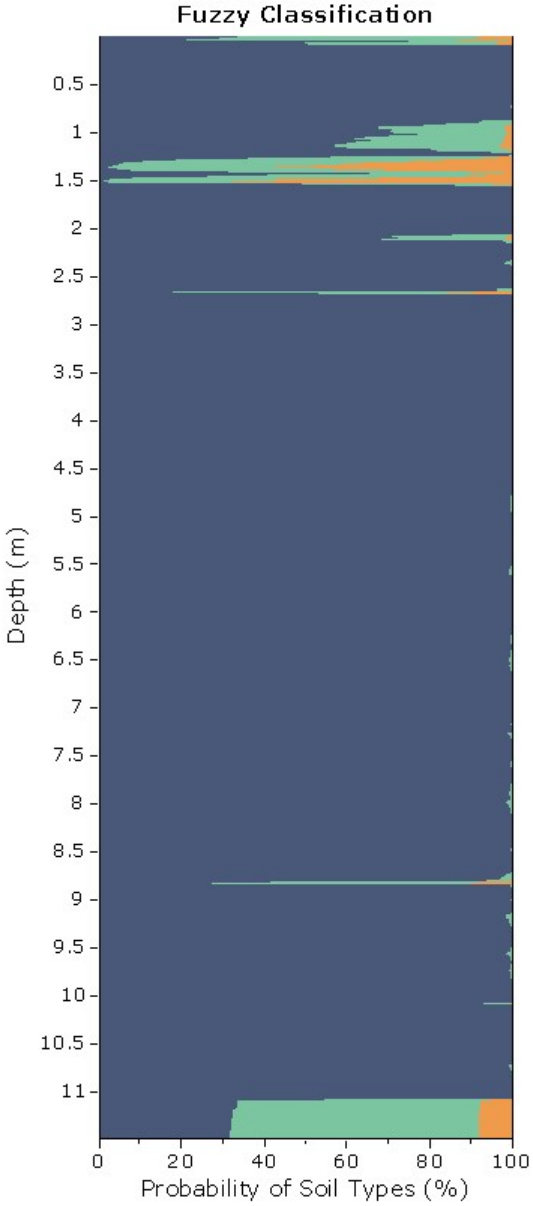
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-06

Project: **CA3043**
Location: **A1B2CH**

Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

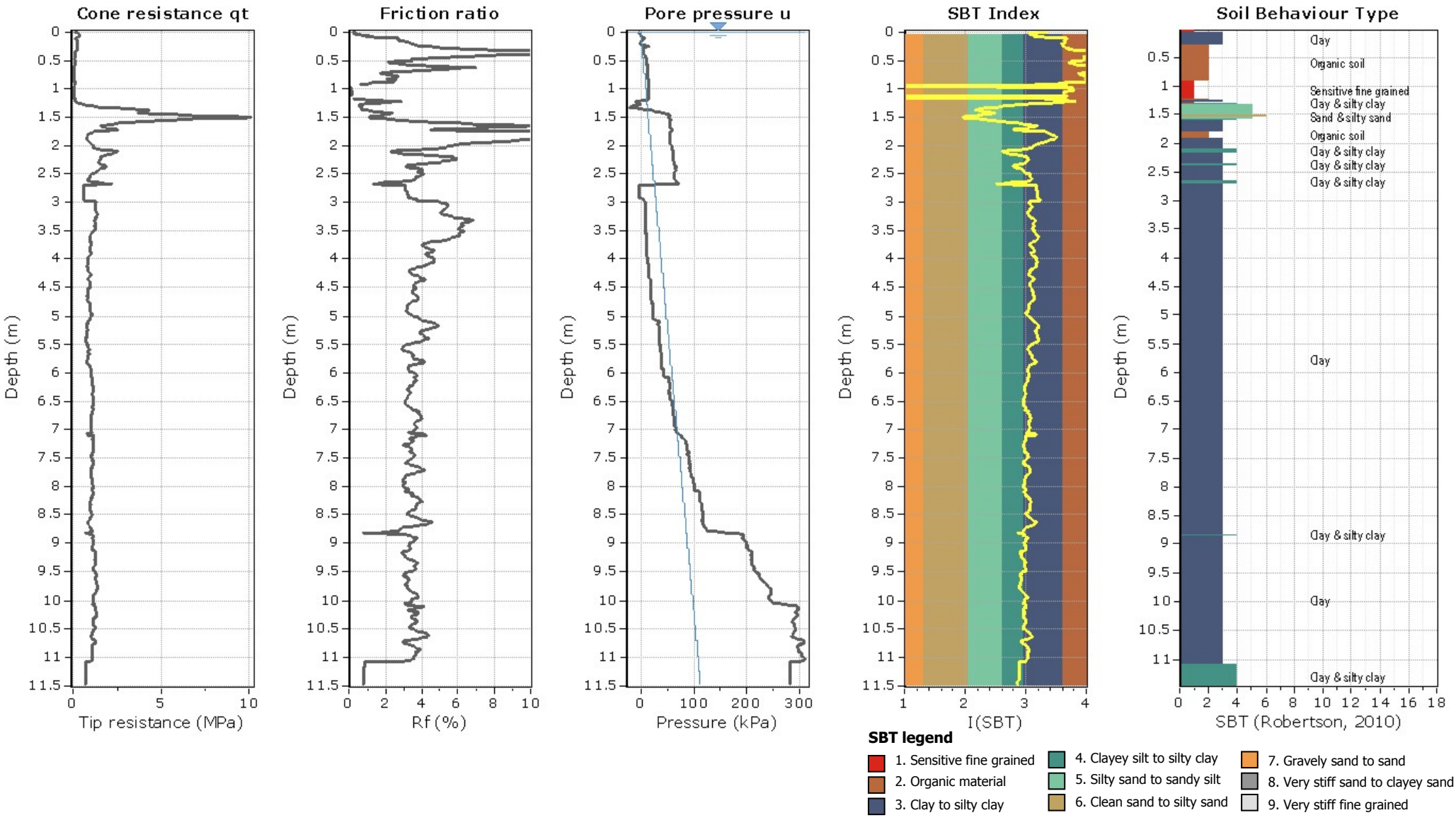




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

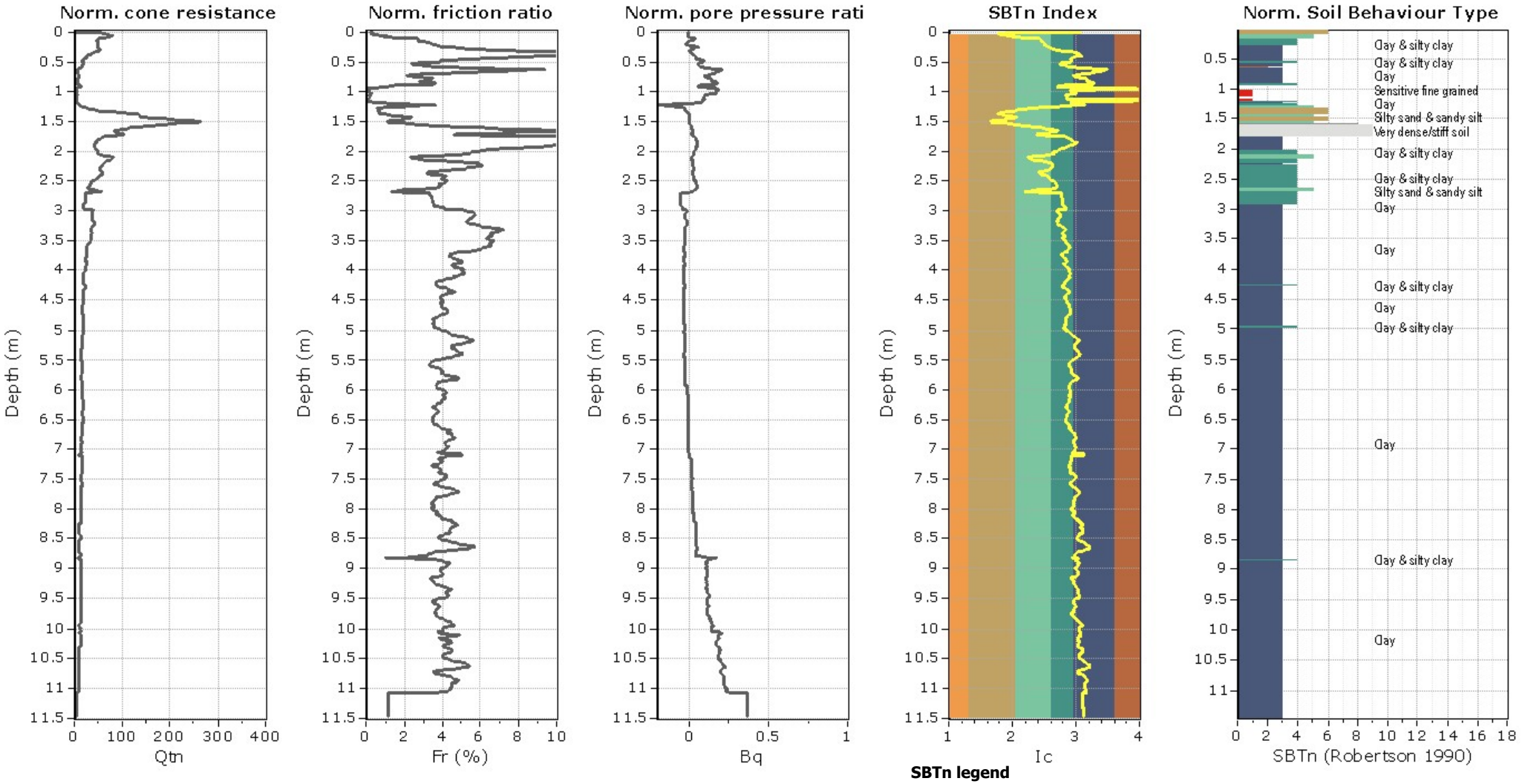
CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



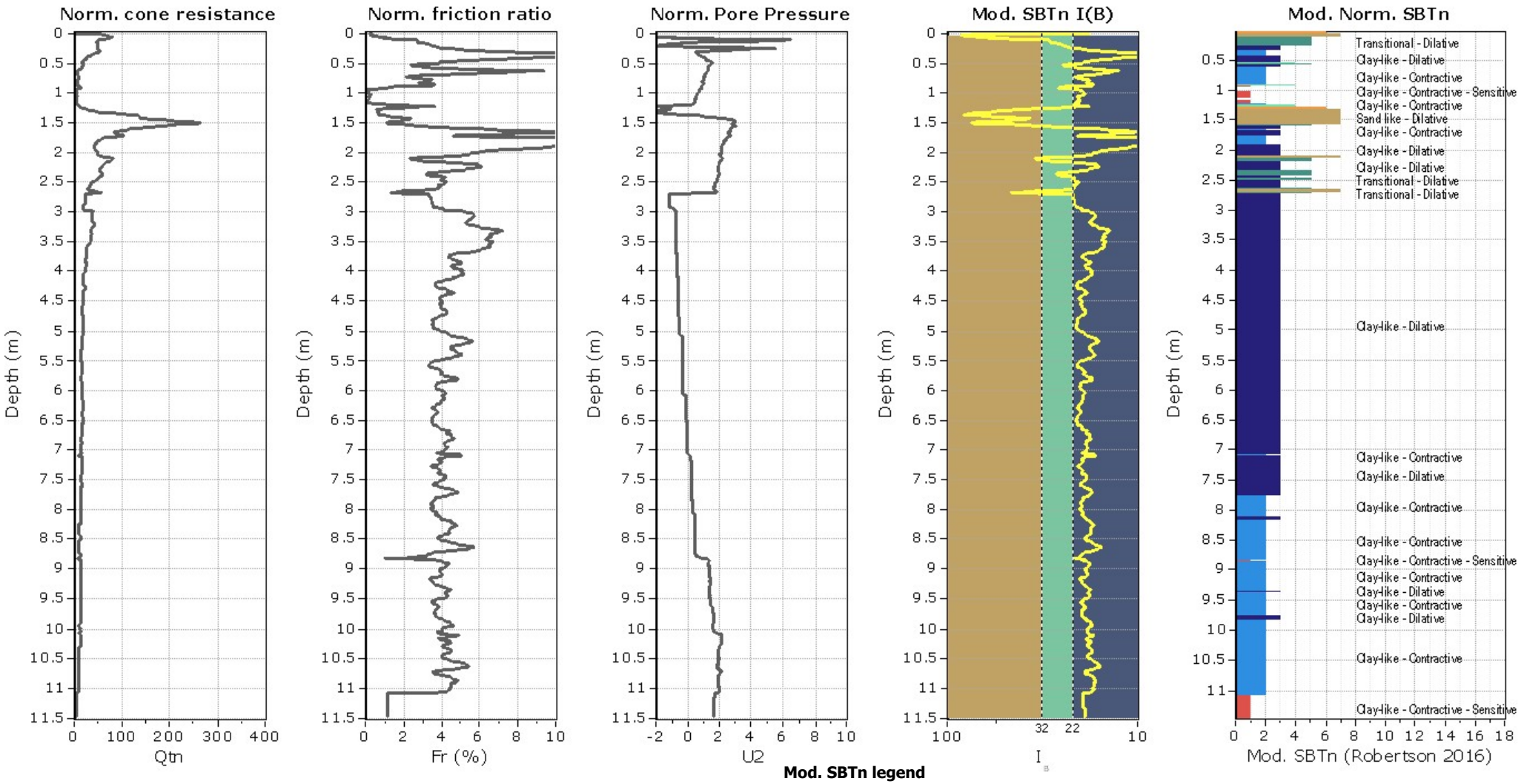
SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

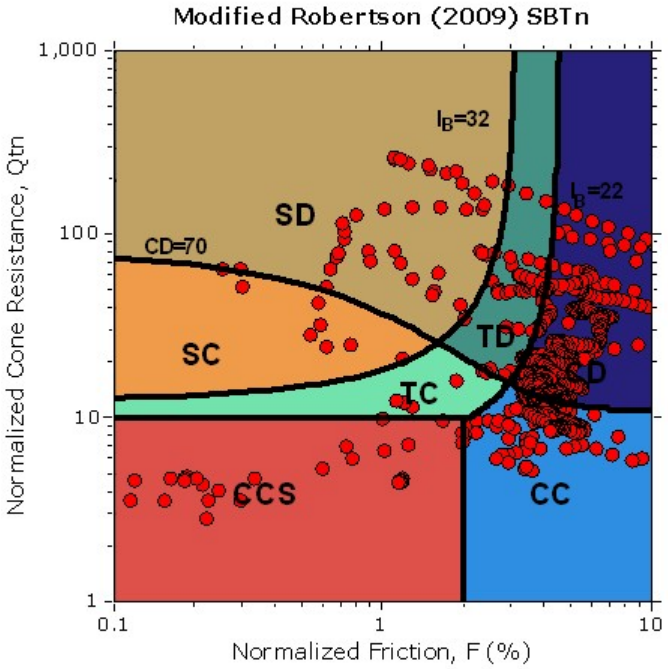


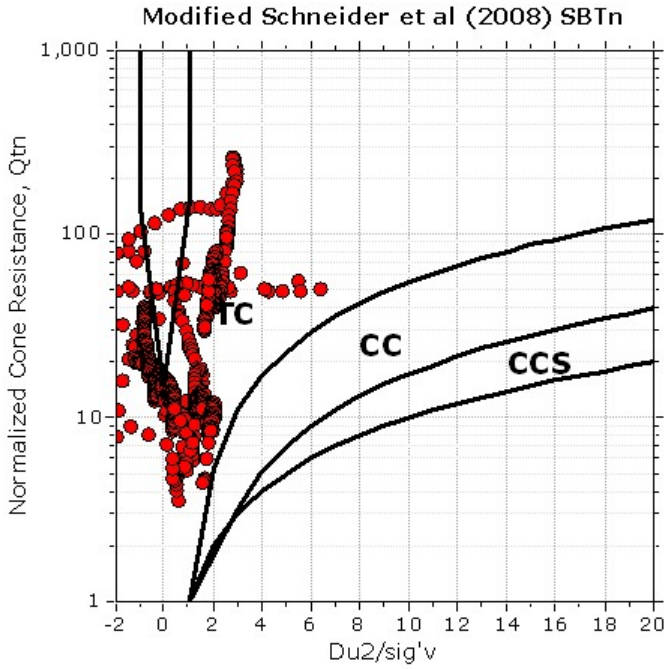
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

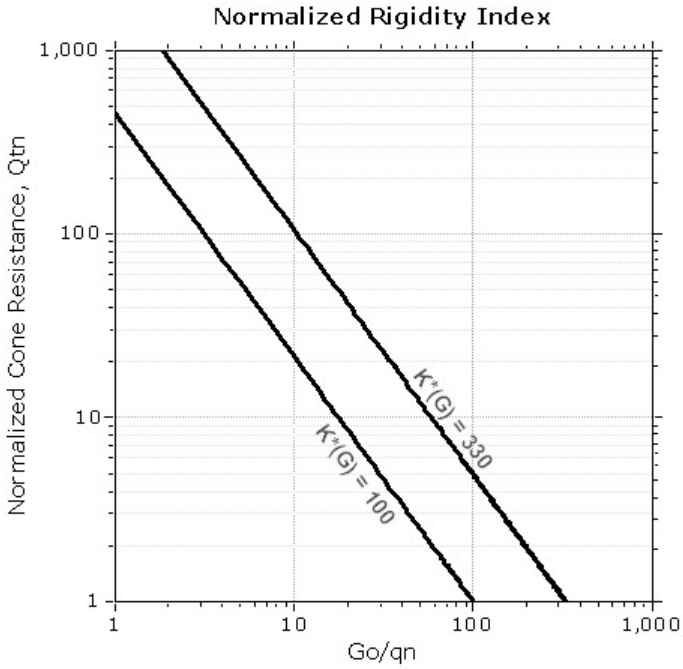
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







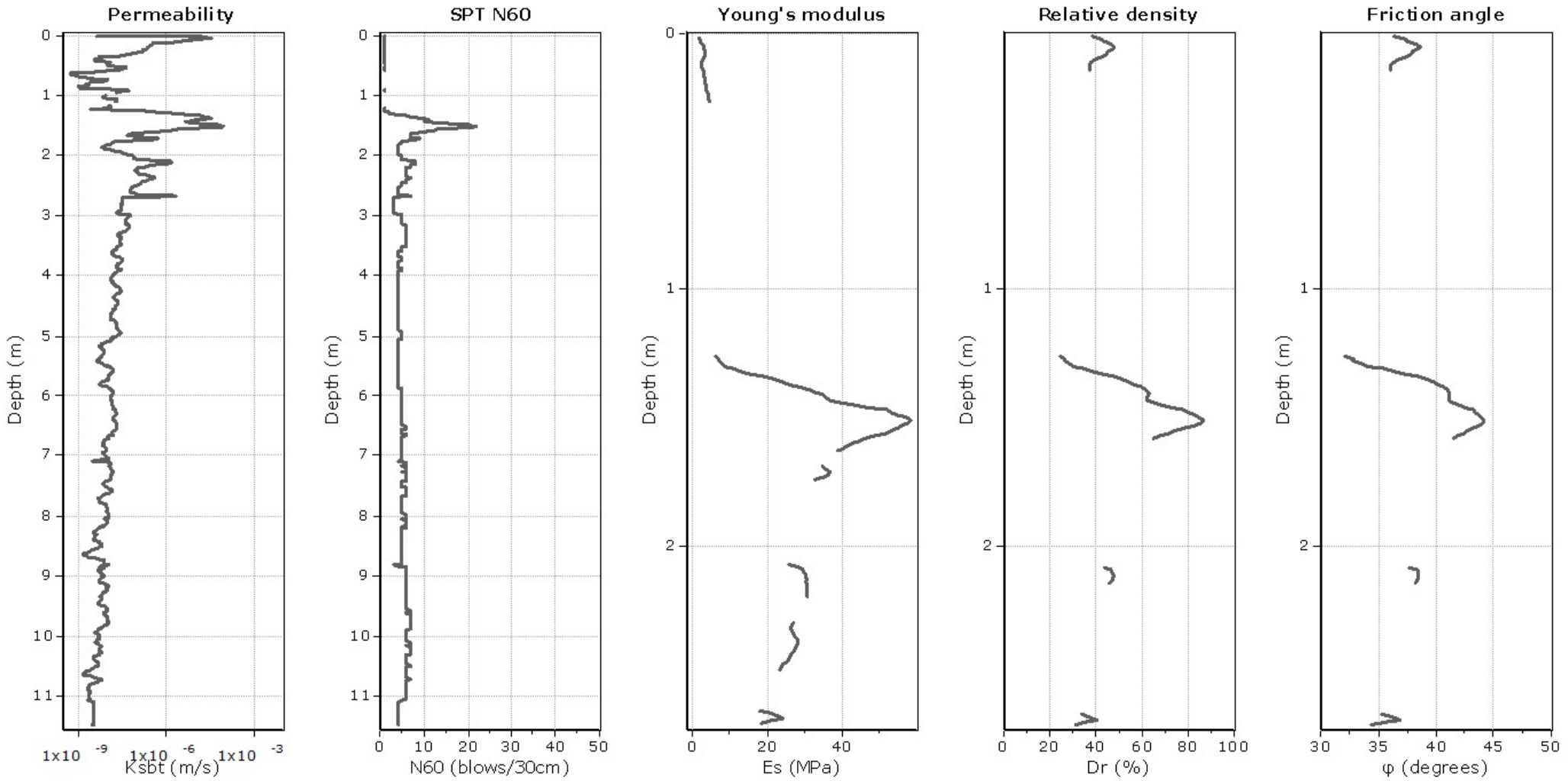
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



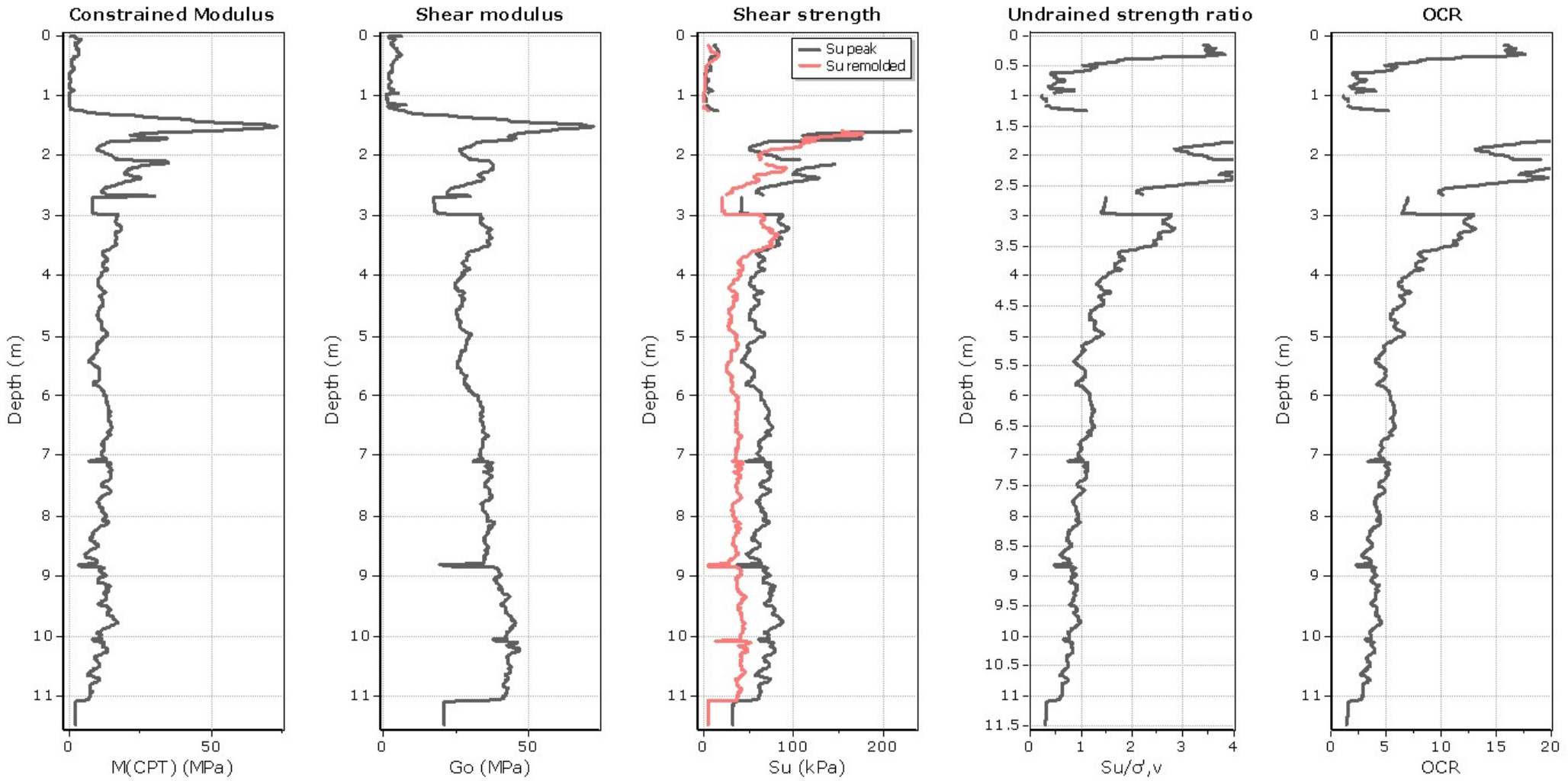
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



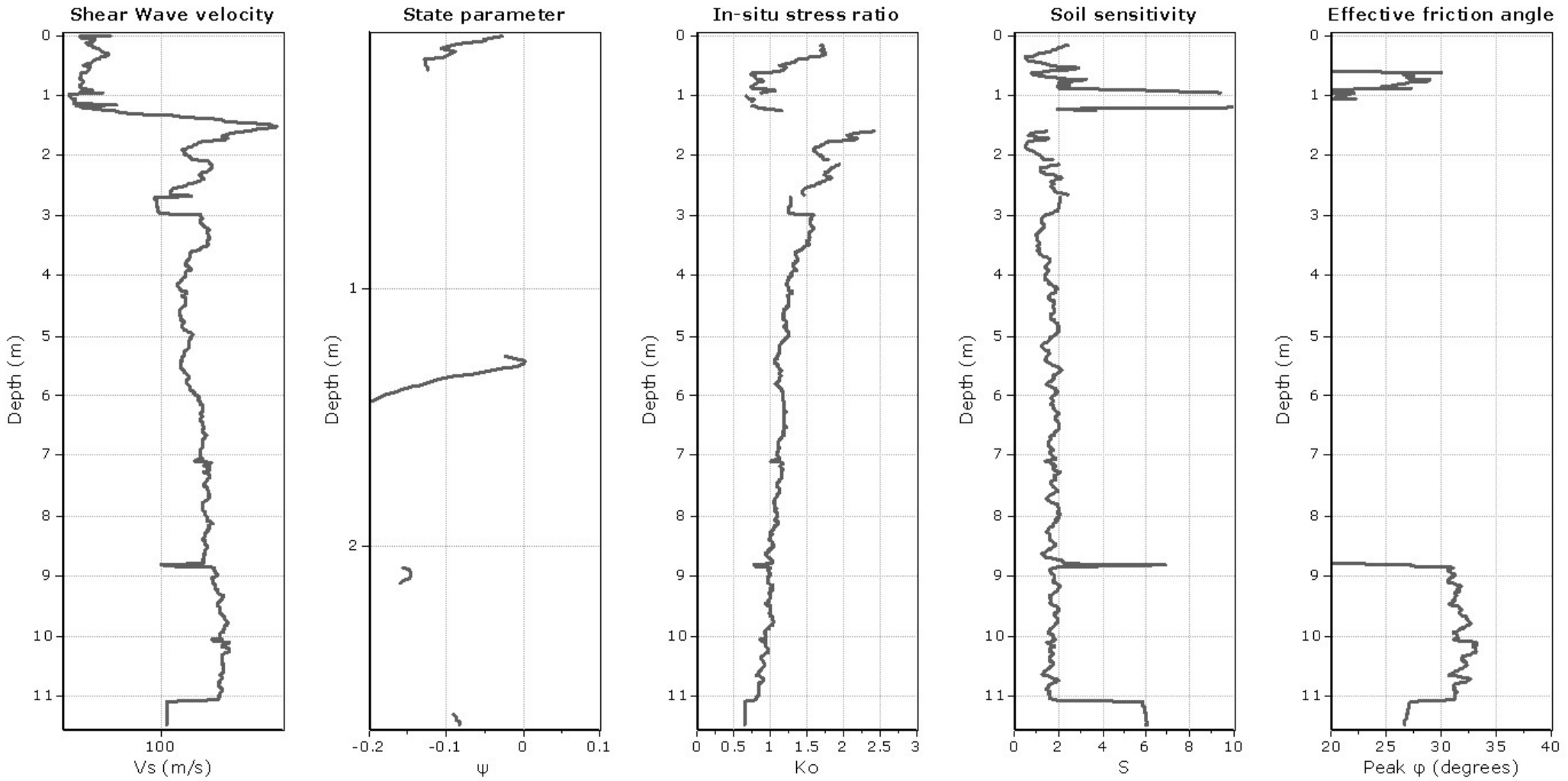
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06
Total depth: 11.48 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

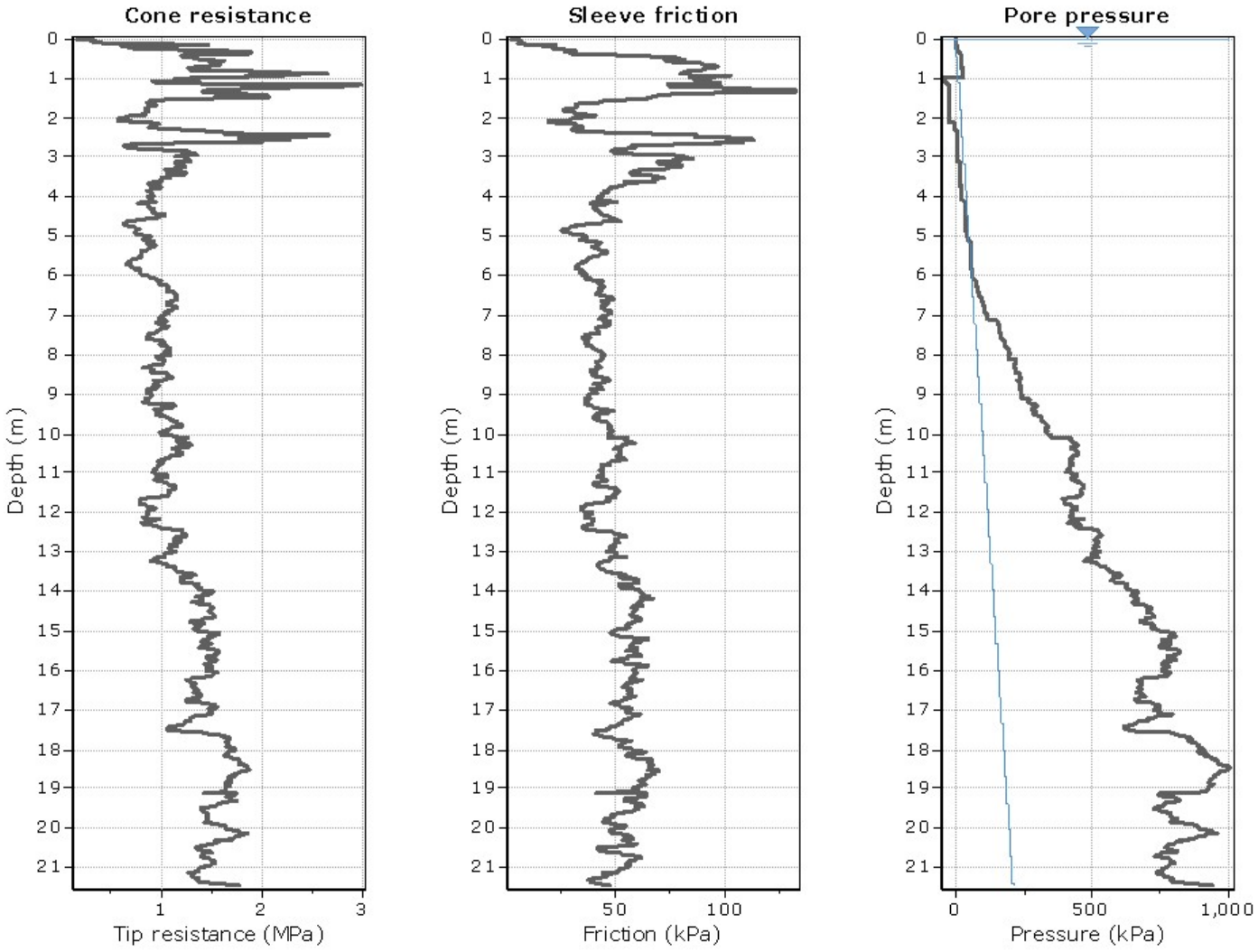
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

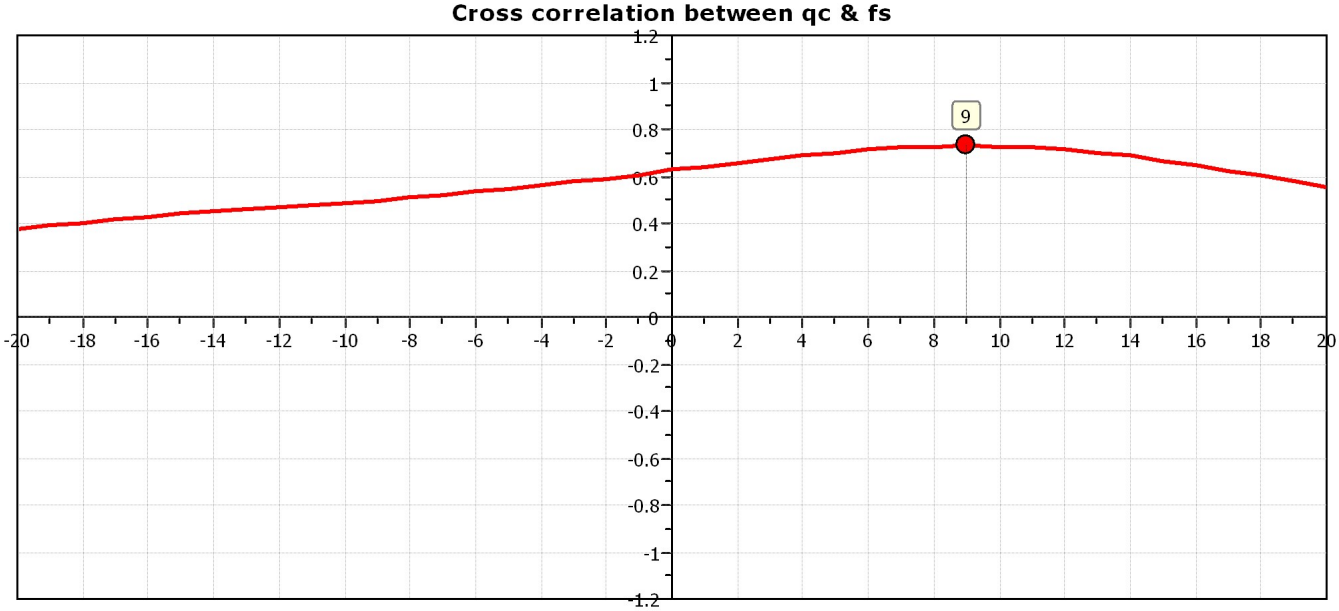
CPT: CPT17-06A

Project: **CA3043**
Location: **A1B2CH**

Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

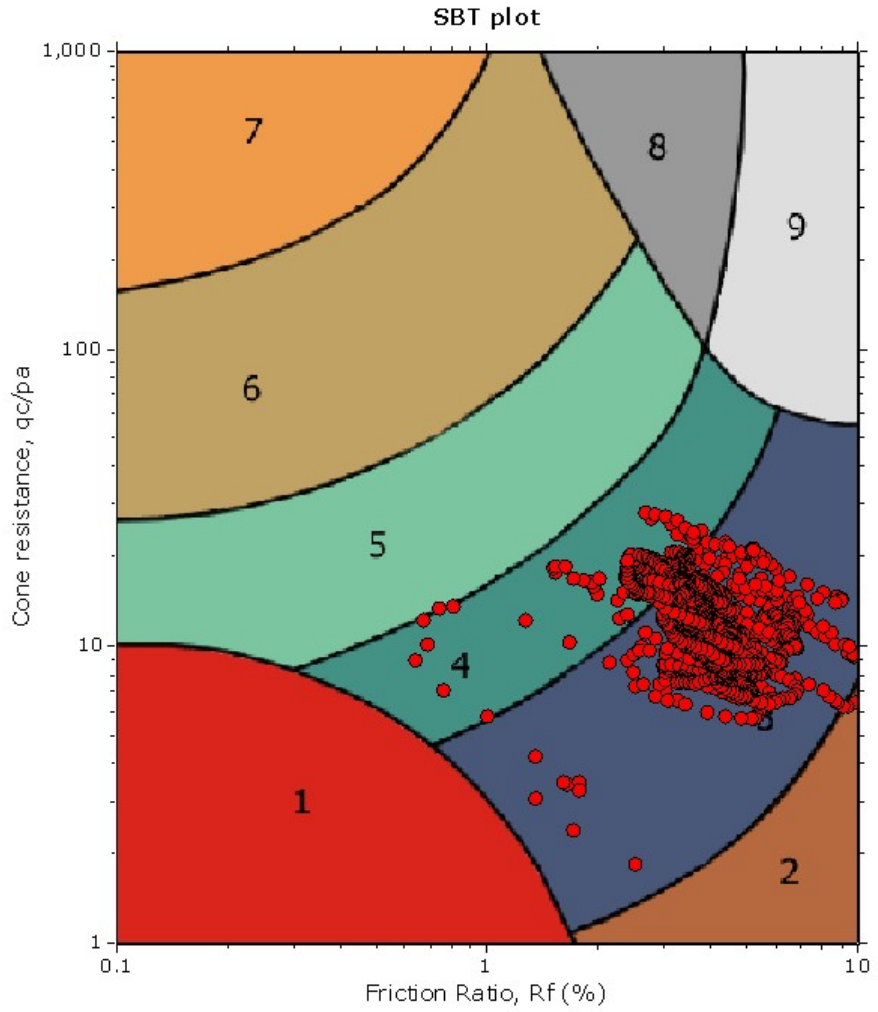


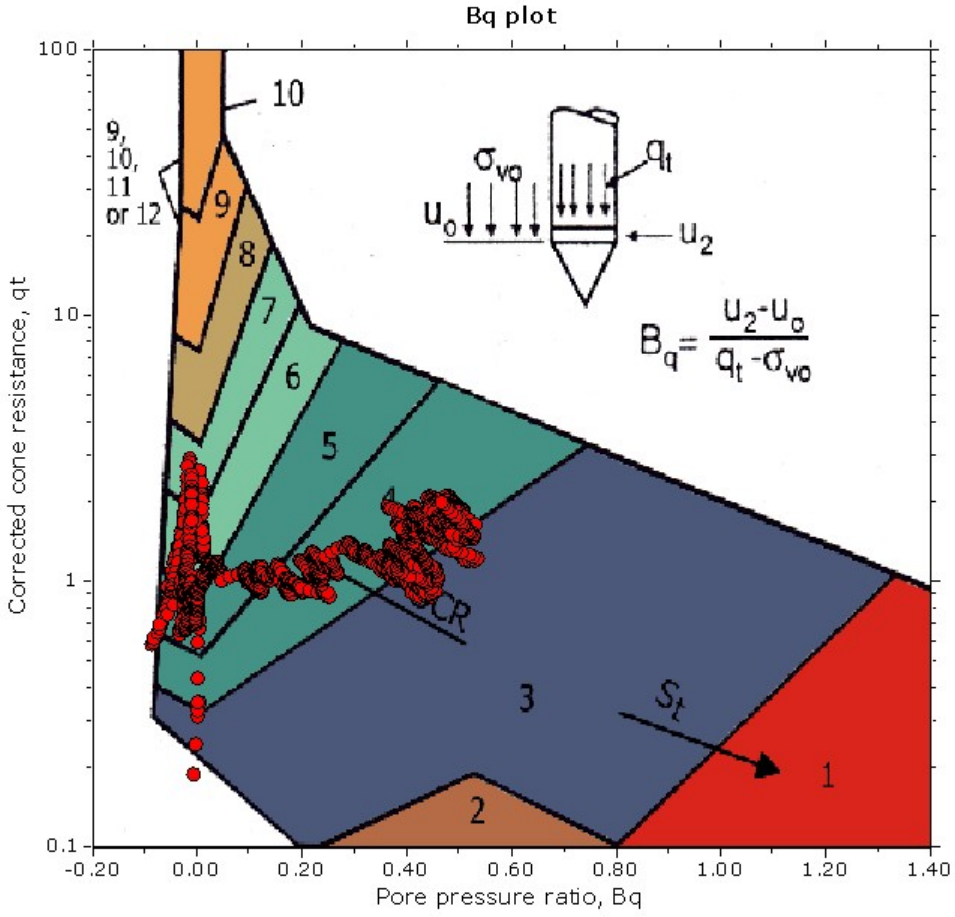
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

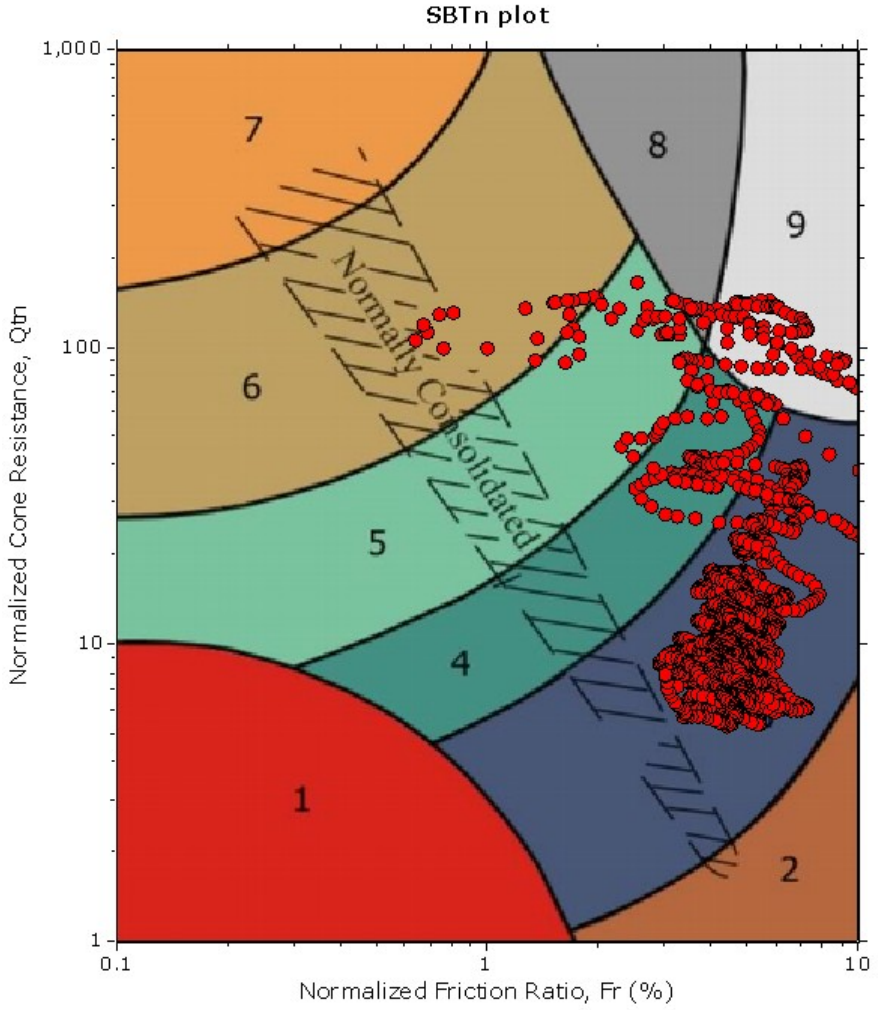
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

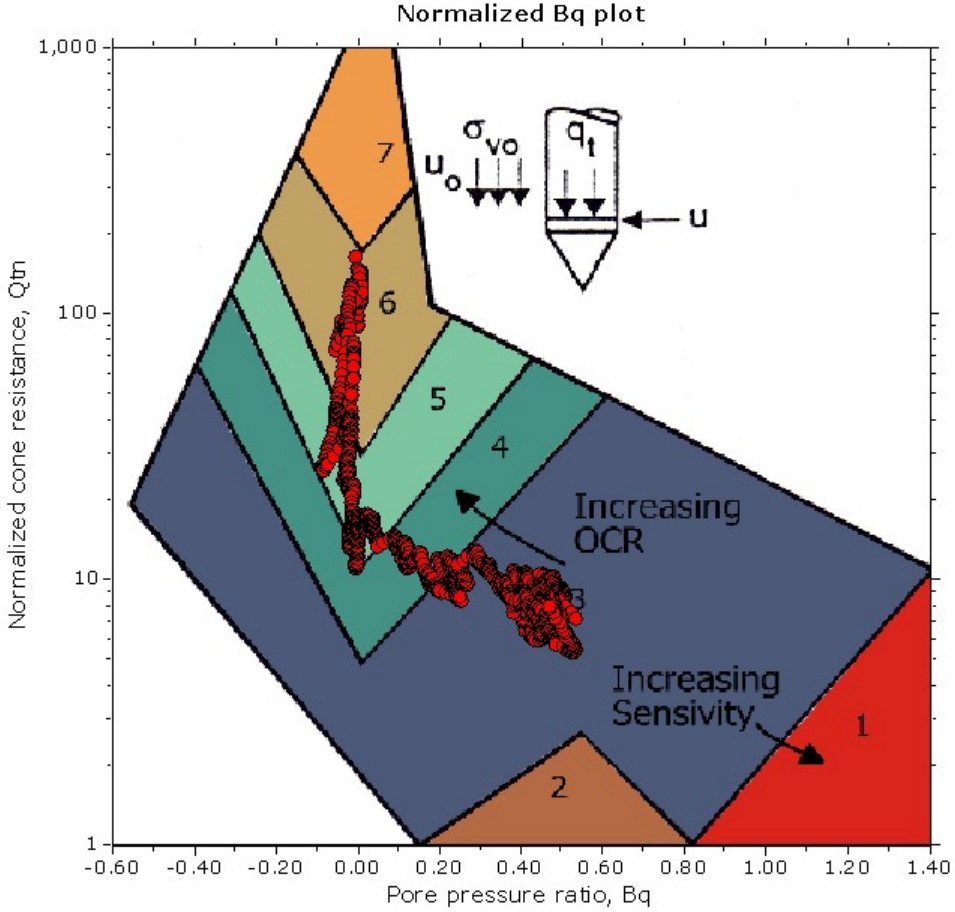
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

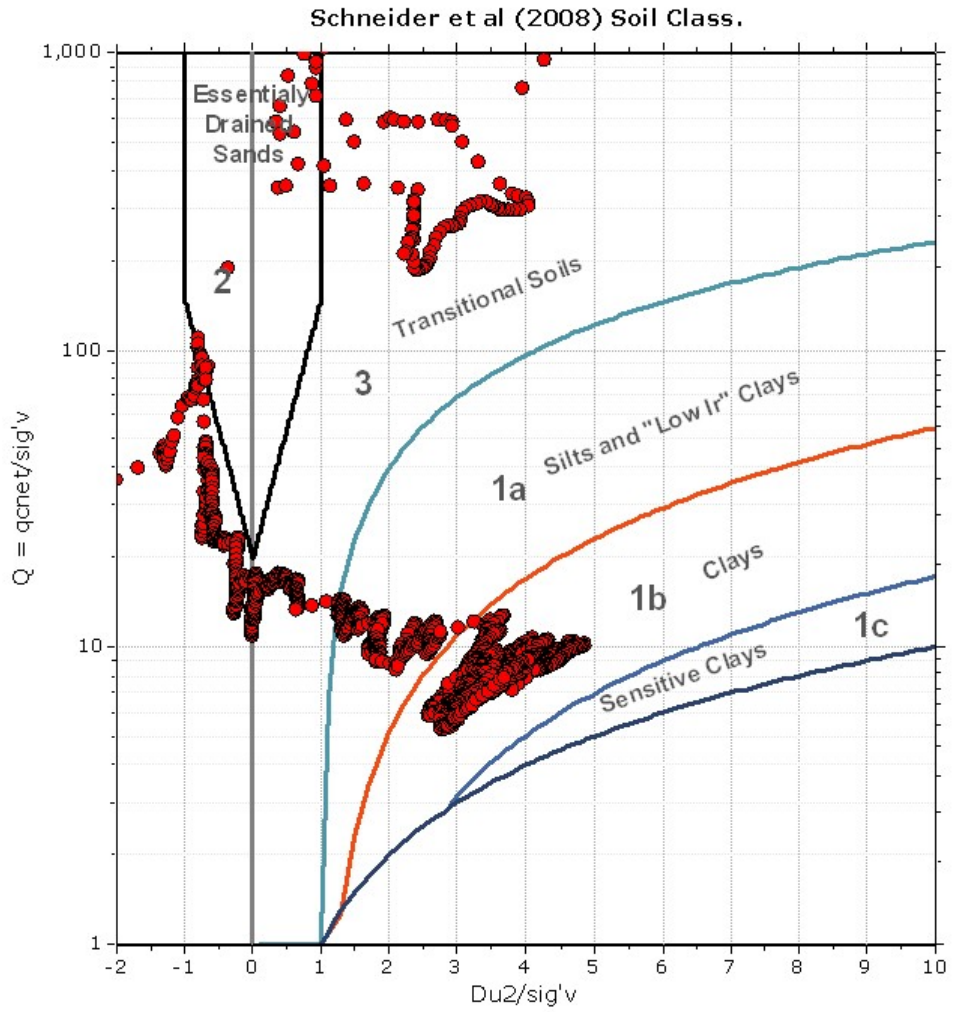
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

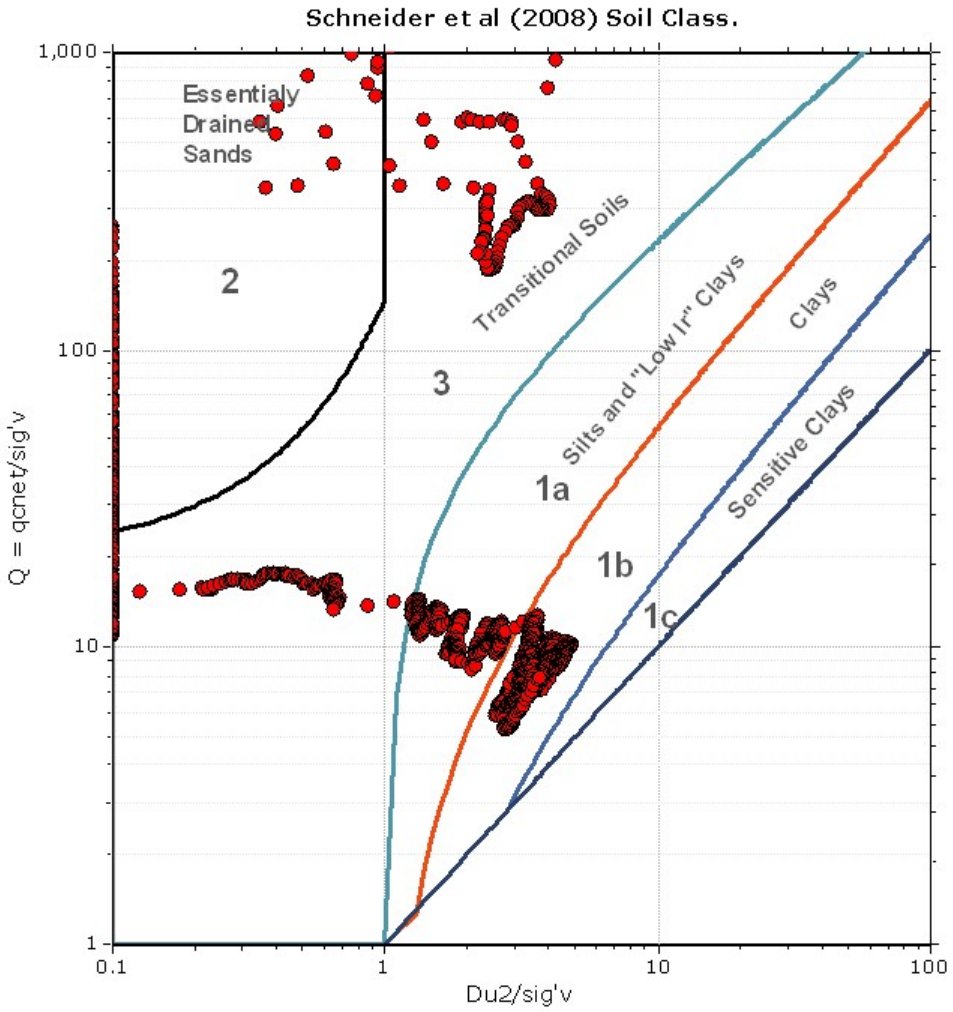
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



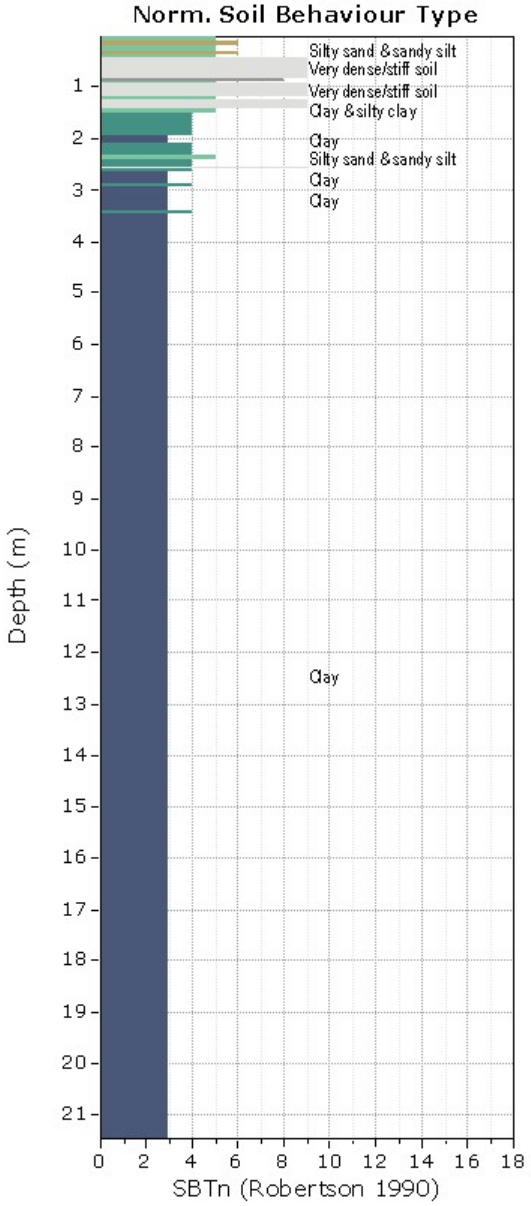


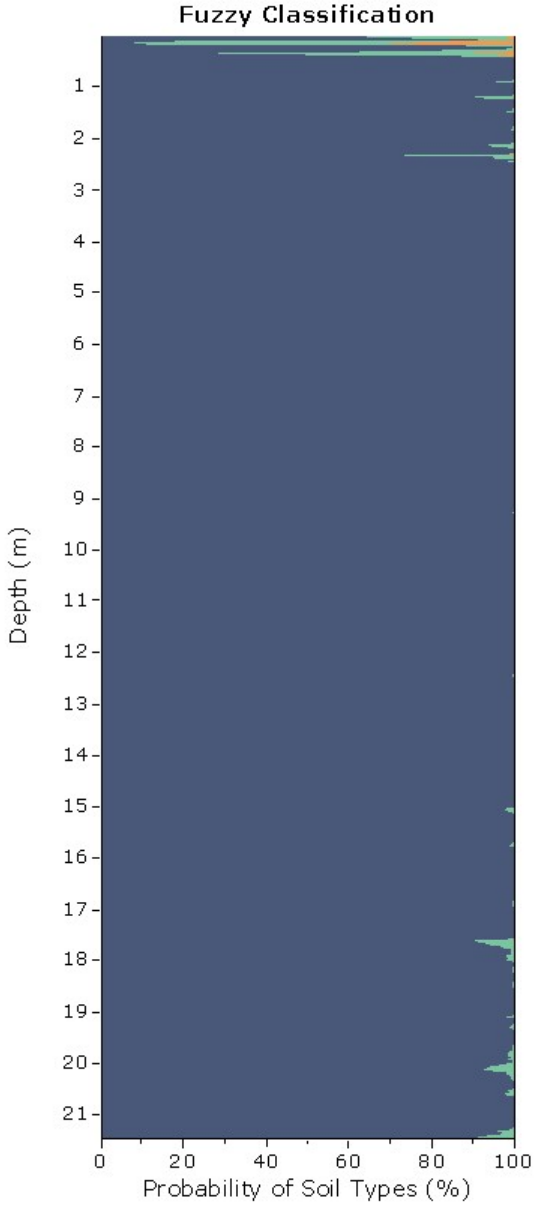
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-06A

Project: **CA3043**
Location: **A1B2CH**

Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

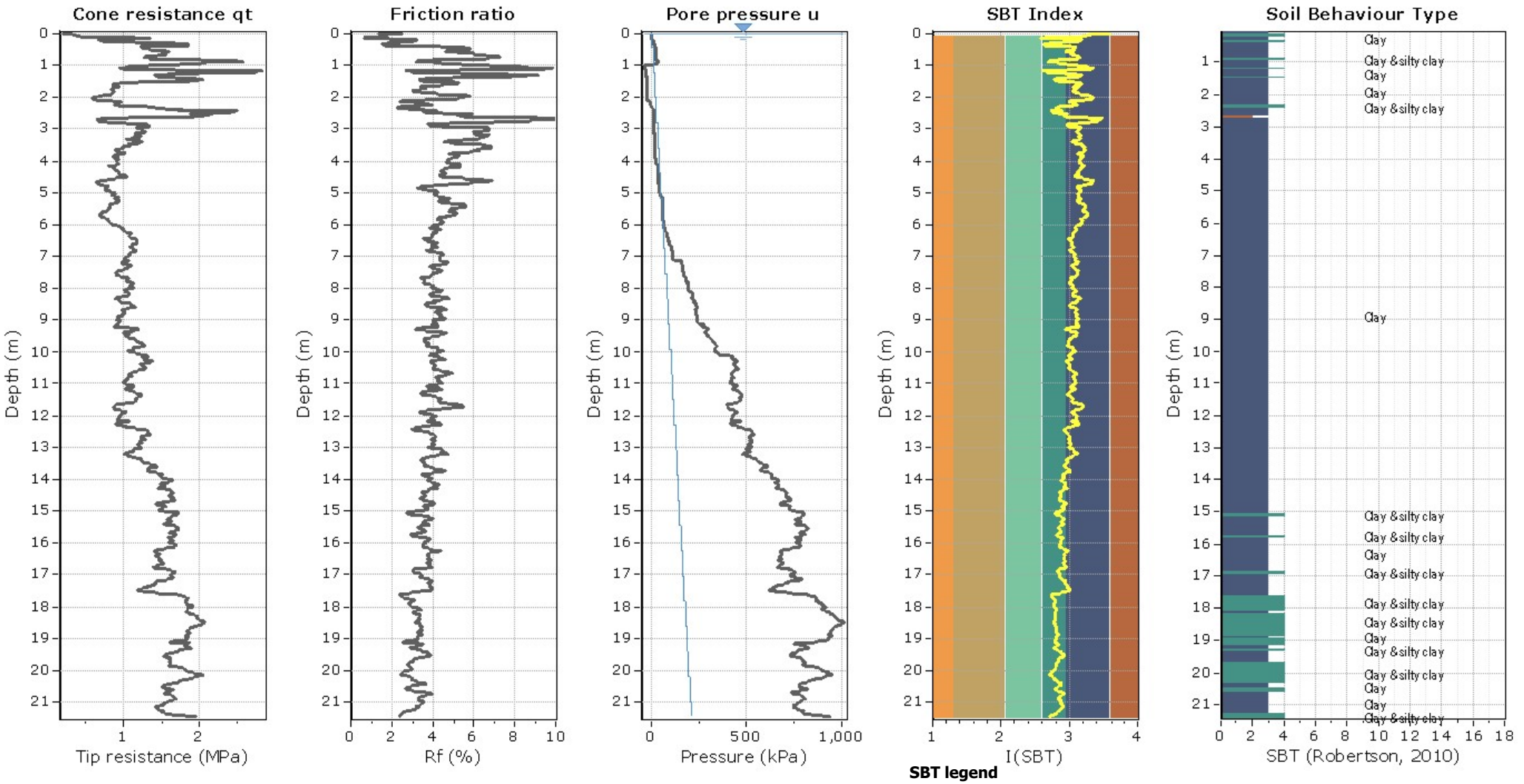




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

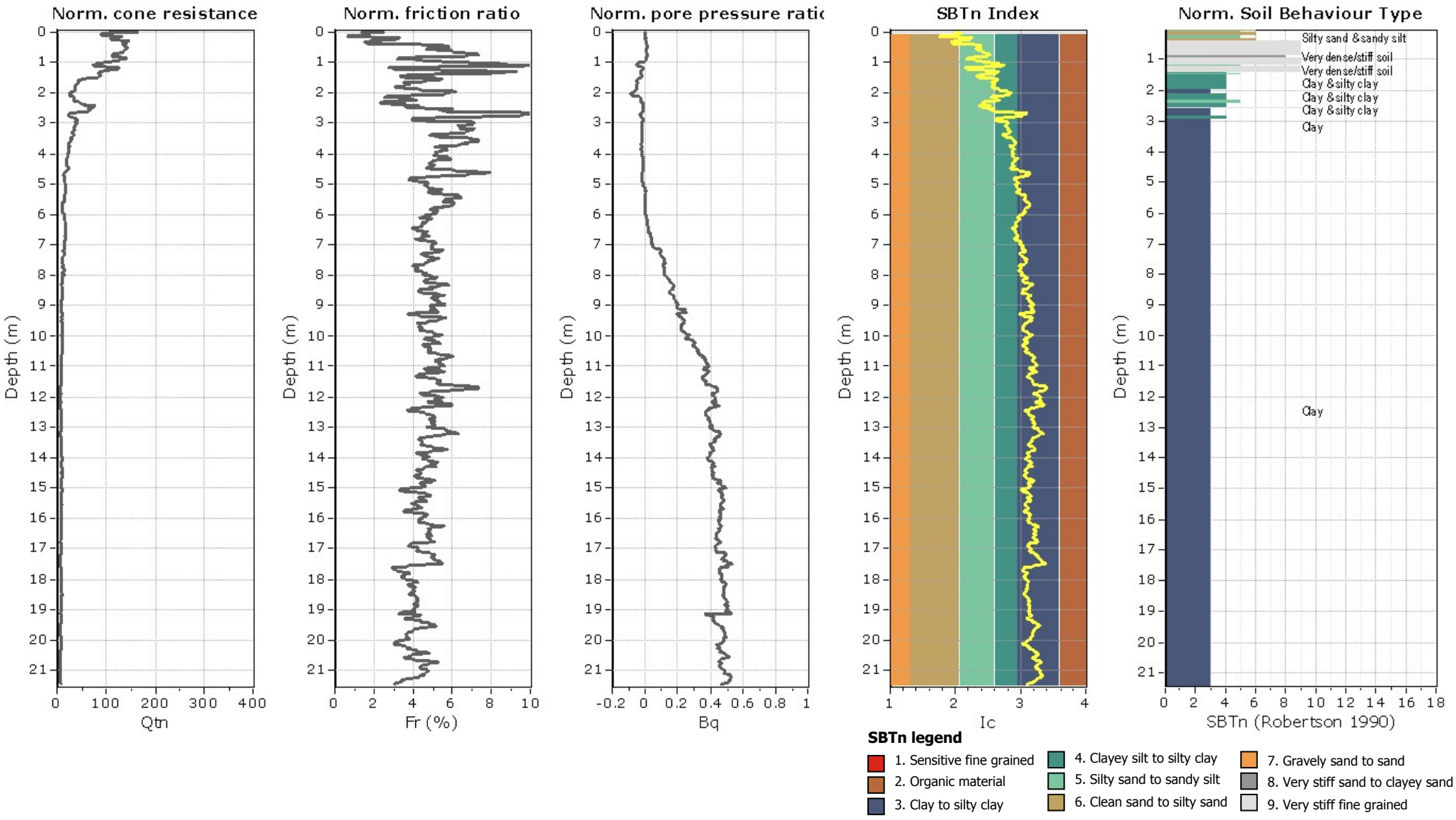
CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

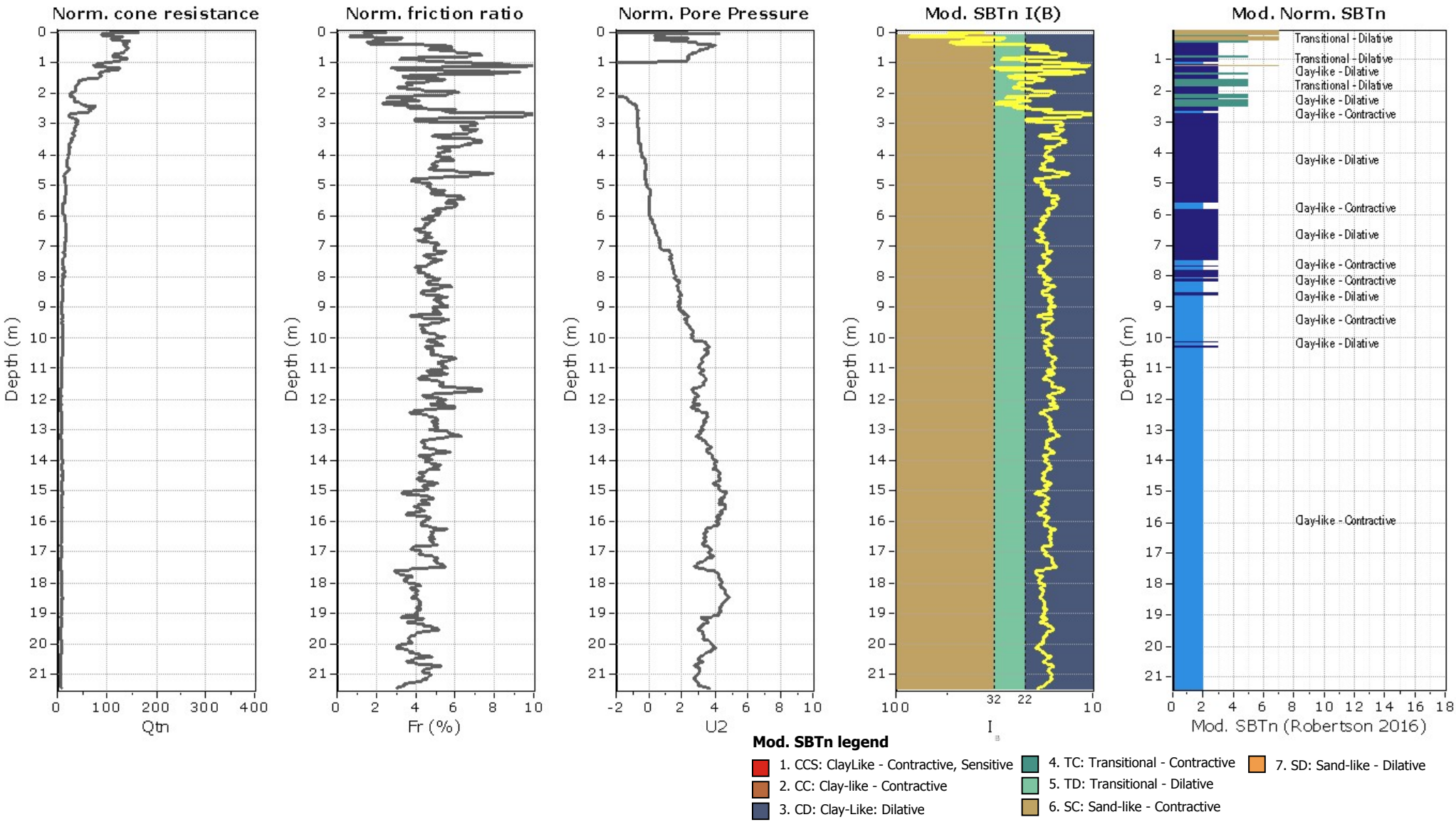
CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

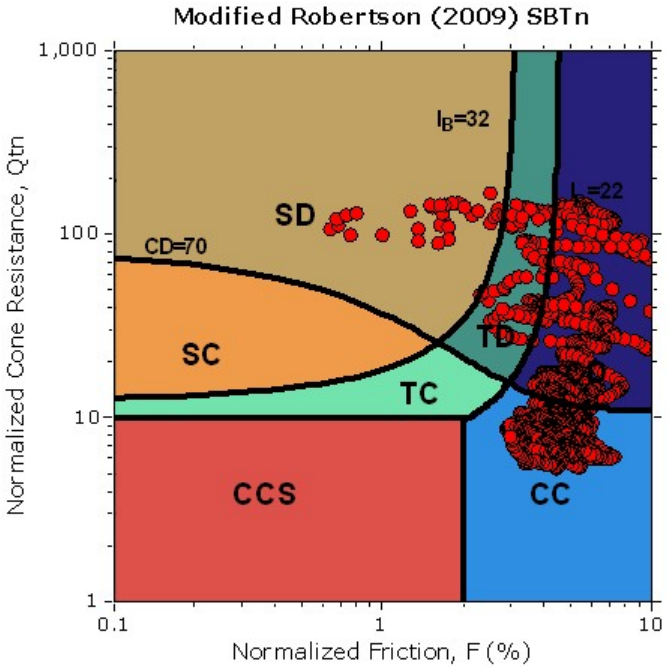


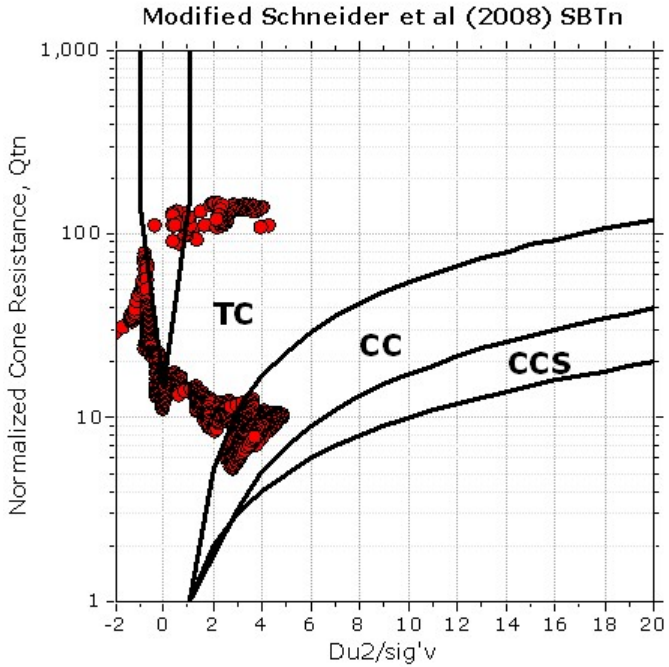
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

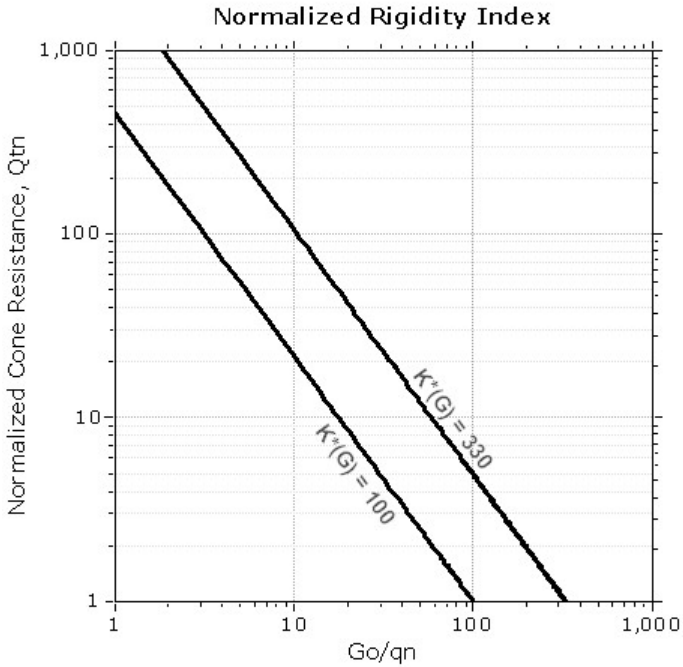
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







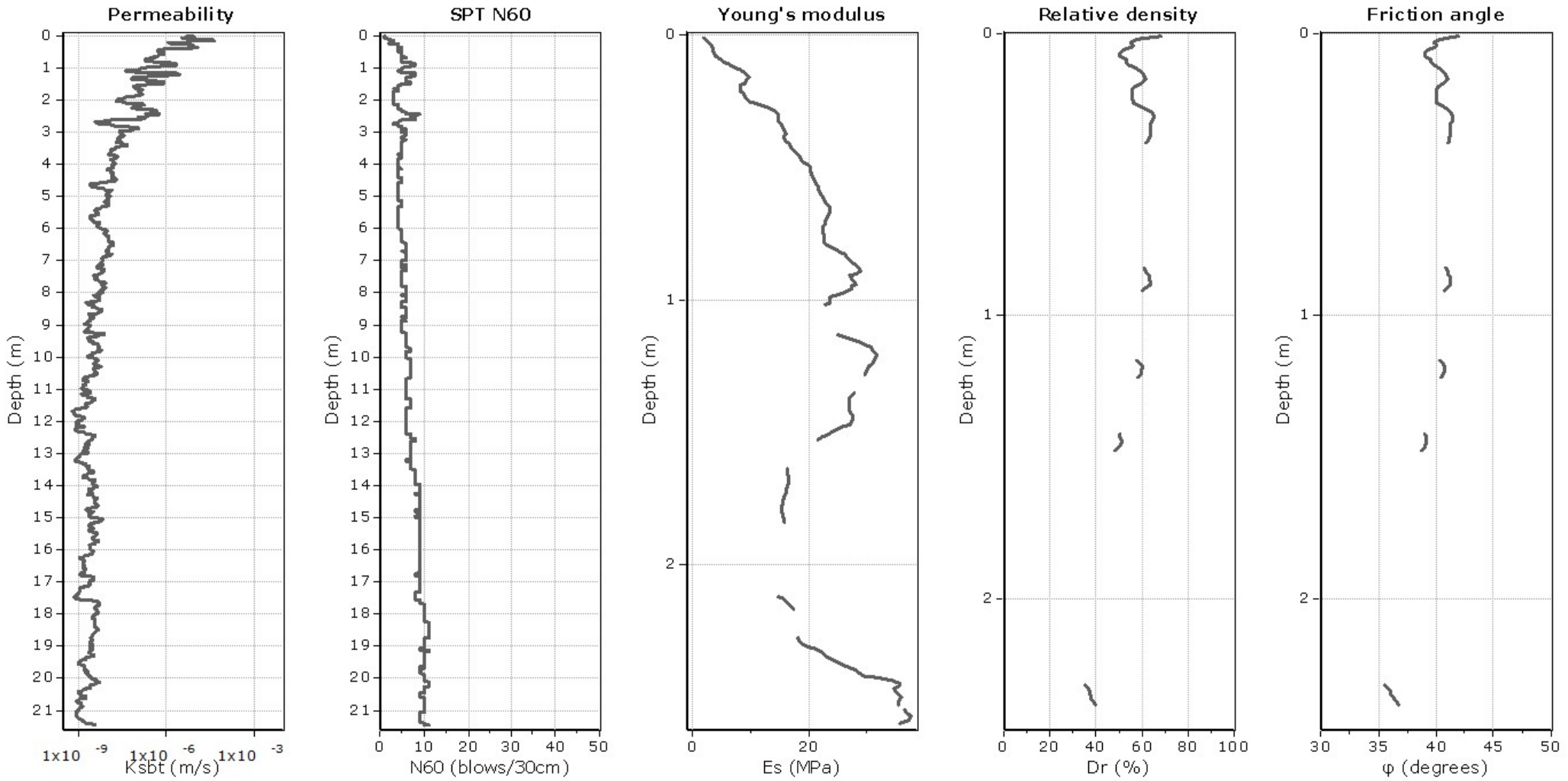
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



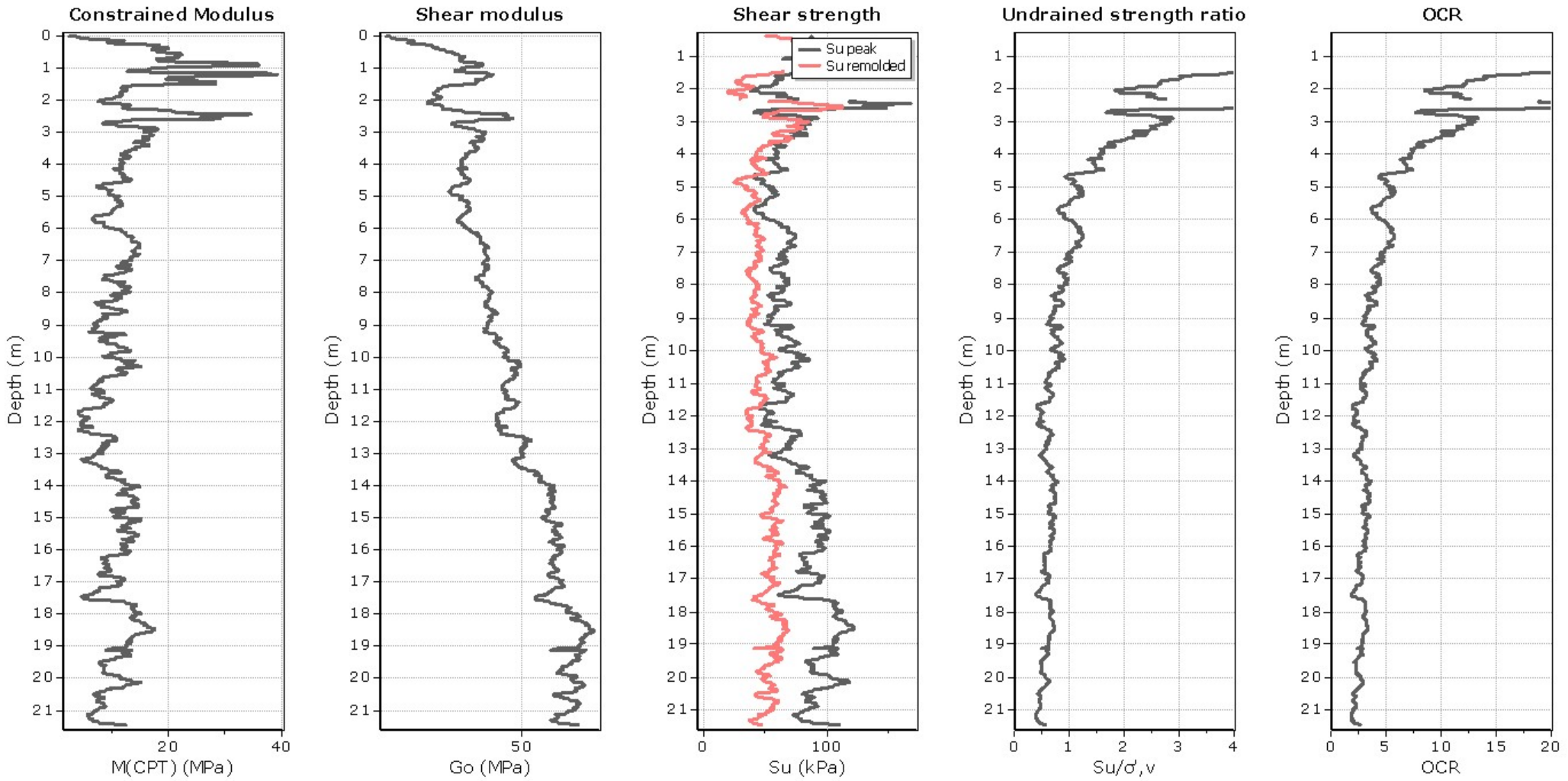
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



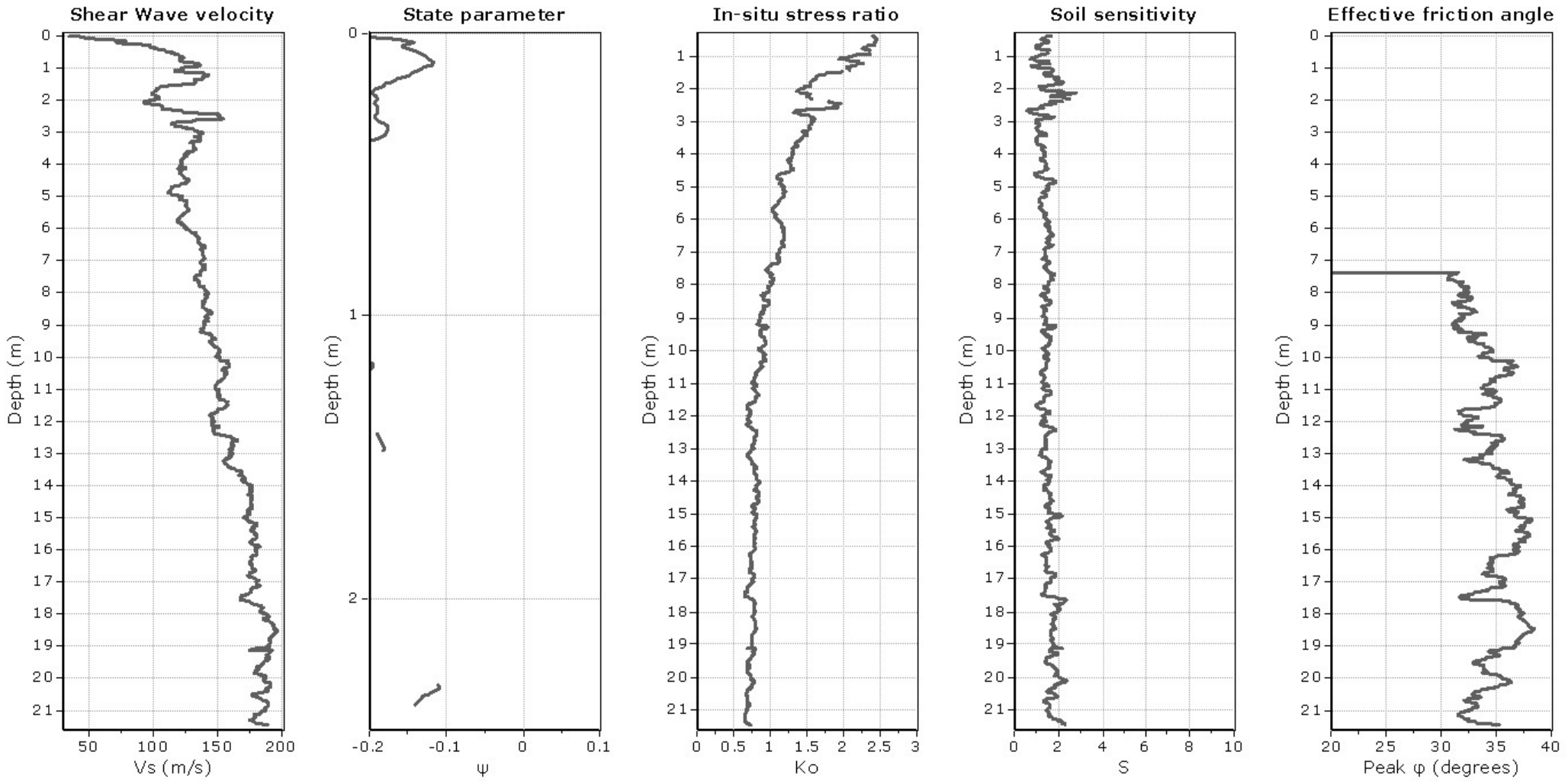
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-06A
Total depth: 21.45 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

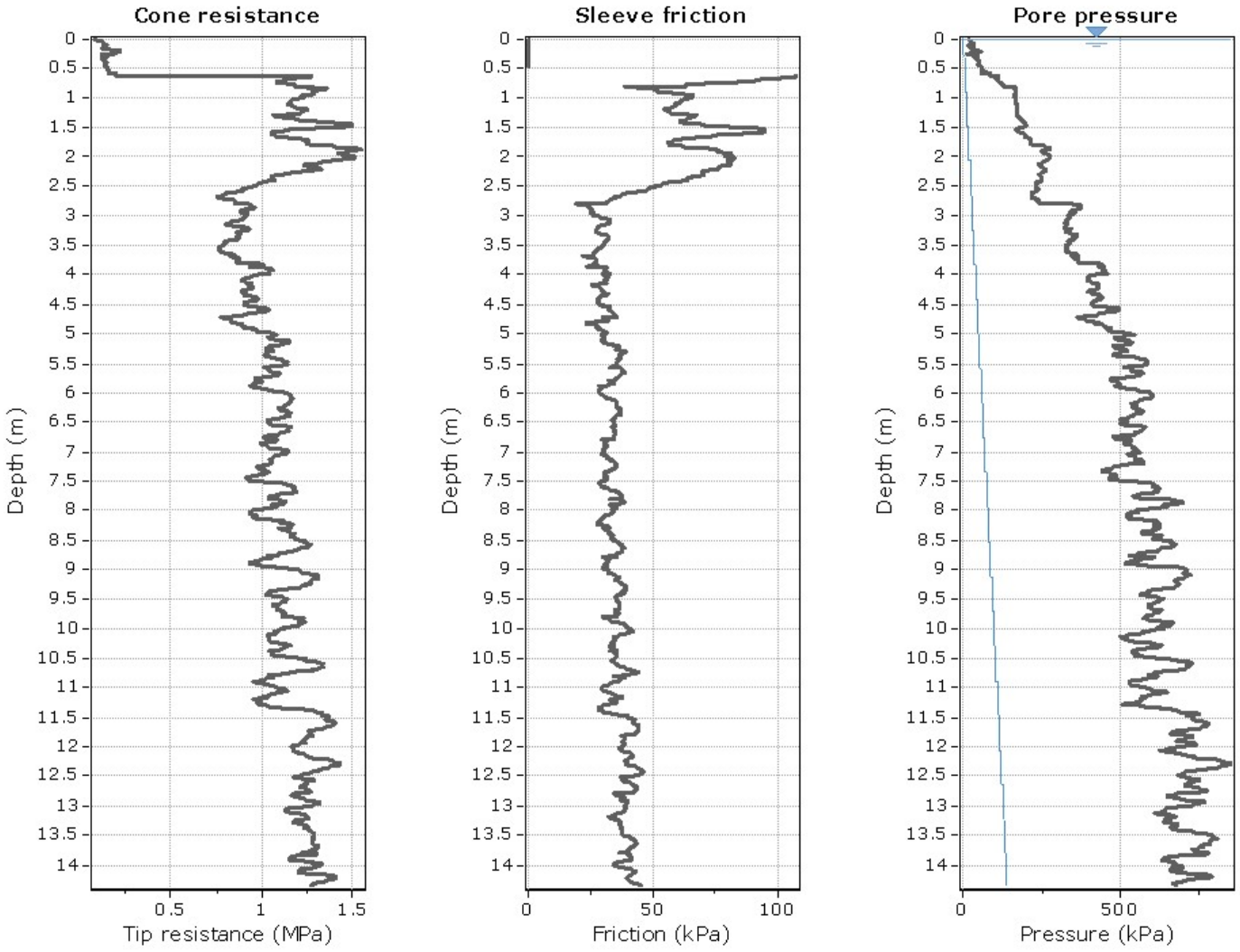
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

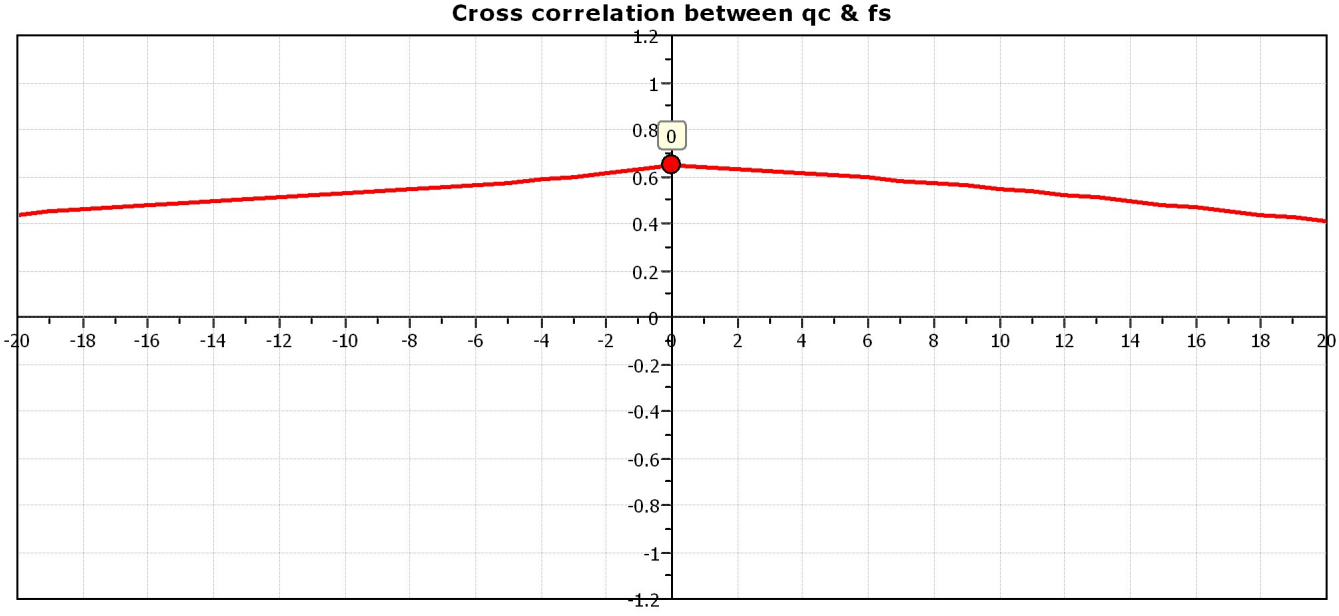
CPT: CPT17-07

Project: **A1B2CH**
Location: **Birtley to Coal House**

Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

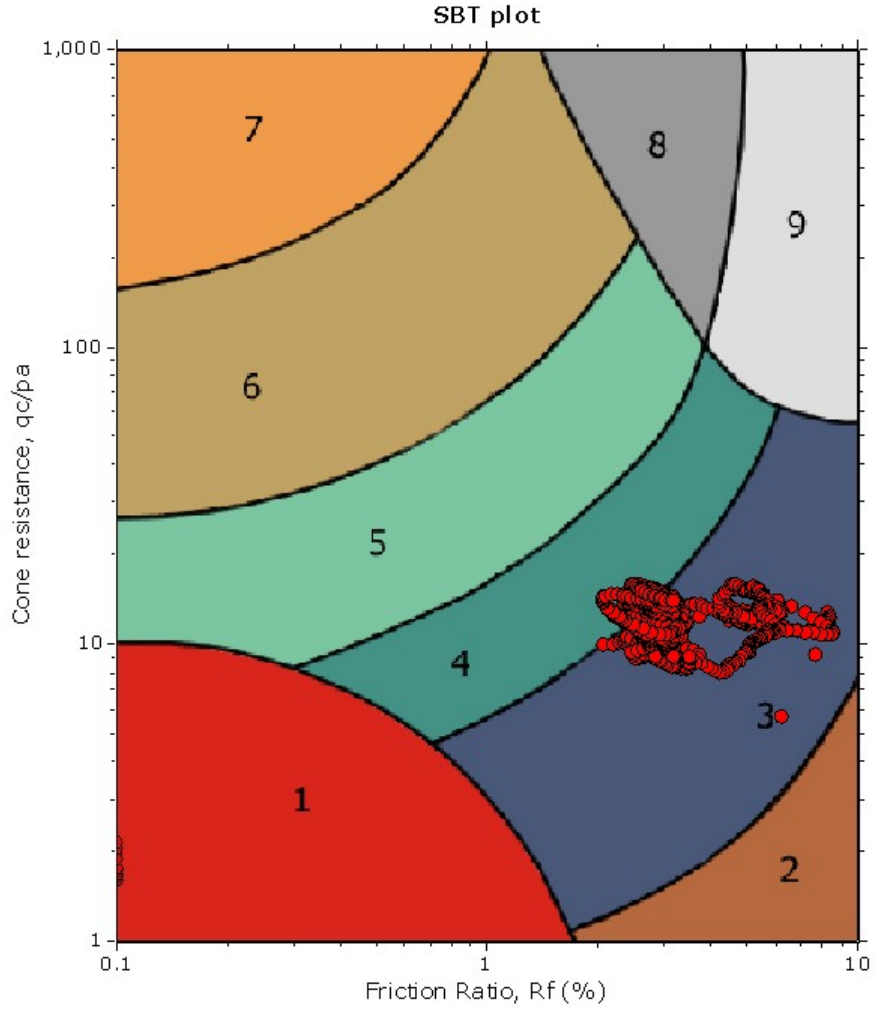


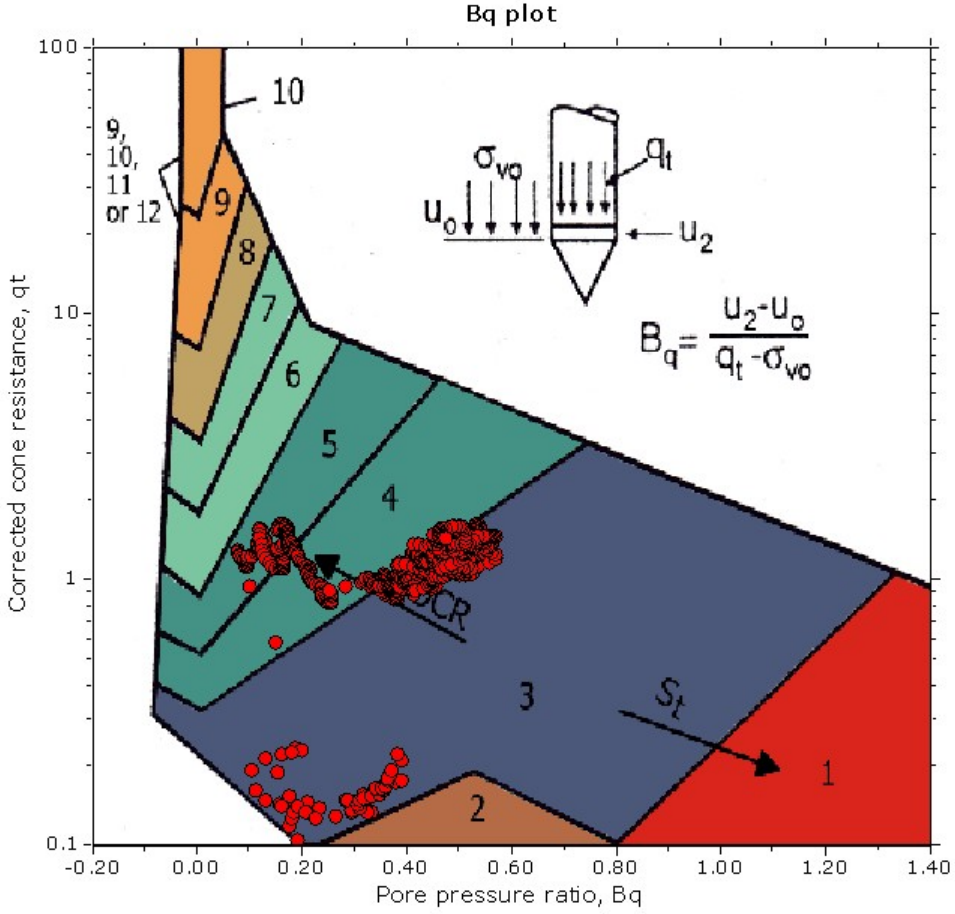
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

SBT - Bq plots





SBT legend

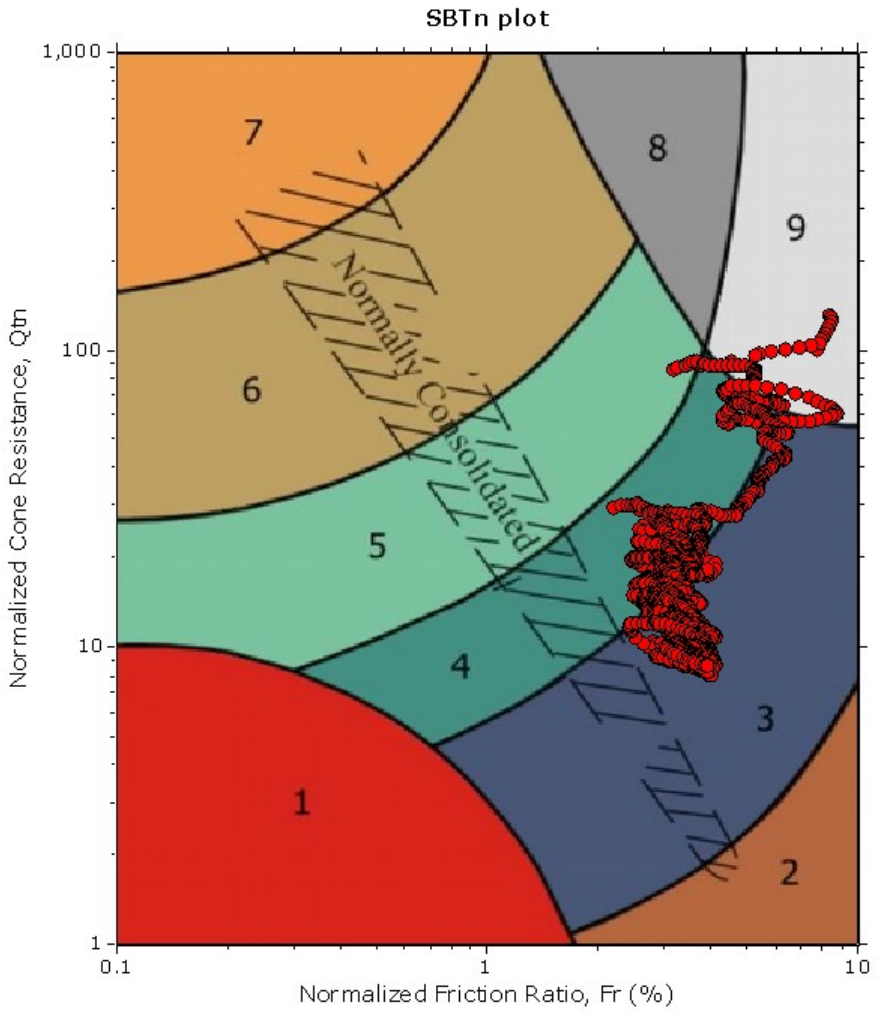
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

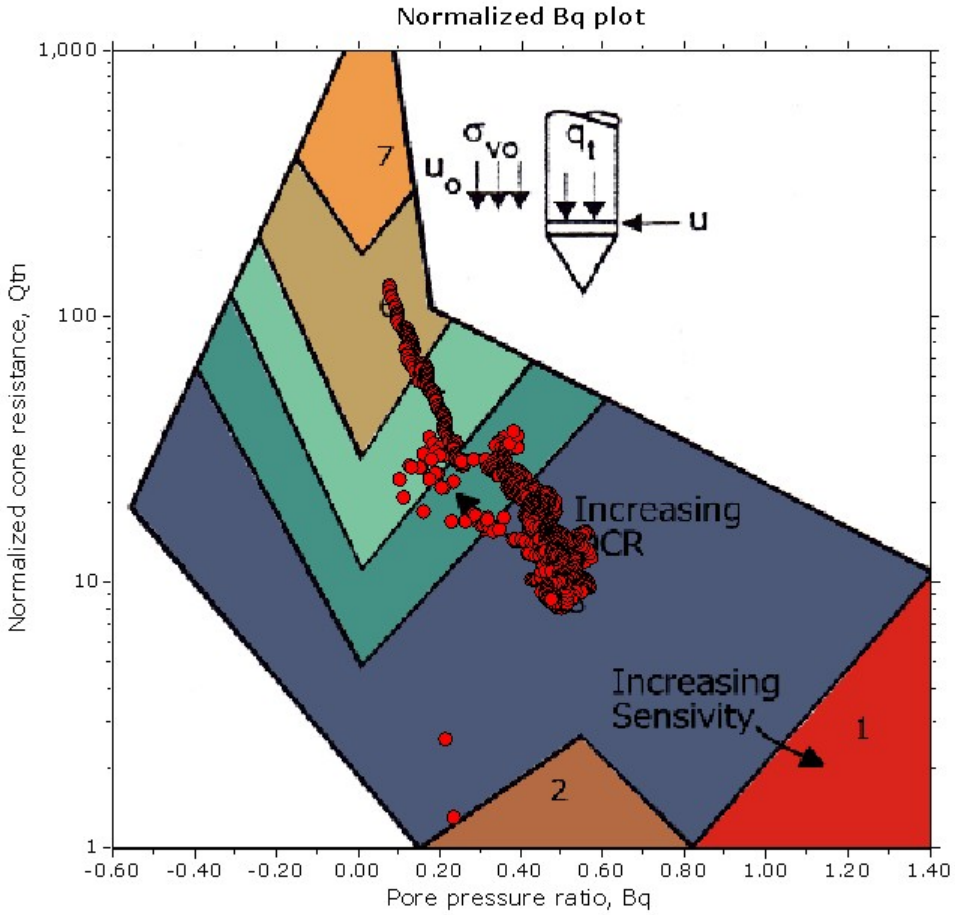
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

SBT - Bq plots (normalized)





SBTn legend

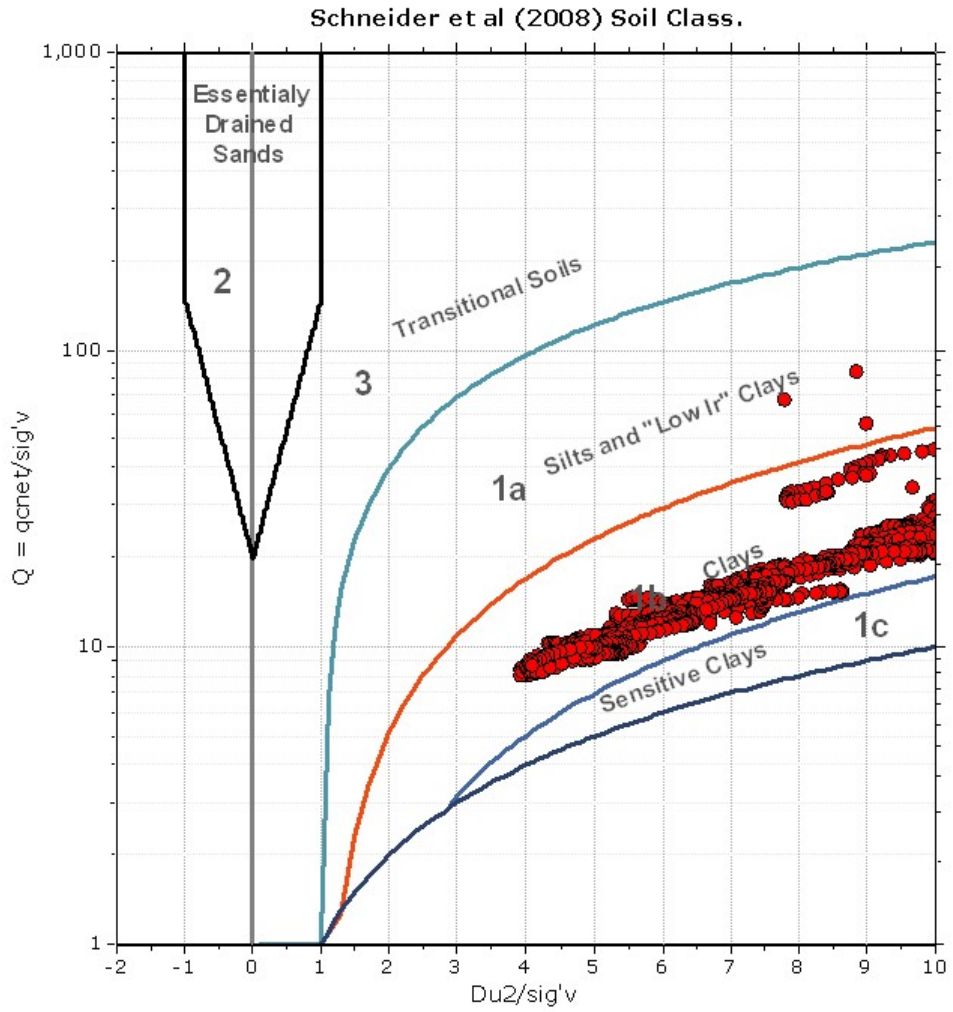
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

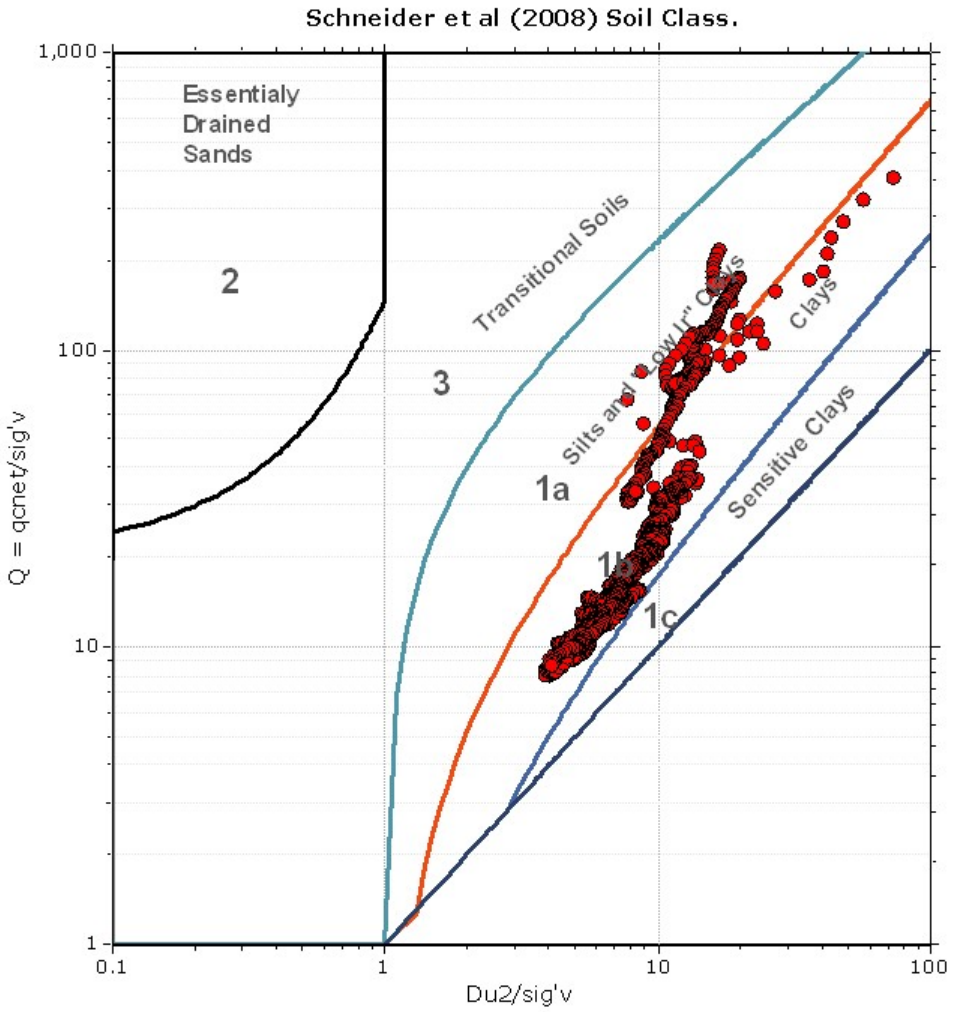
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

Bq plots (Schneider)

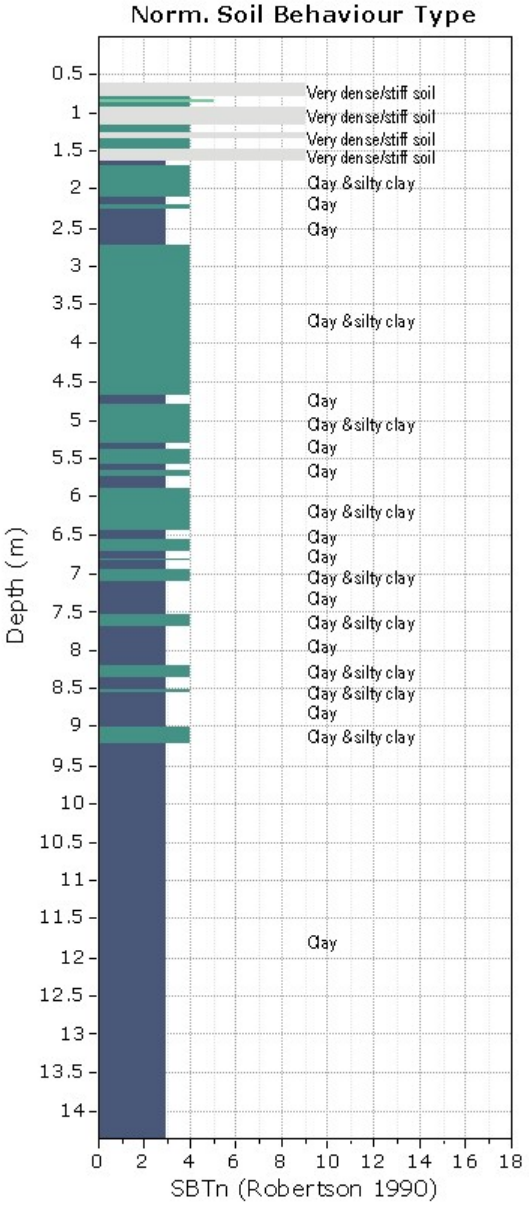


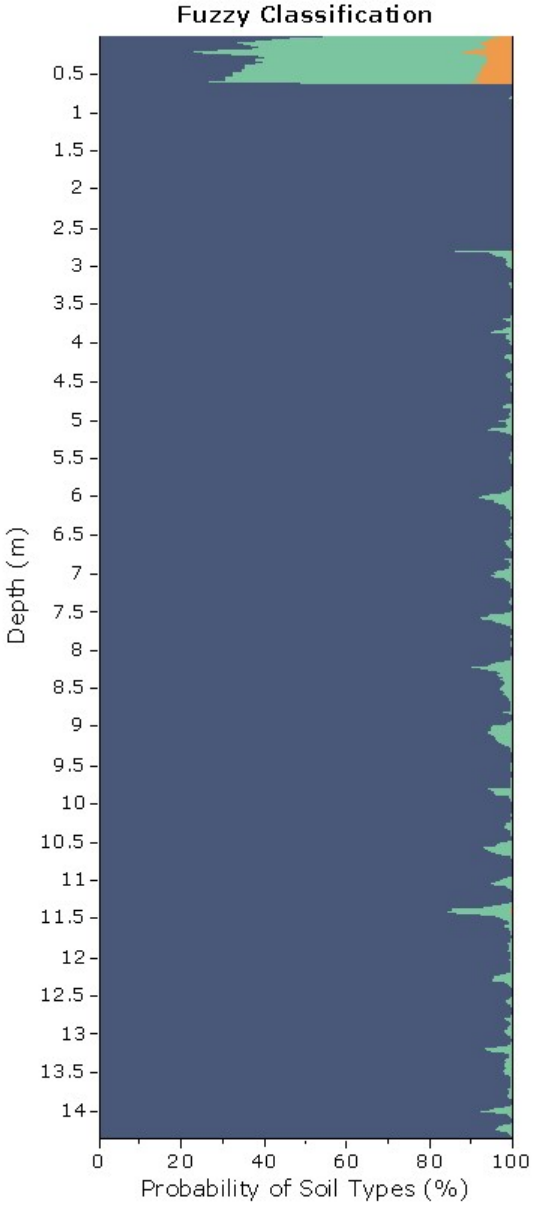


Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

Project: **A1B2CH**
Location: **Birtley to Coal House**

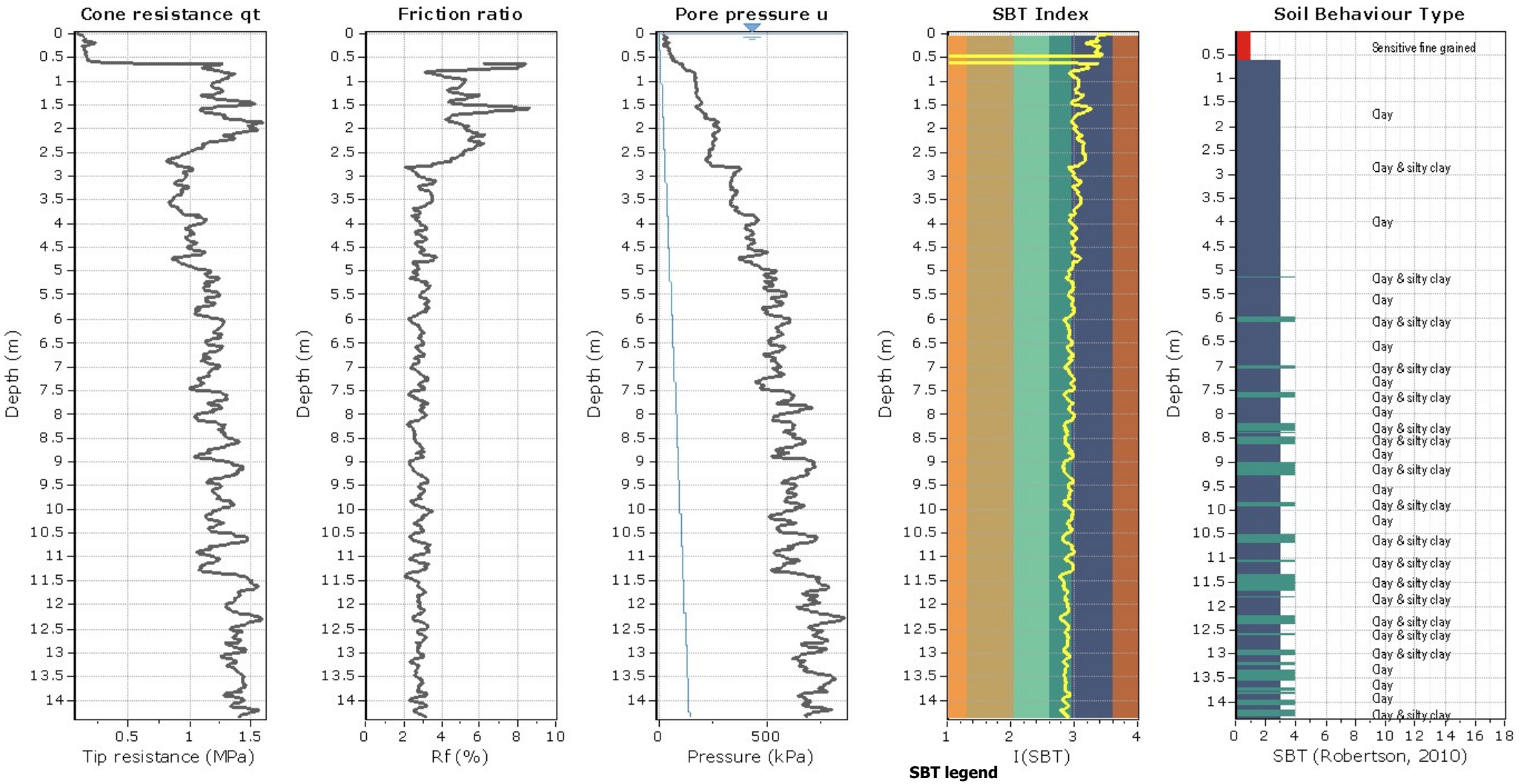




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

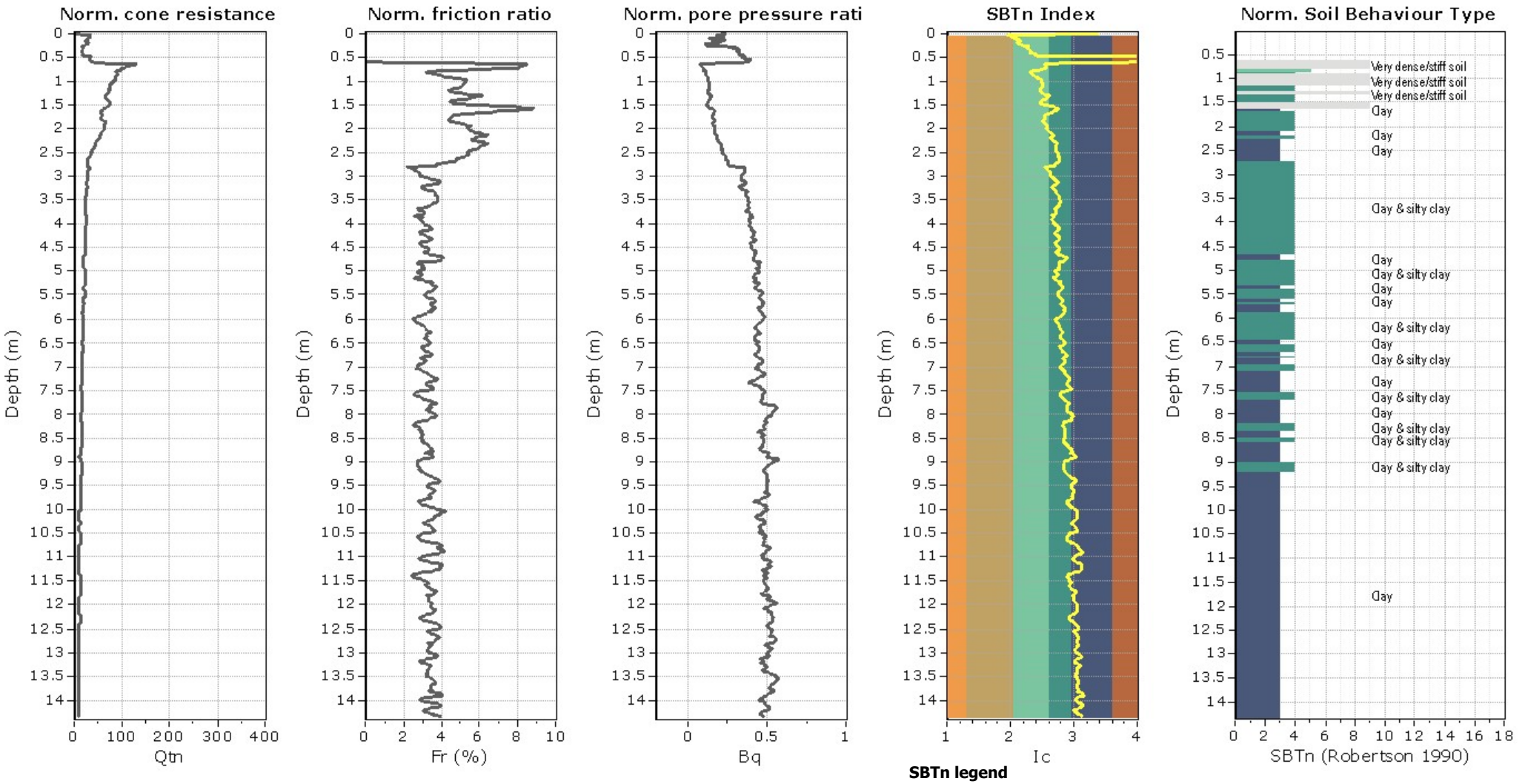
Project: **A1B2CH**
Location: **Birtley to Coal House**



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

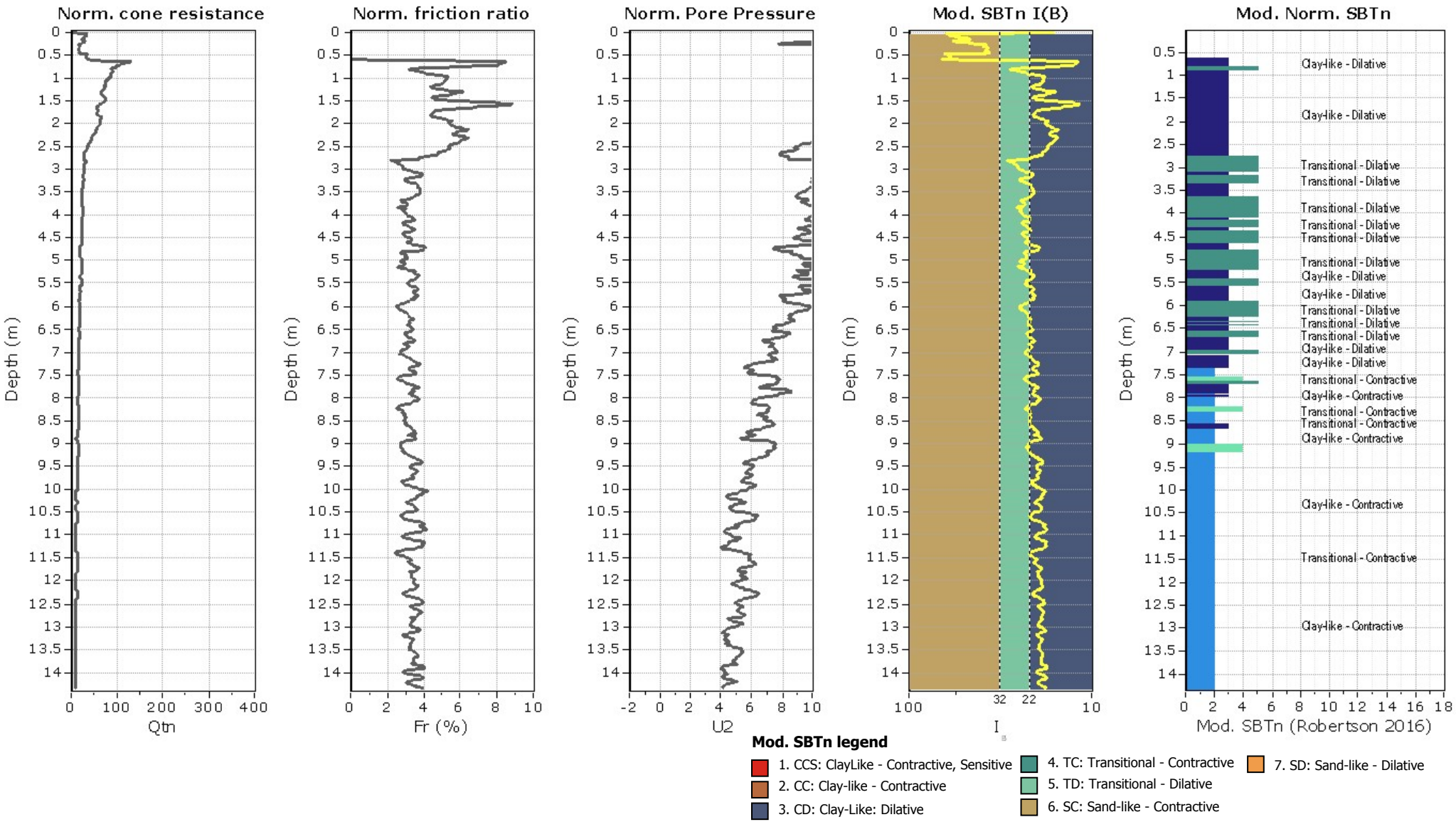
CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

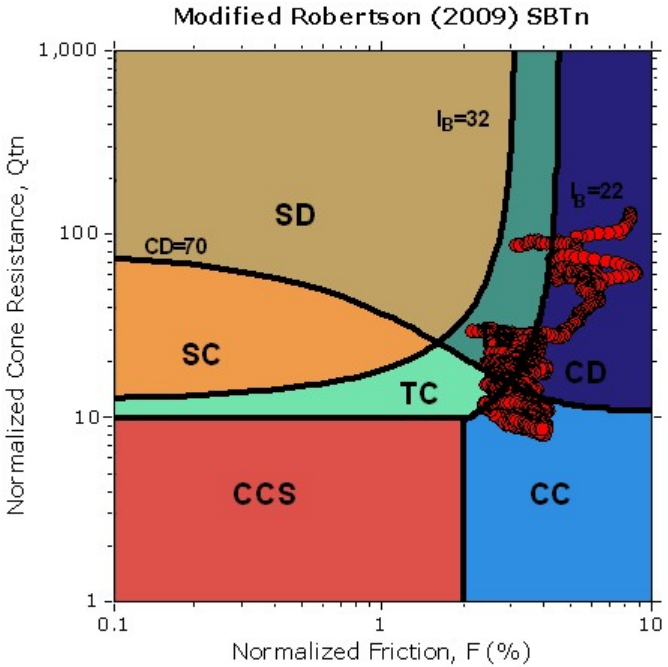


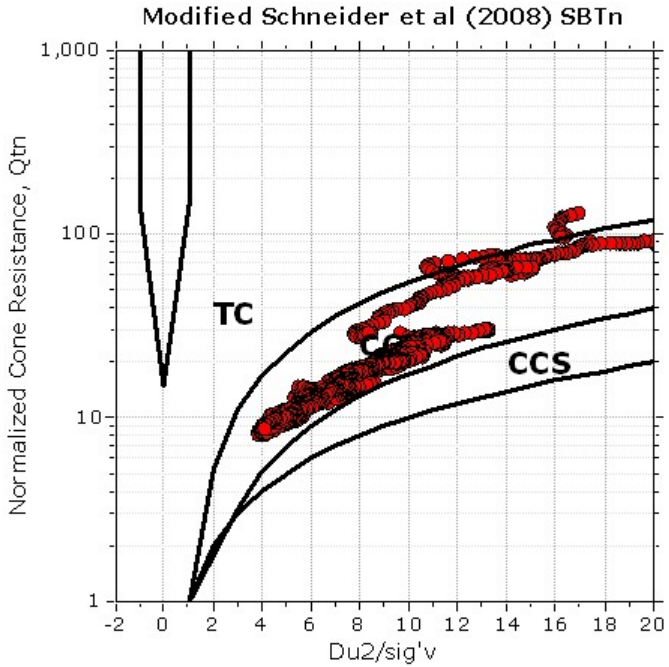
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

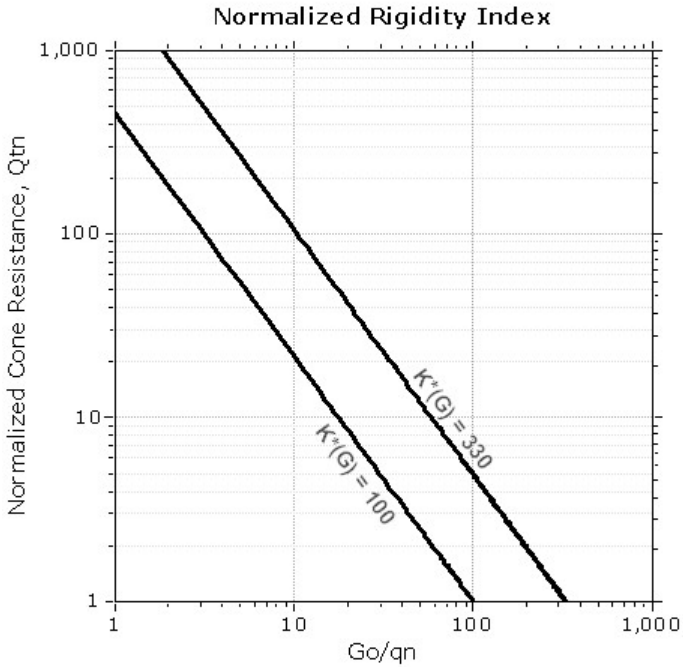
Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

Updated SBTn plots







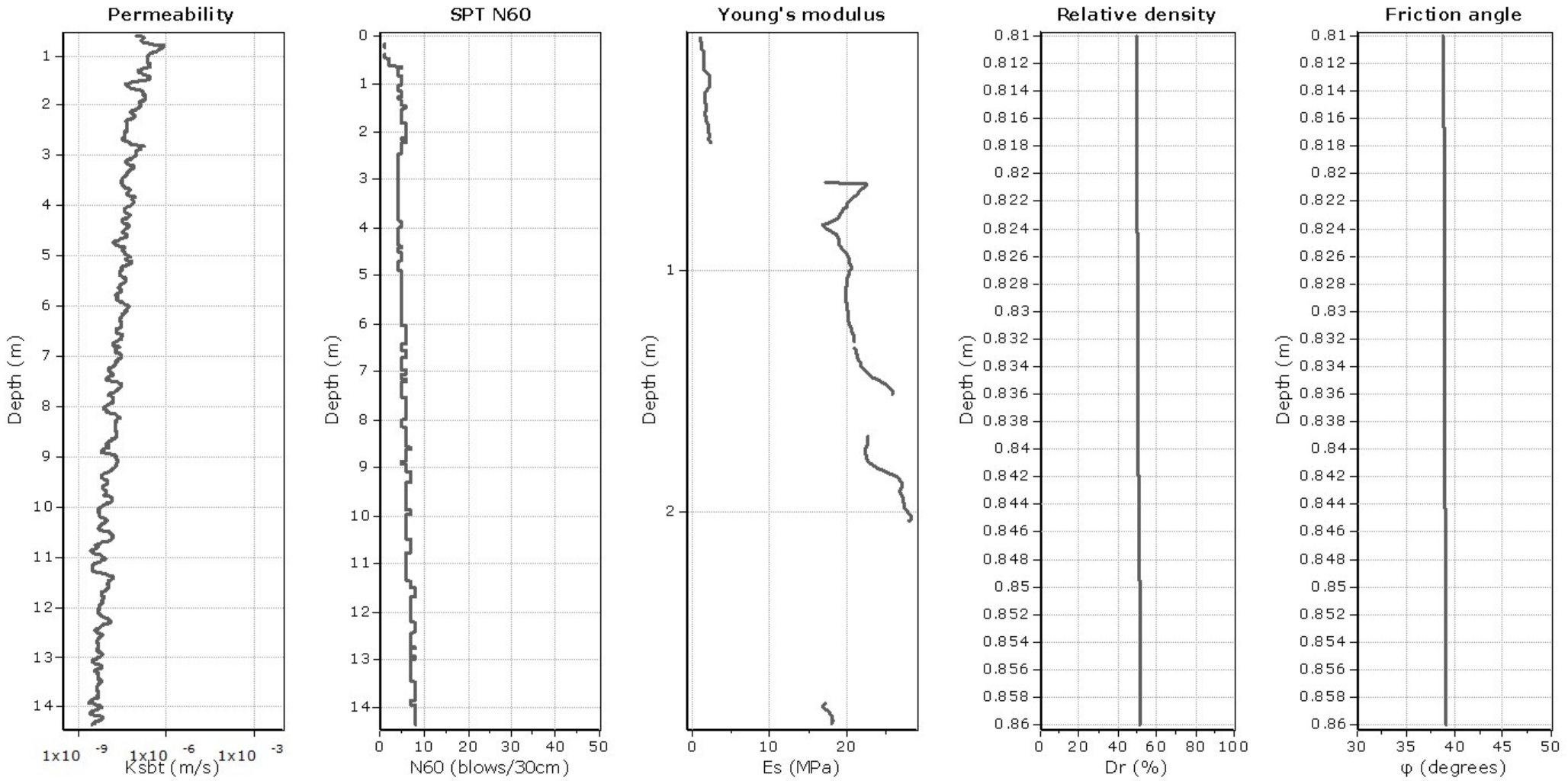
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH



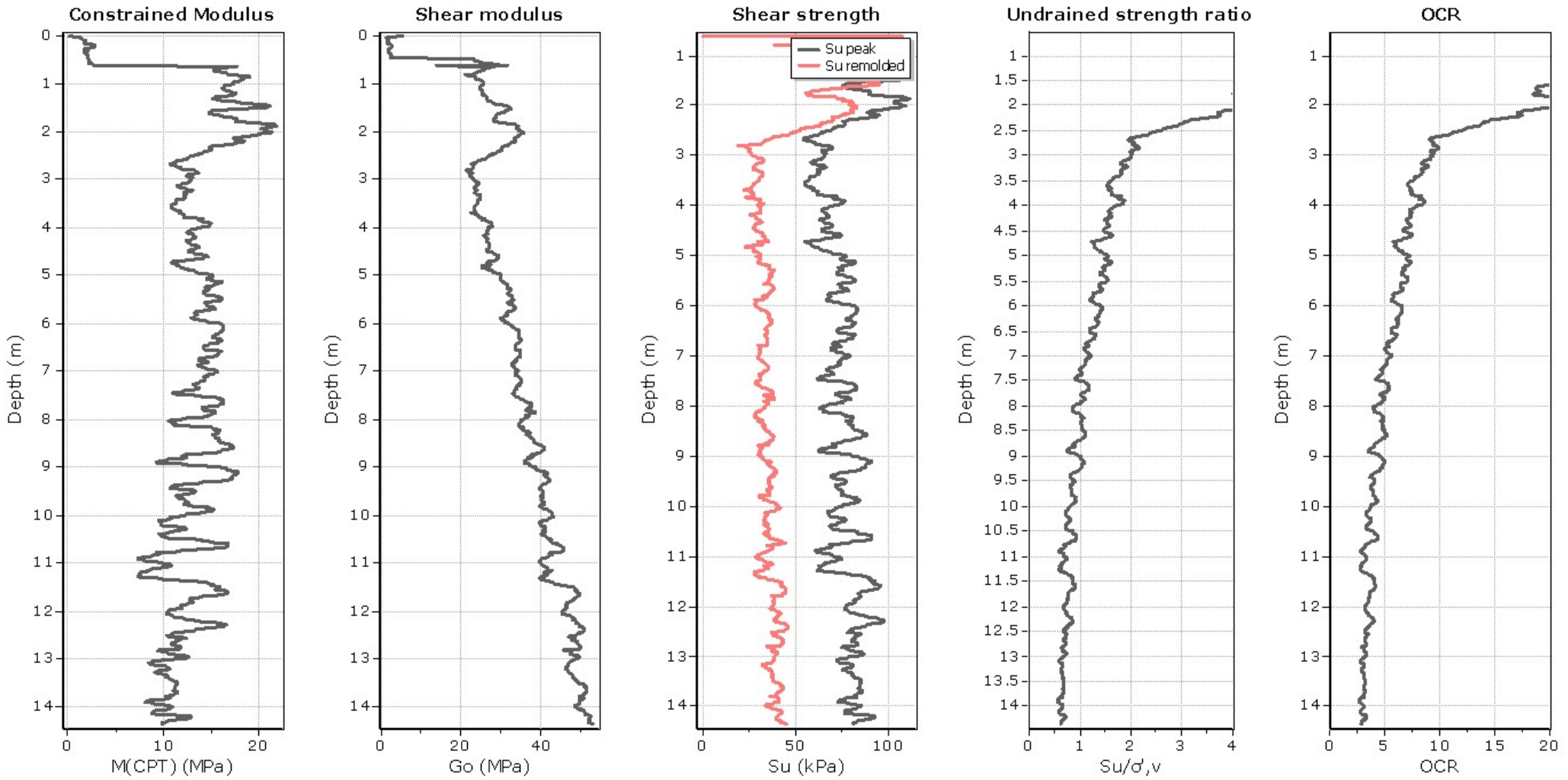
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

Project: **A1B2CH**
Location: **Birtley to Coal House**



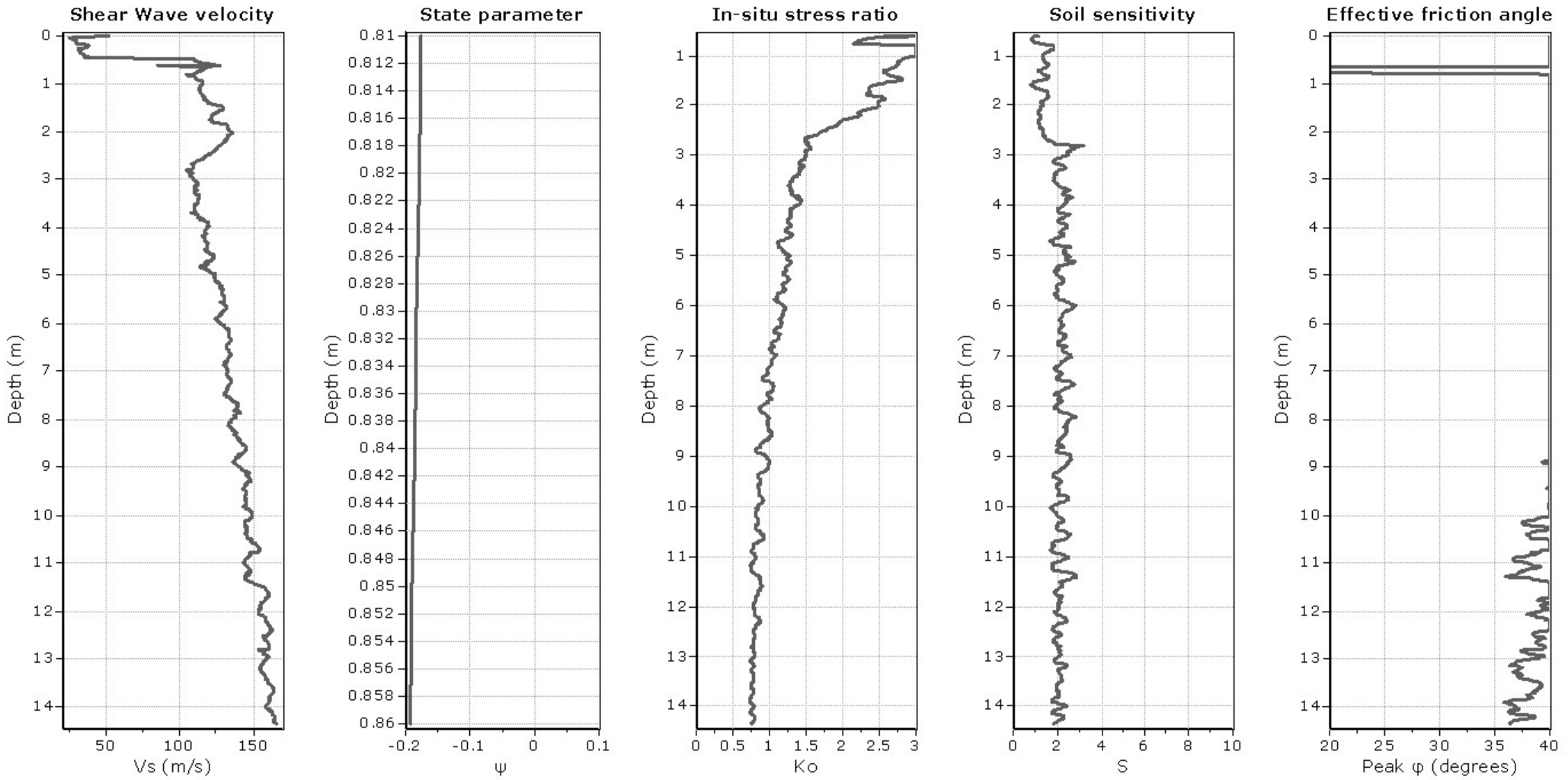
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-07
Total depth: 14.35 m, Date: 18/01/2018
Cone Operator: JG CH

Project: **A1B2CH**
Location: **Birtley to Coal House**



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

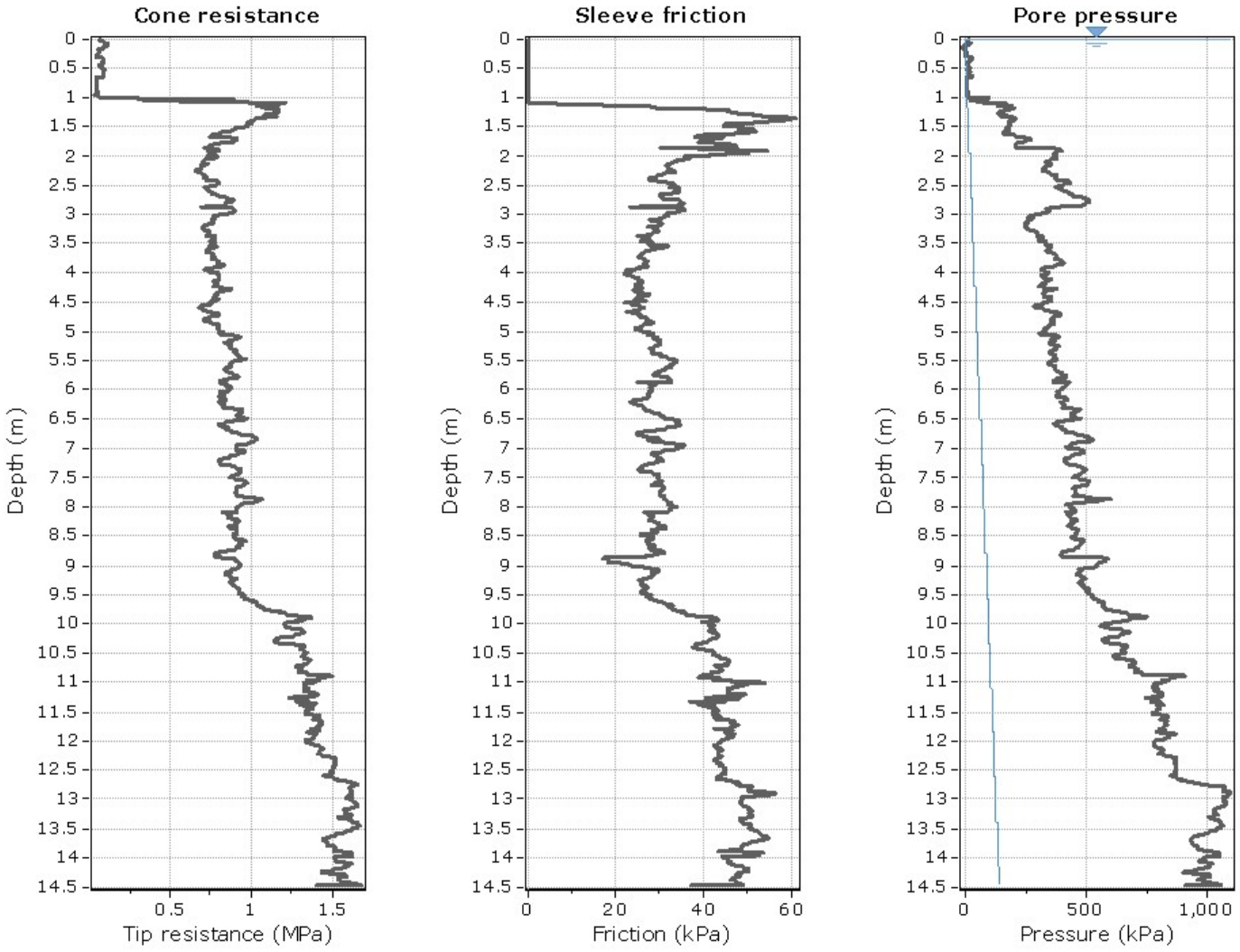
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-08

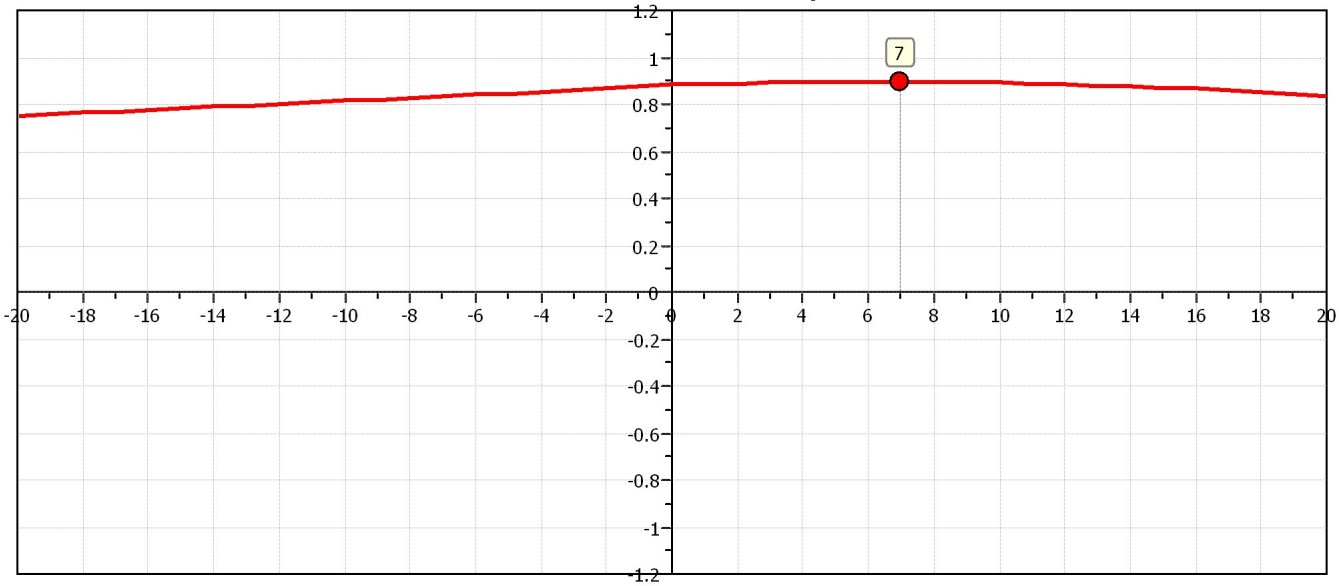
Project: **CA3043**
Location: **A1B2CH**

Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

Cross correlation between qc & fs

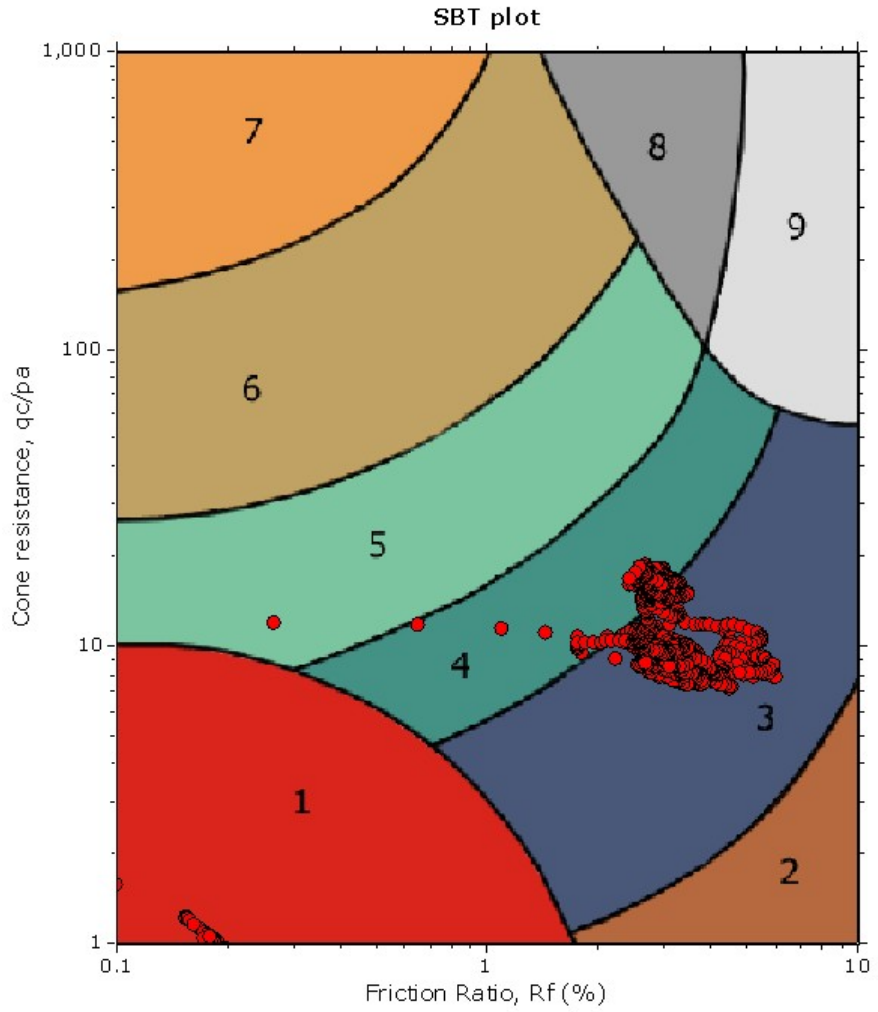


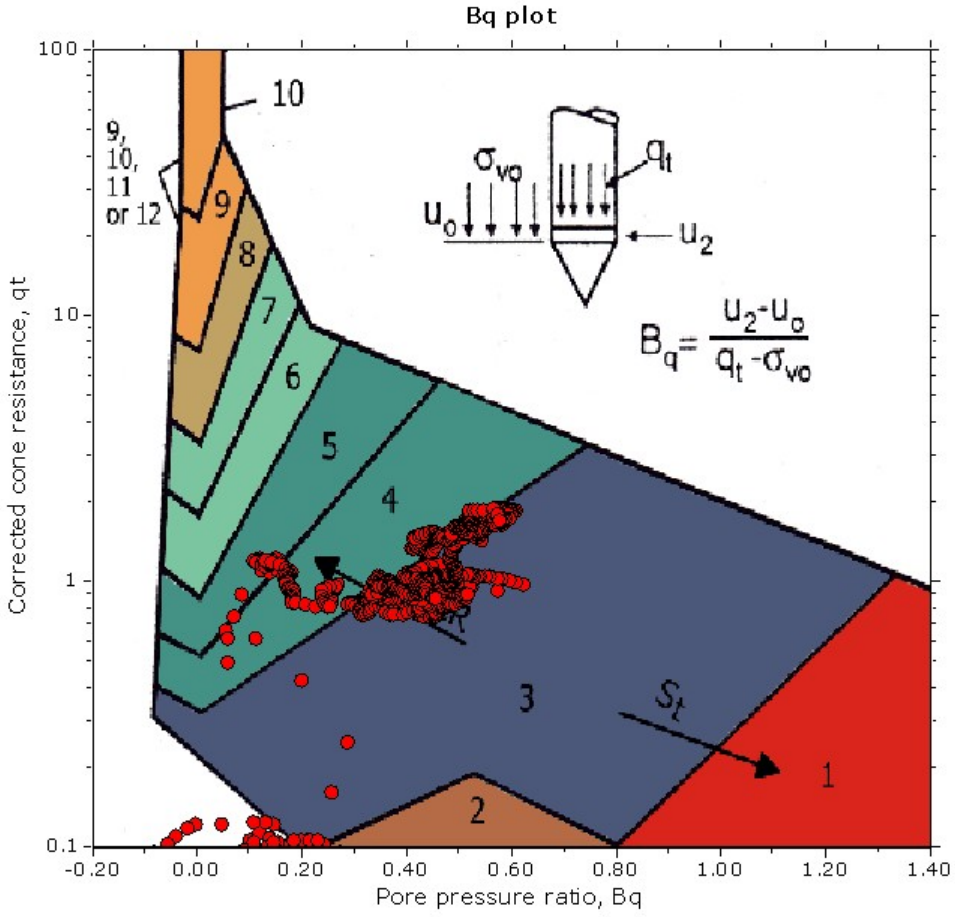
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

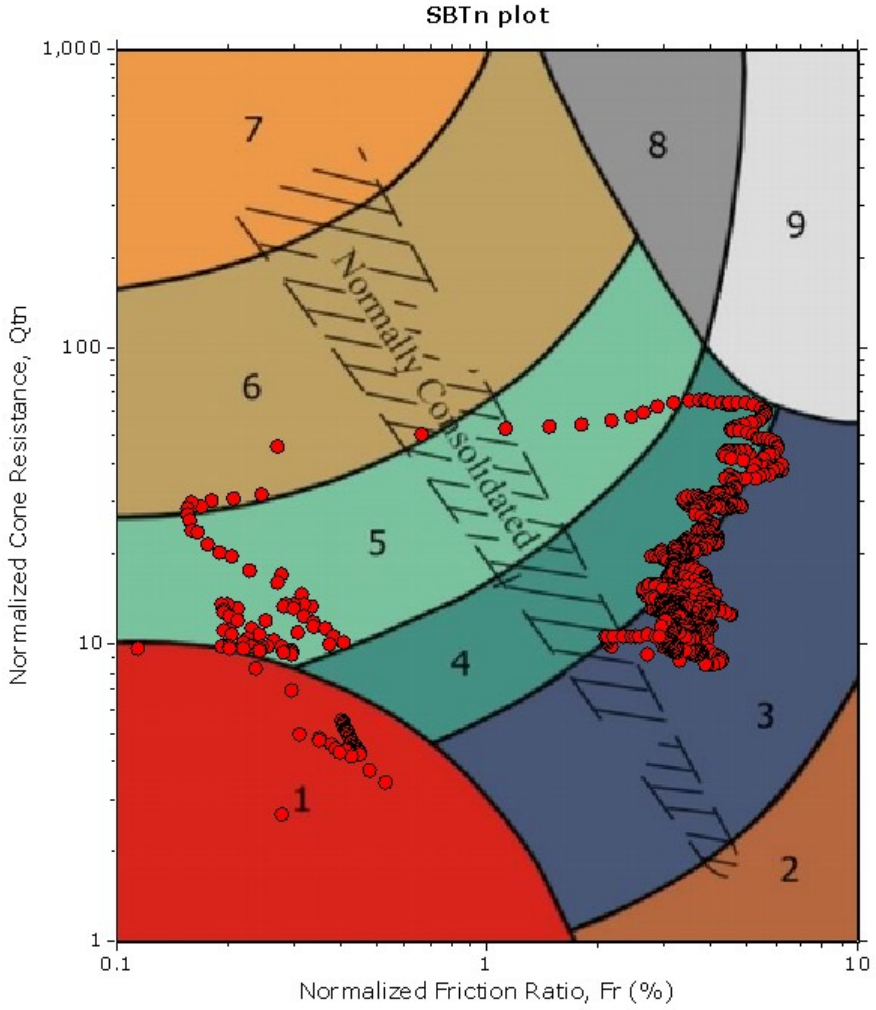
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

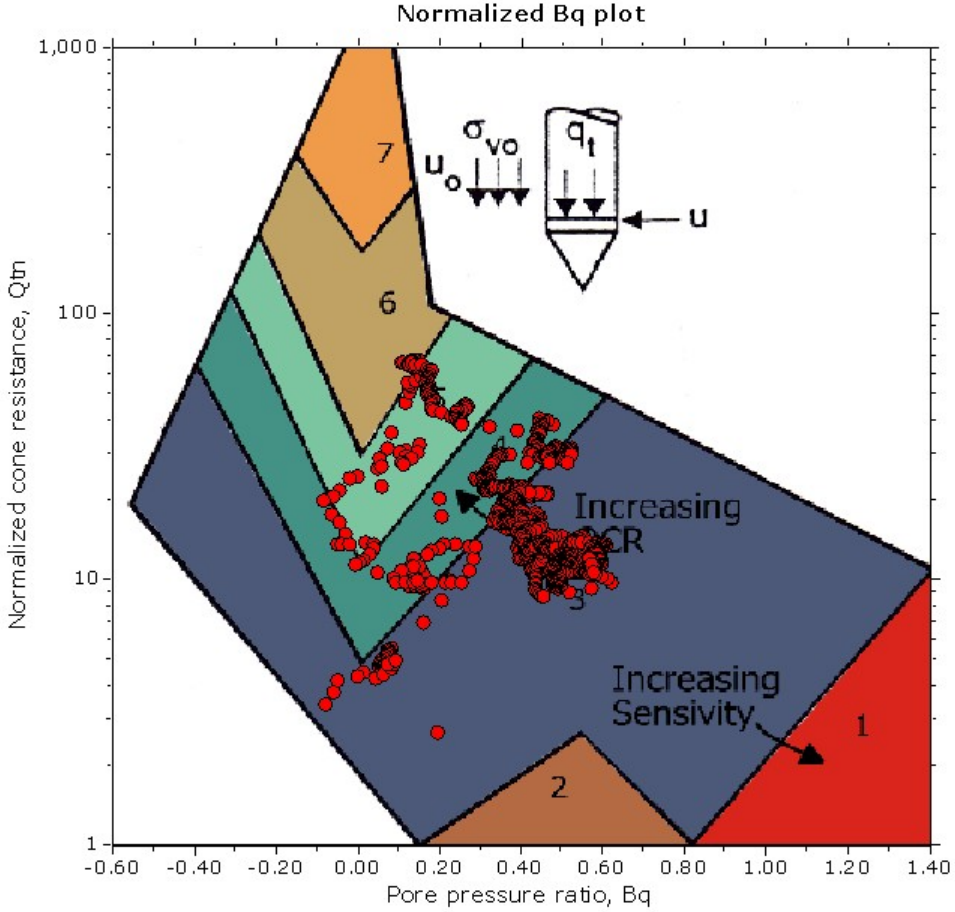
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

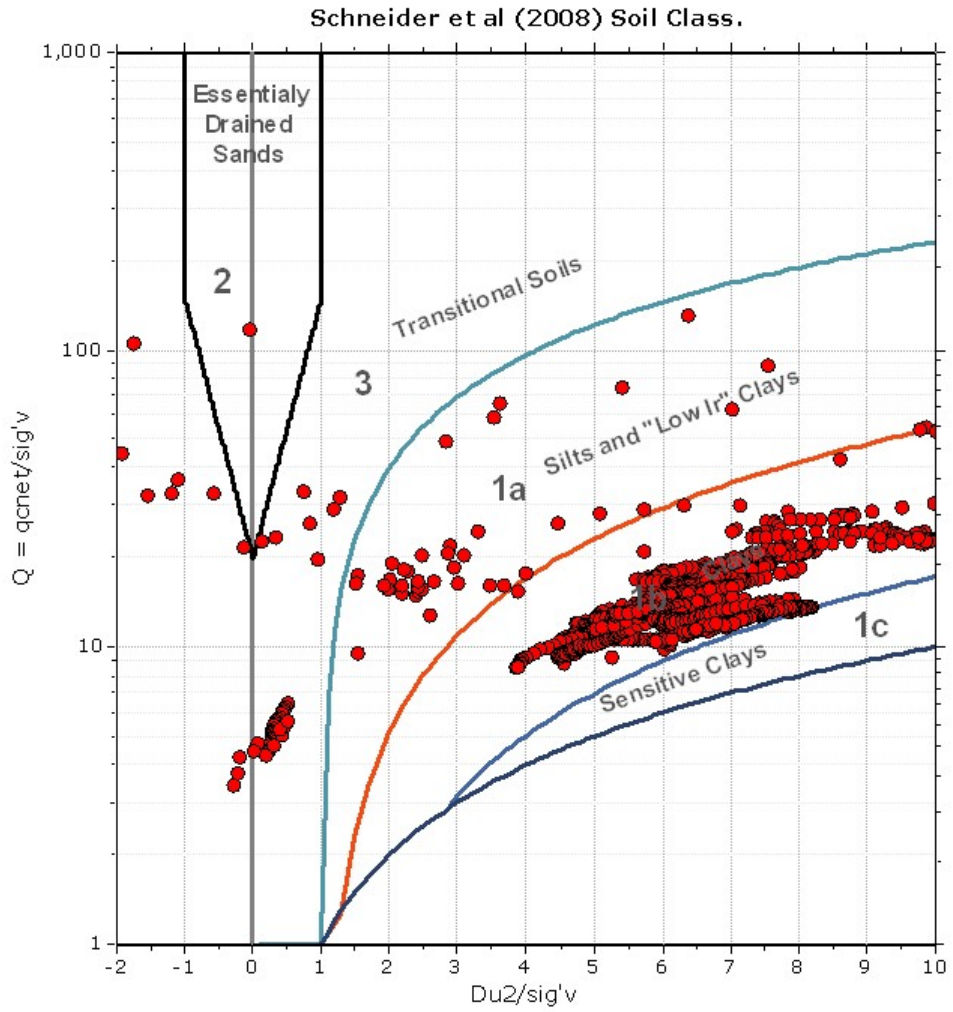
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

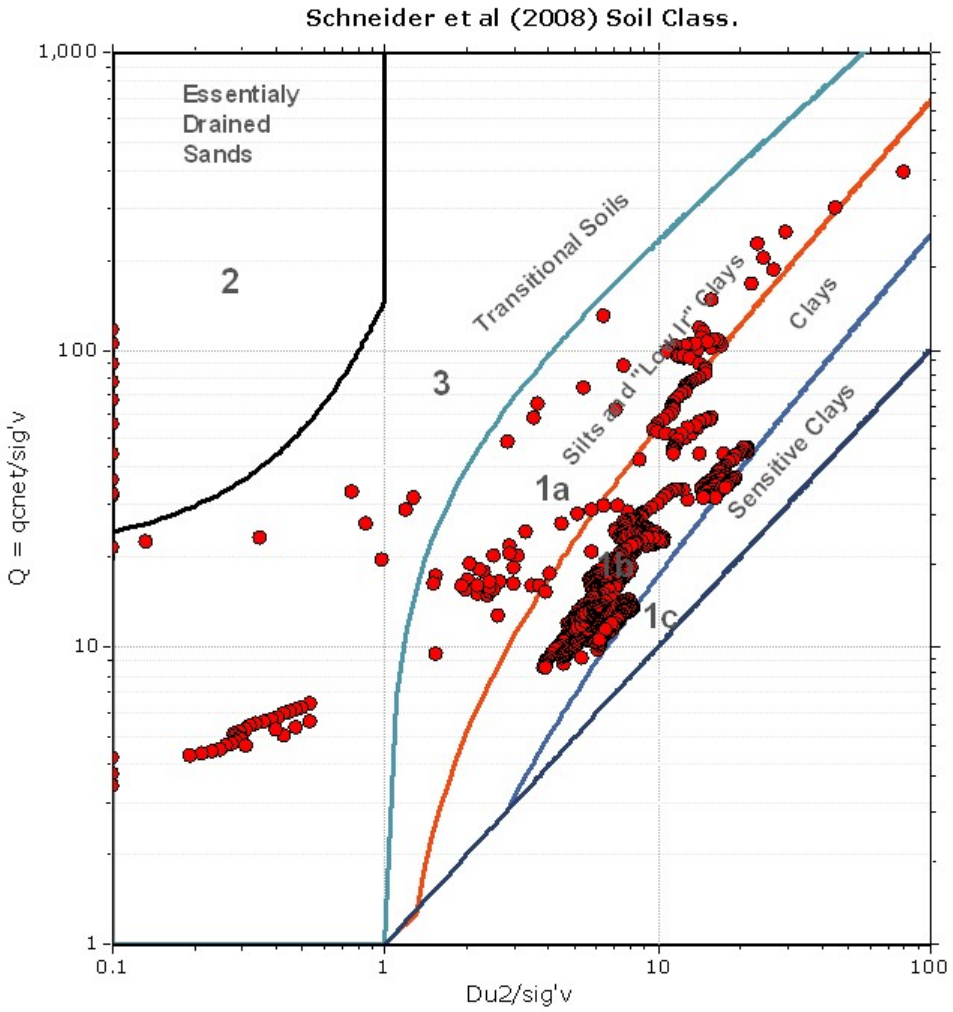
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



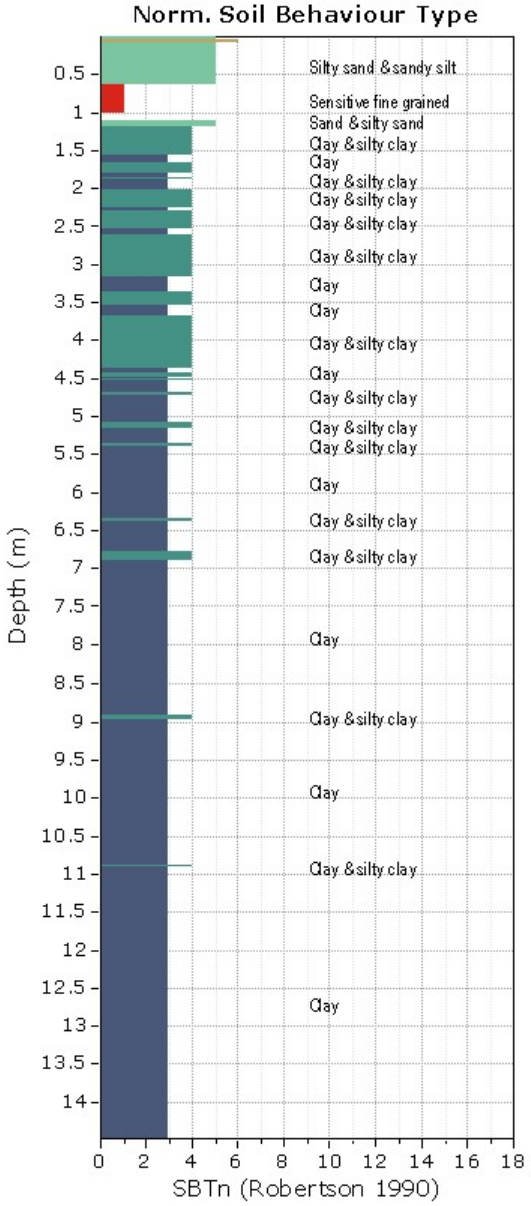


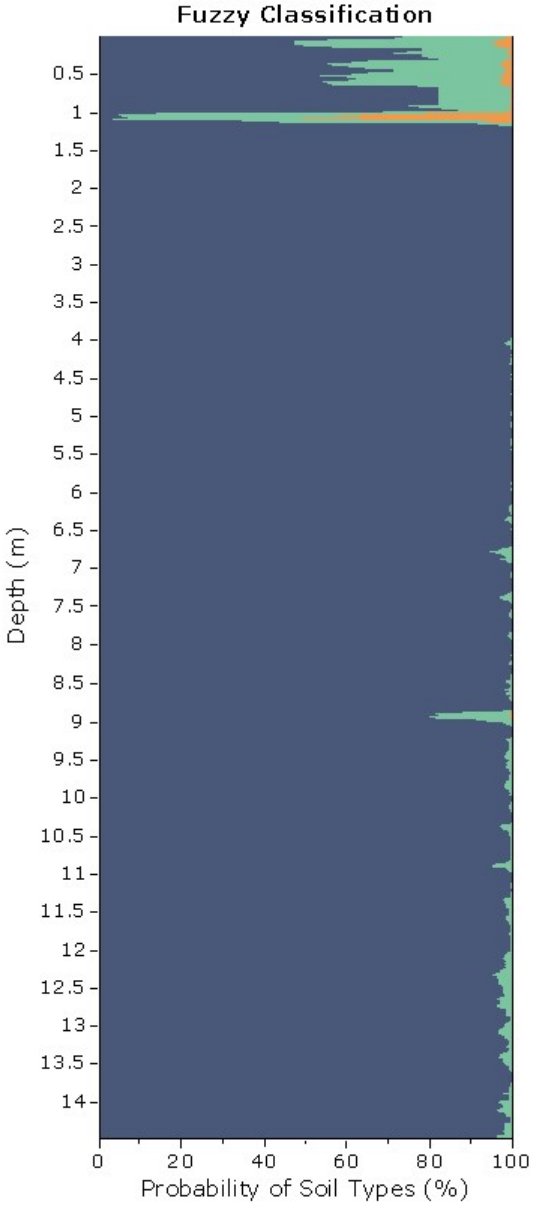
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-08

Project: **CA3043**
Location: **A1B2CH**

Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

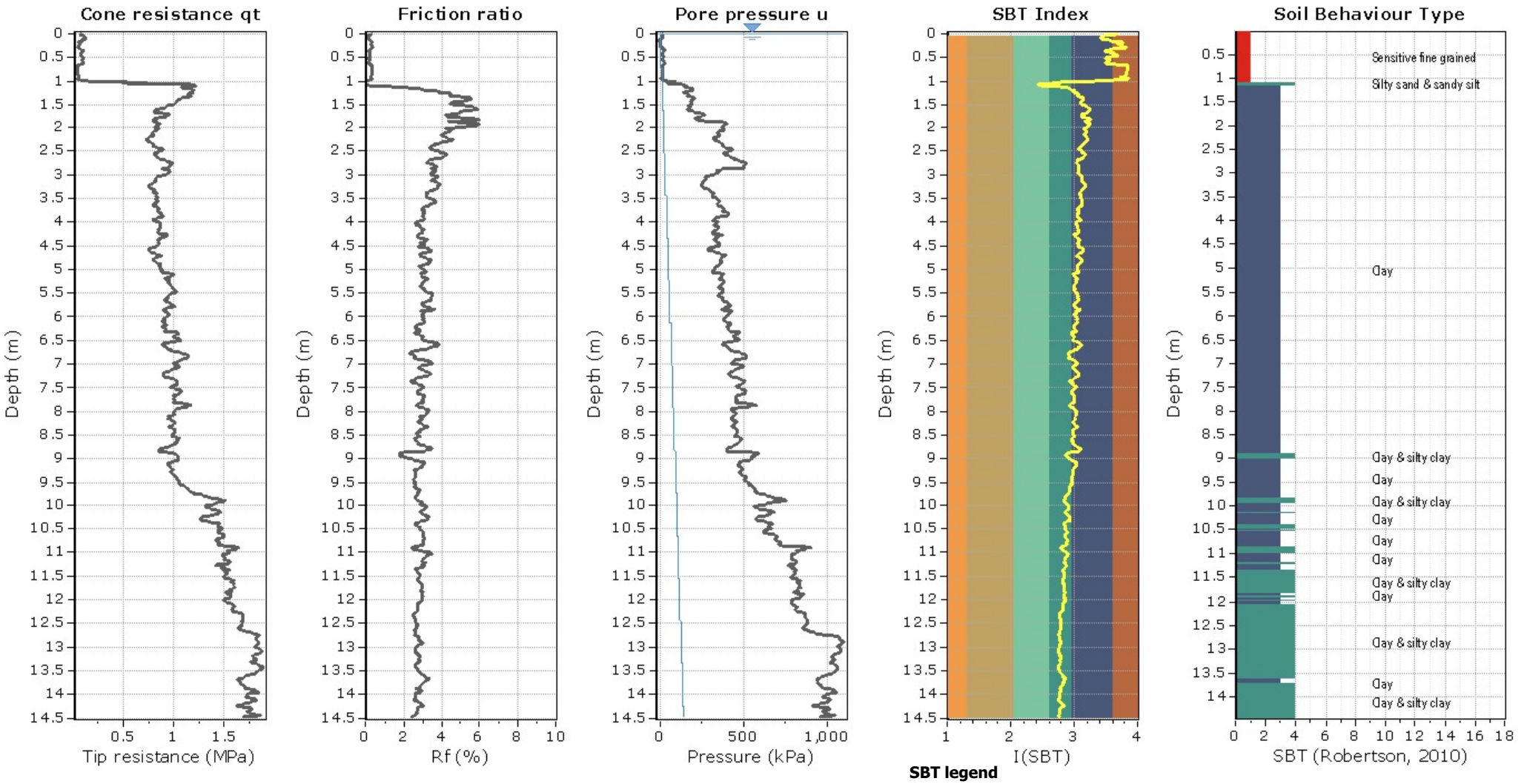




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

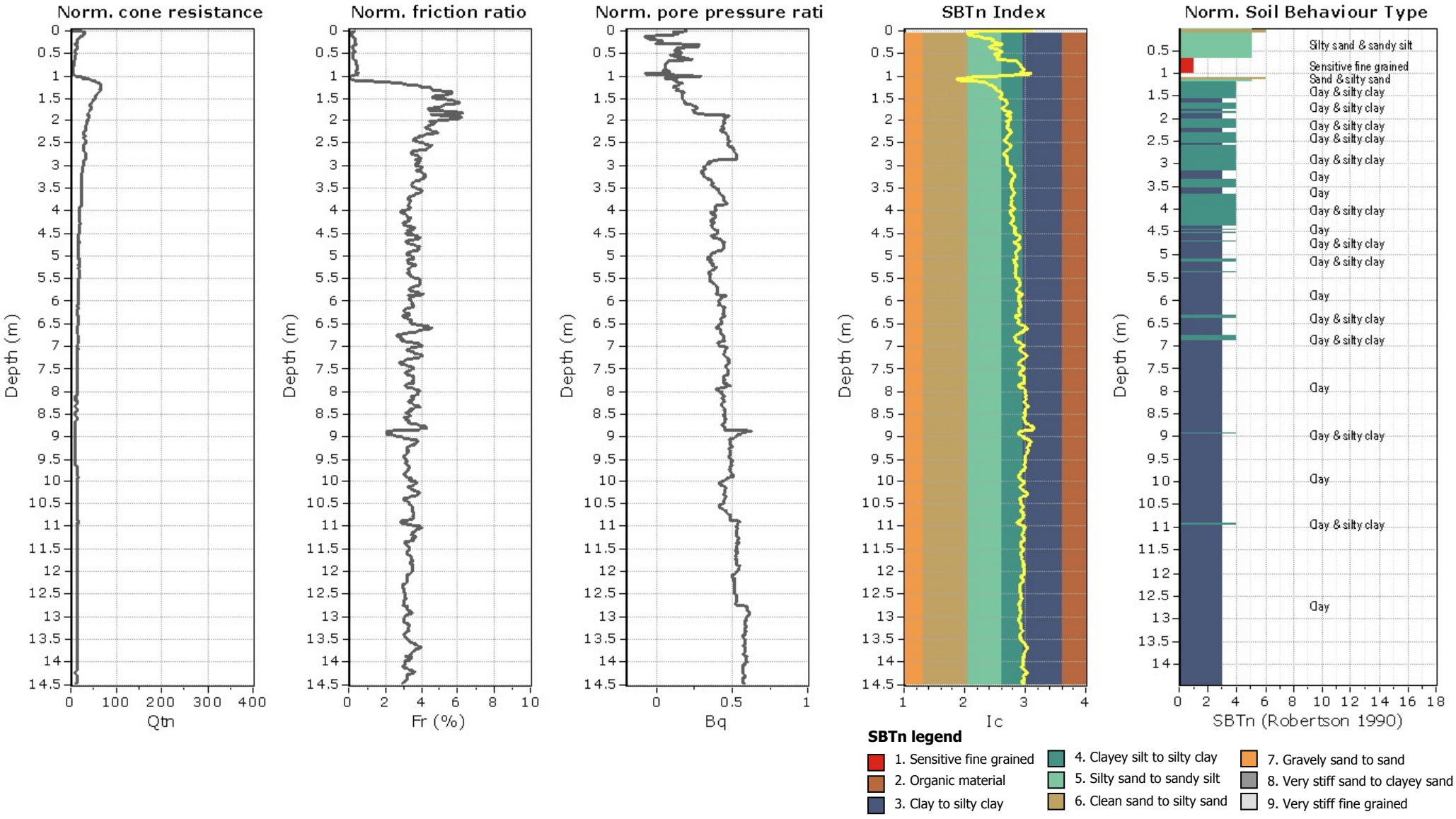
CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

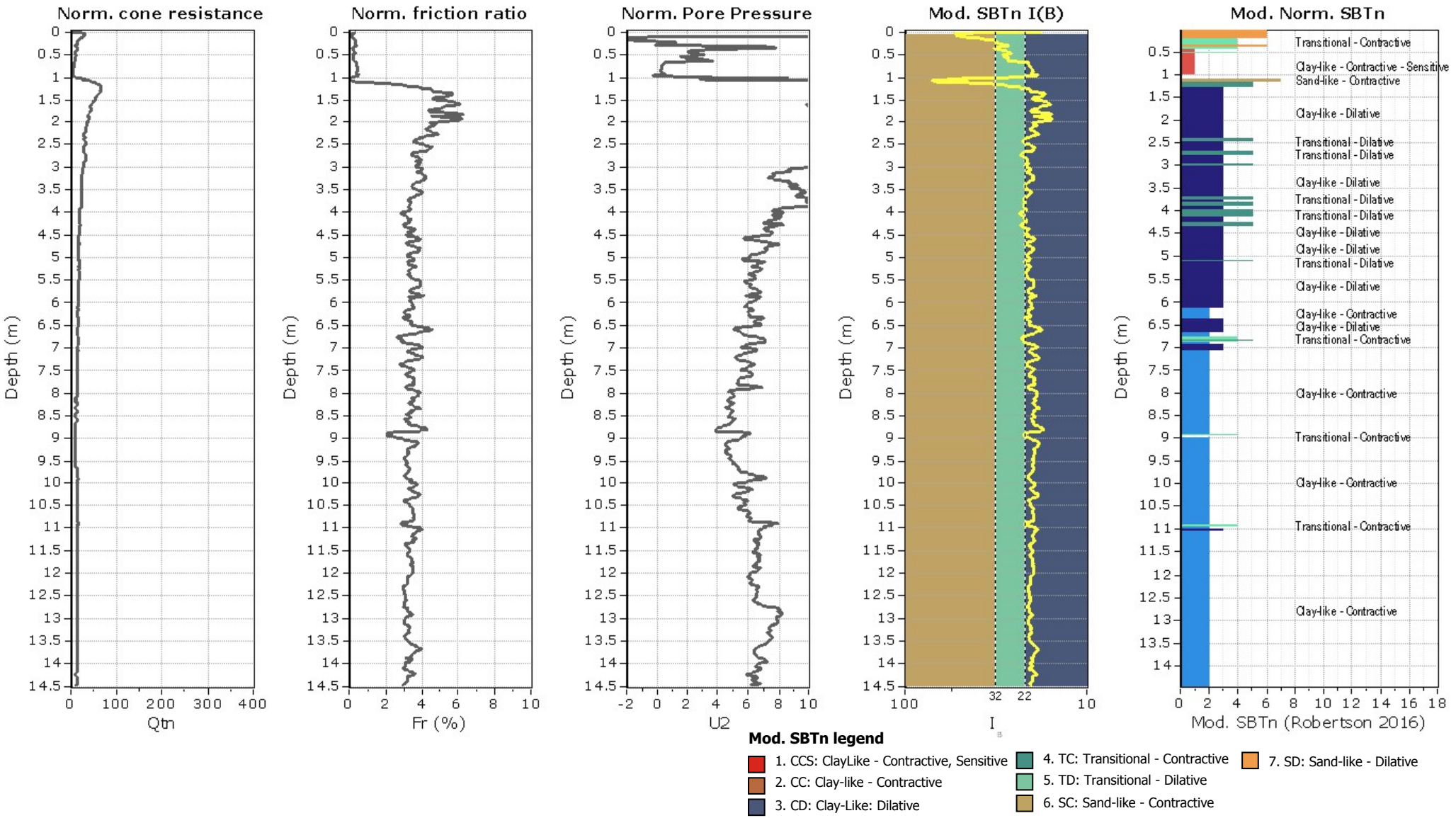
CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

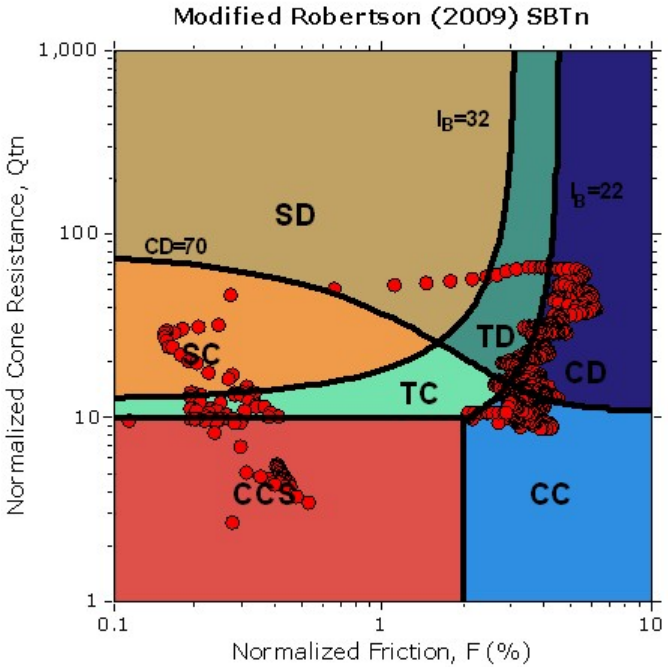


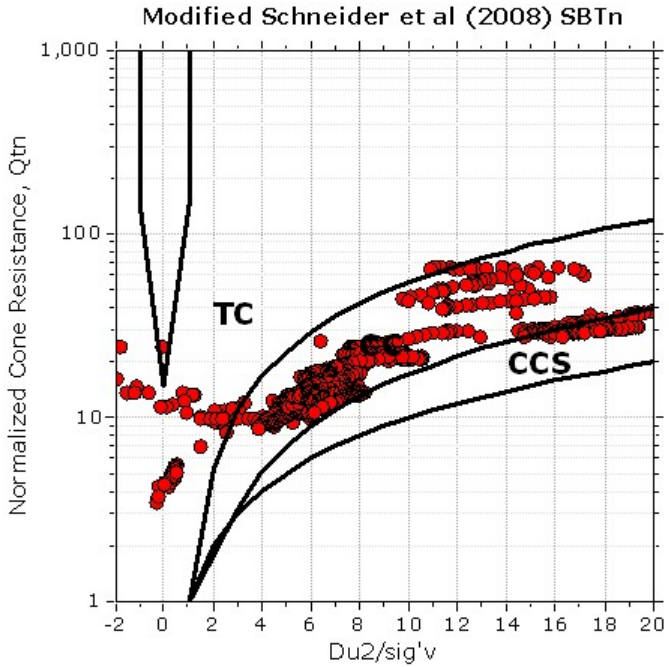
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

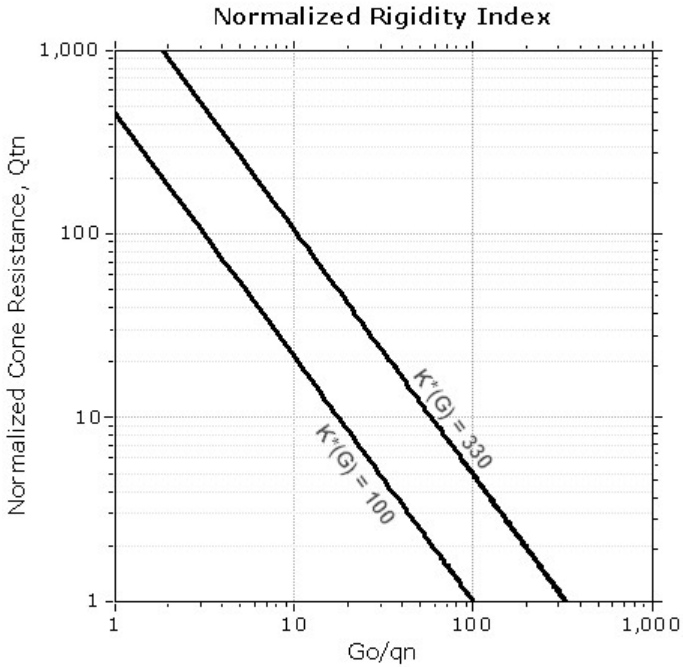
Project: CA3043
Location: A1B2CH

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







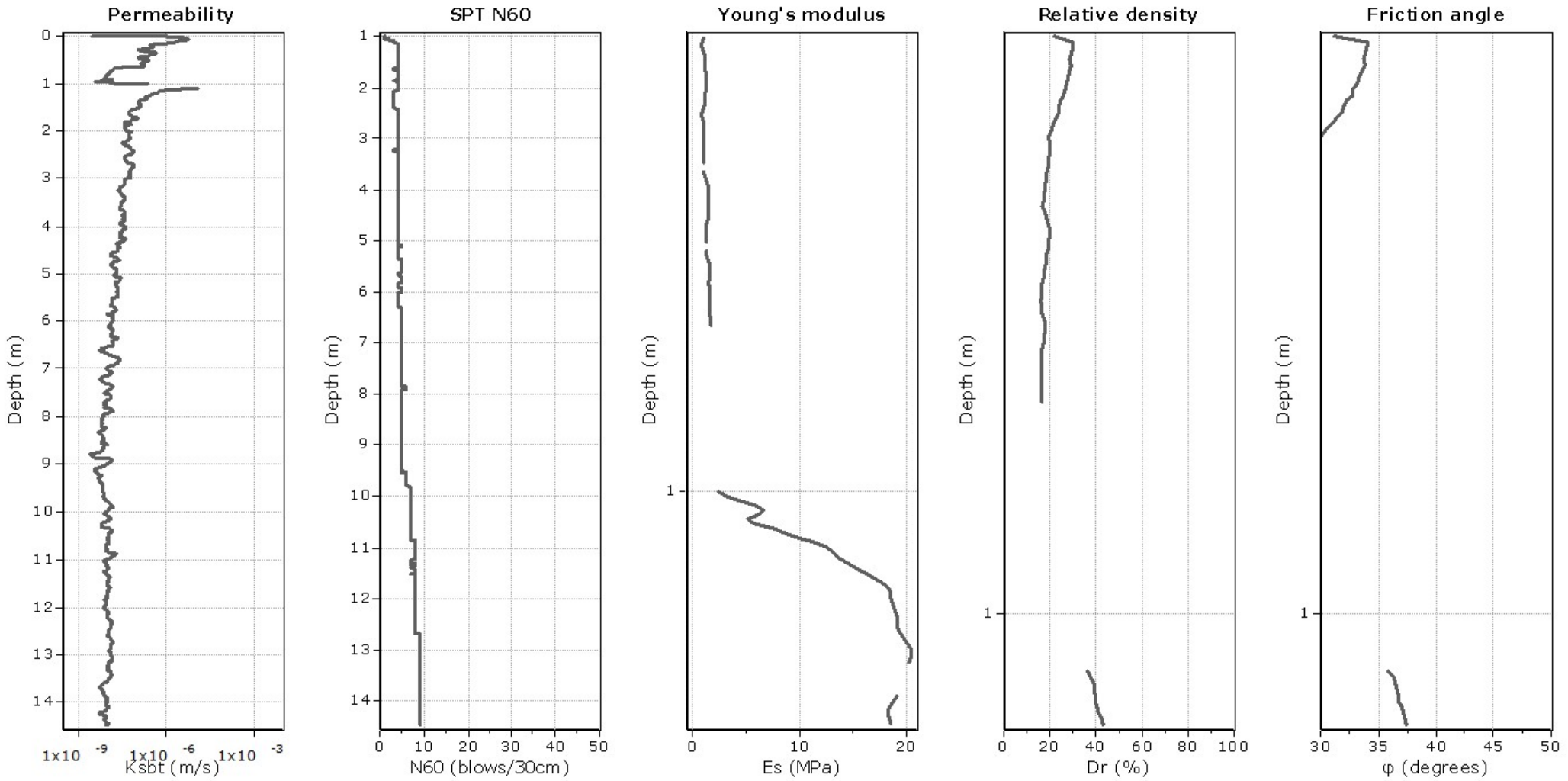
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



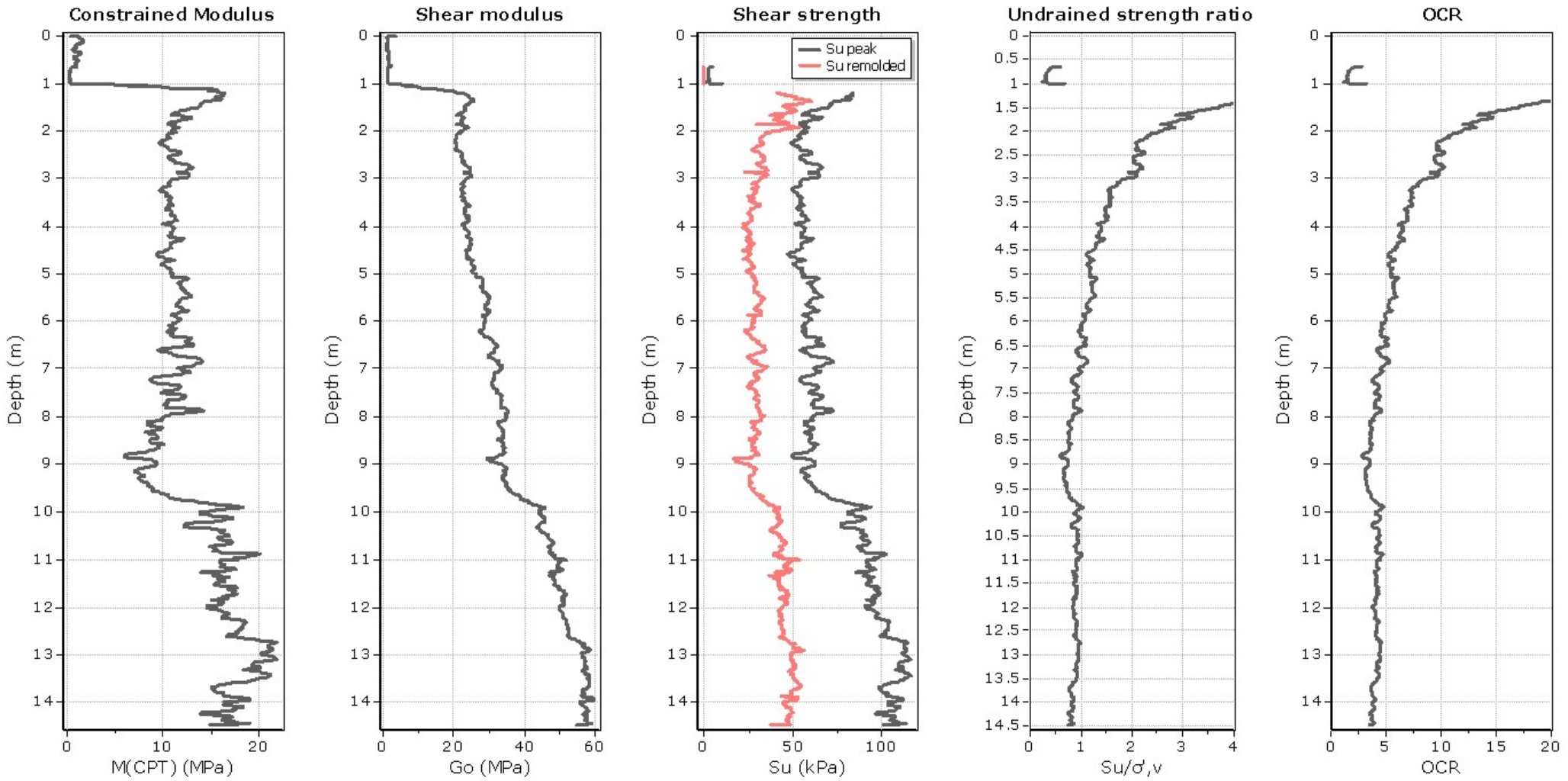
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



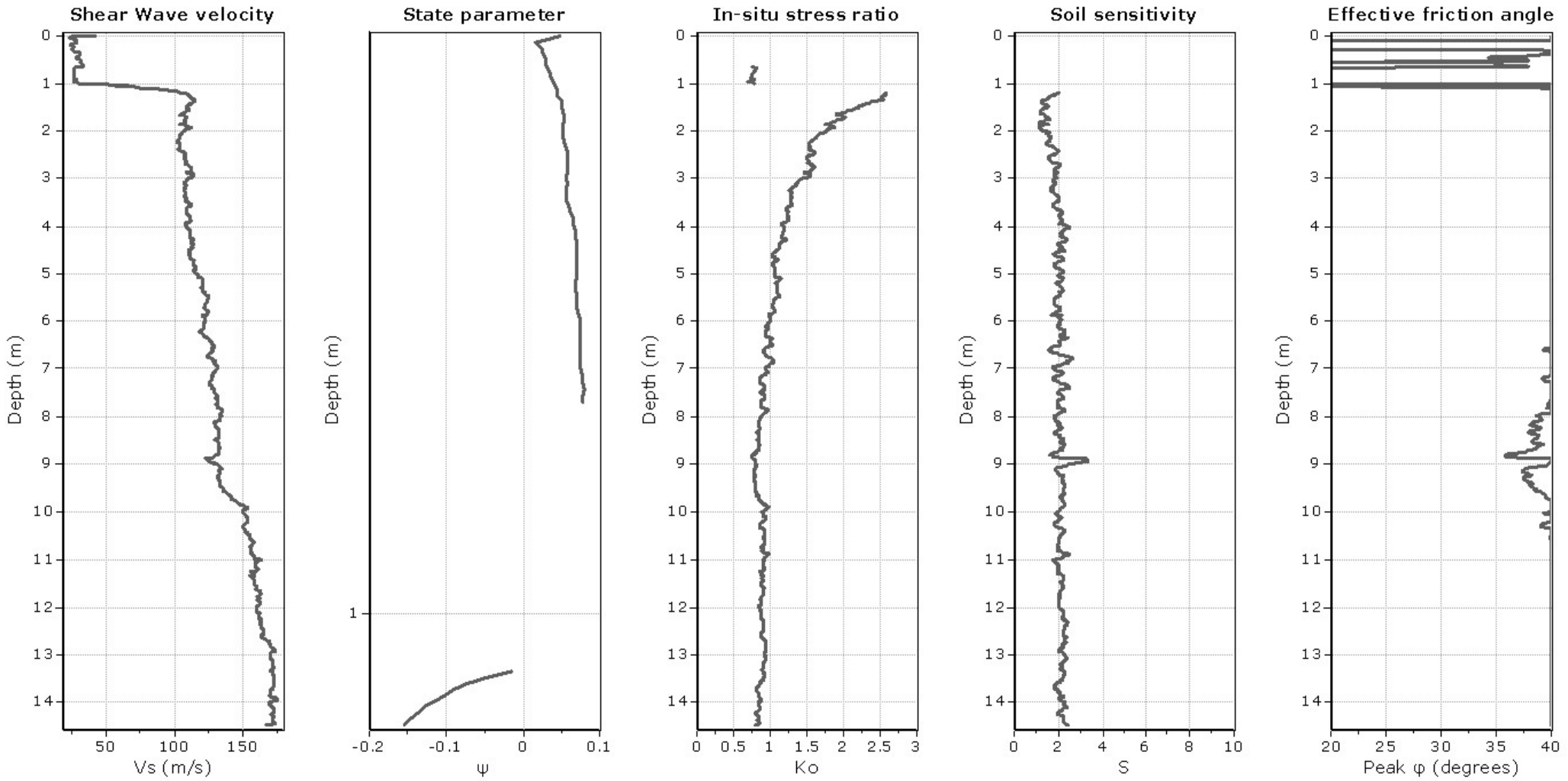
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-08
Total depth: 14.47 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

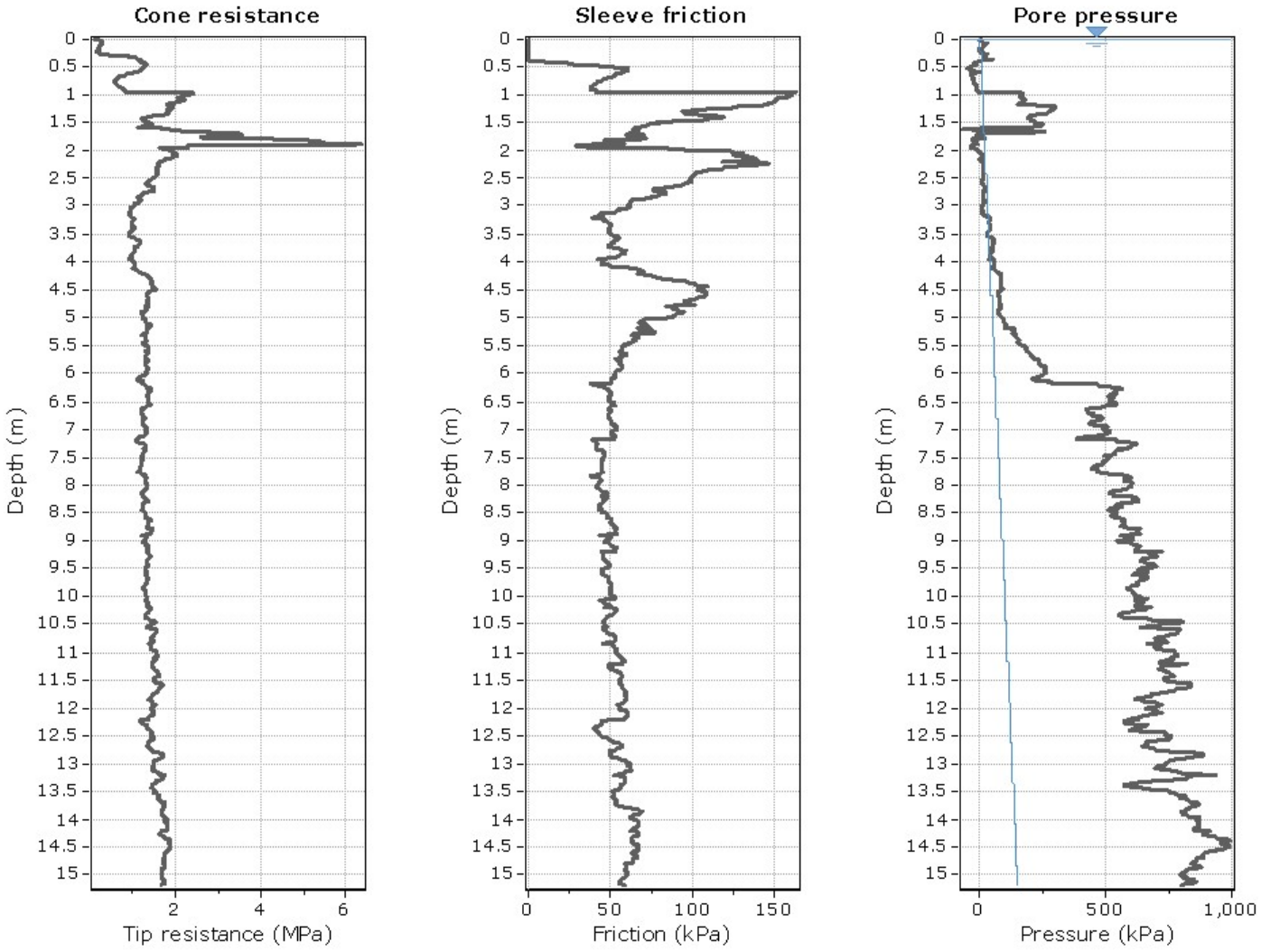
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-12

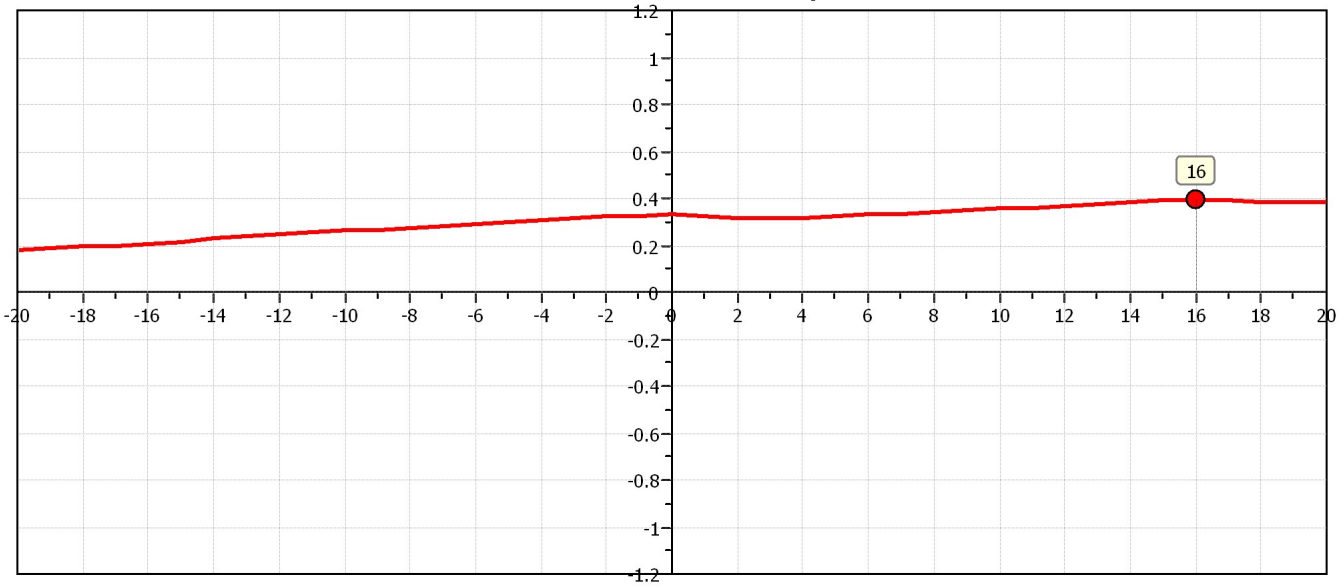
Project: **A1B2CH**
Location: **Birtley to Coal House**

Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

Cross correlation between qc & fs

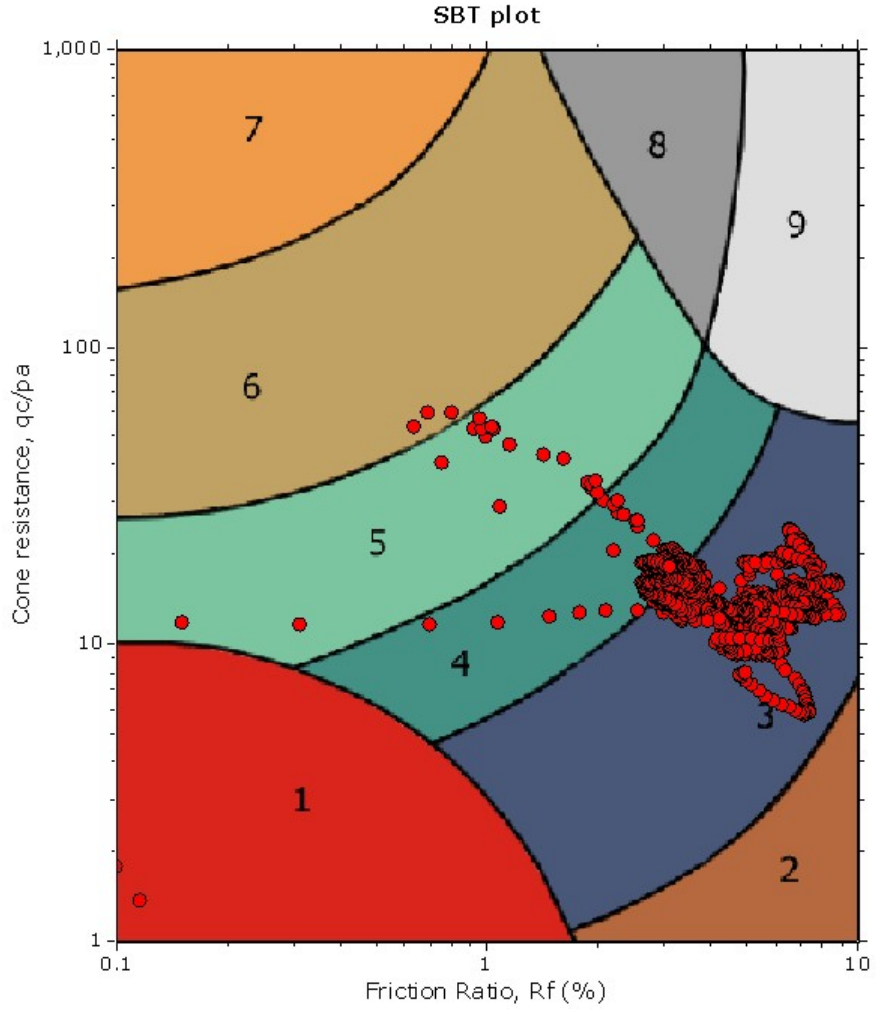


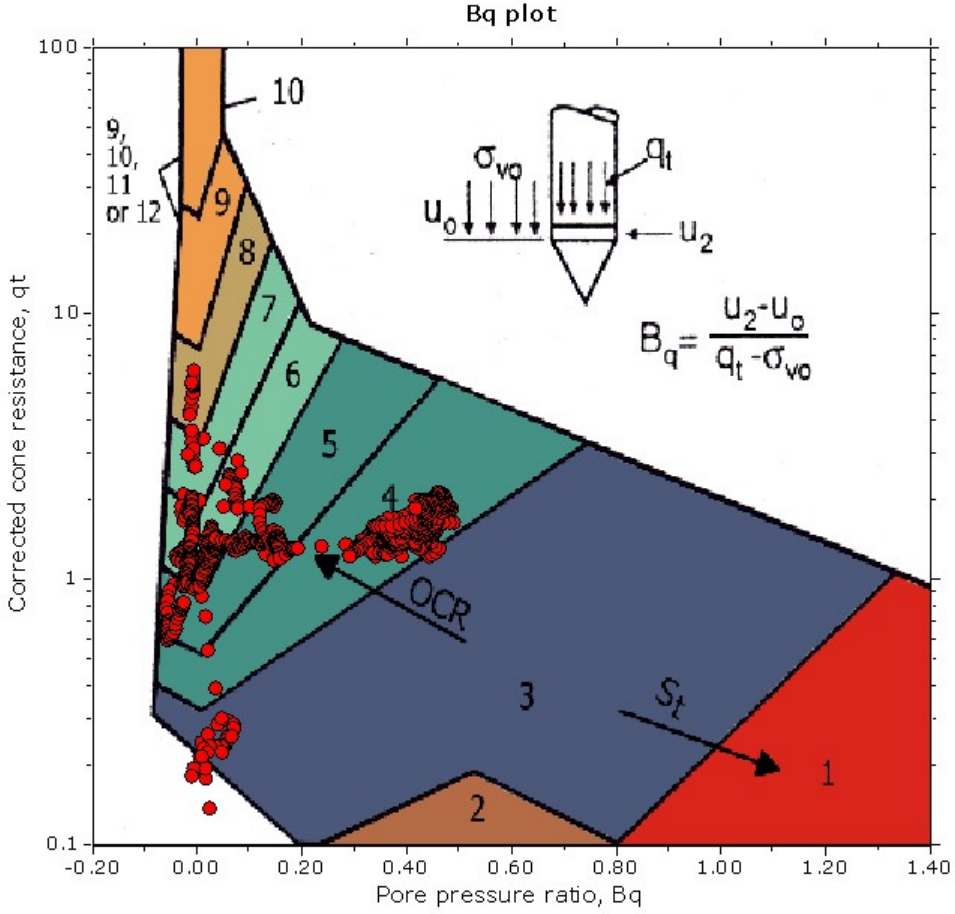
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

SBT - Bq plots





SBT legend

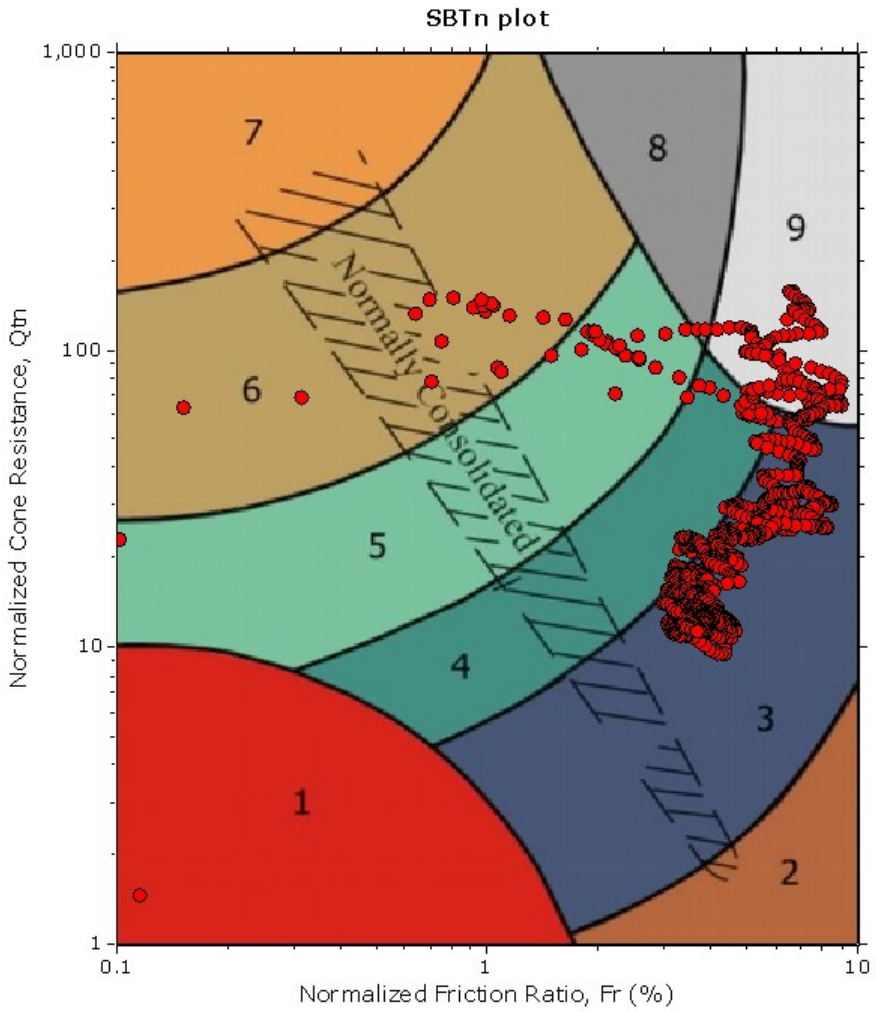
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

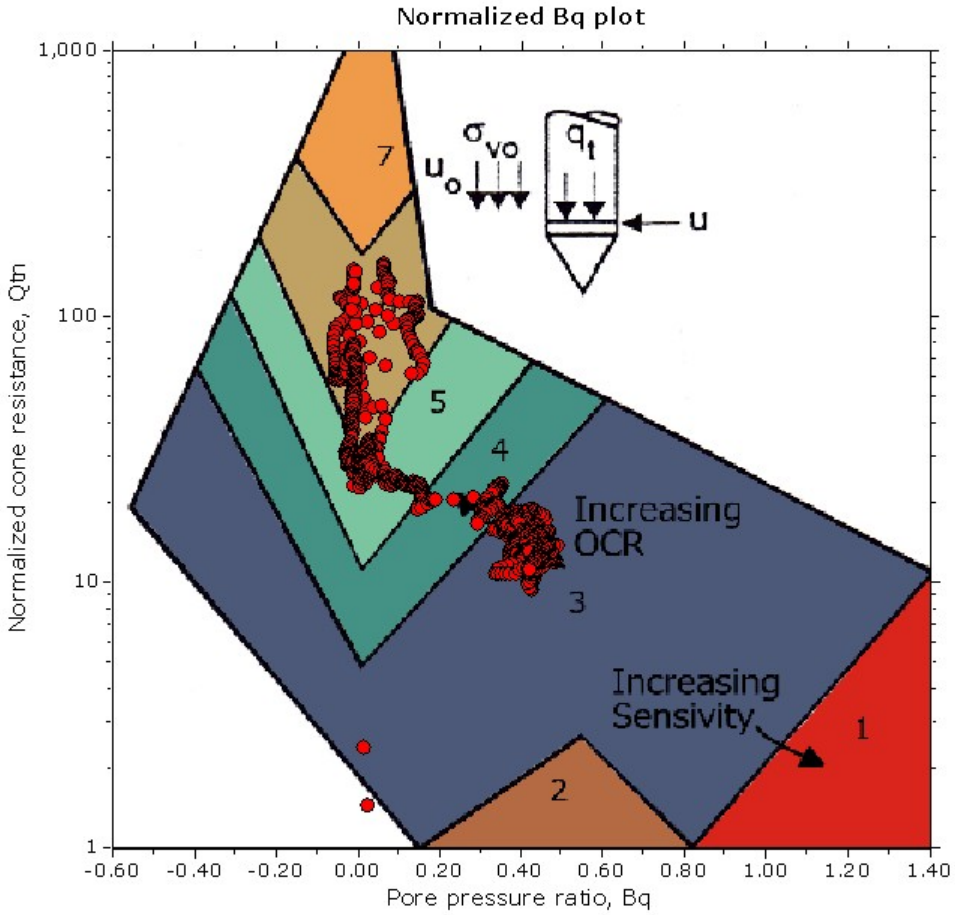
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

SBT - Bq plots (normalized)





SBTn legend

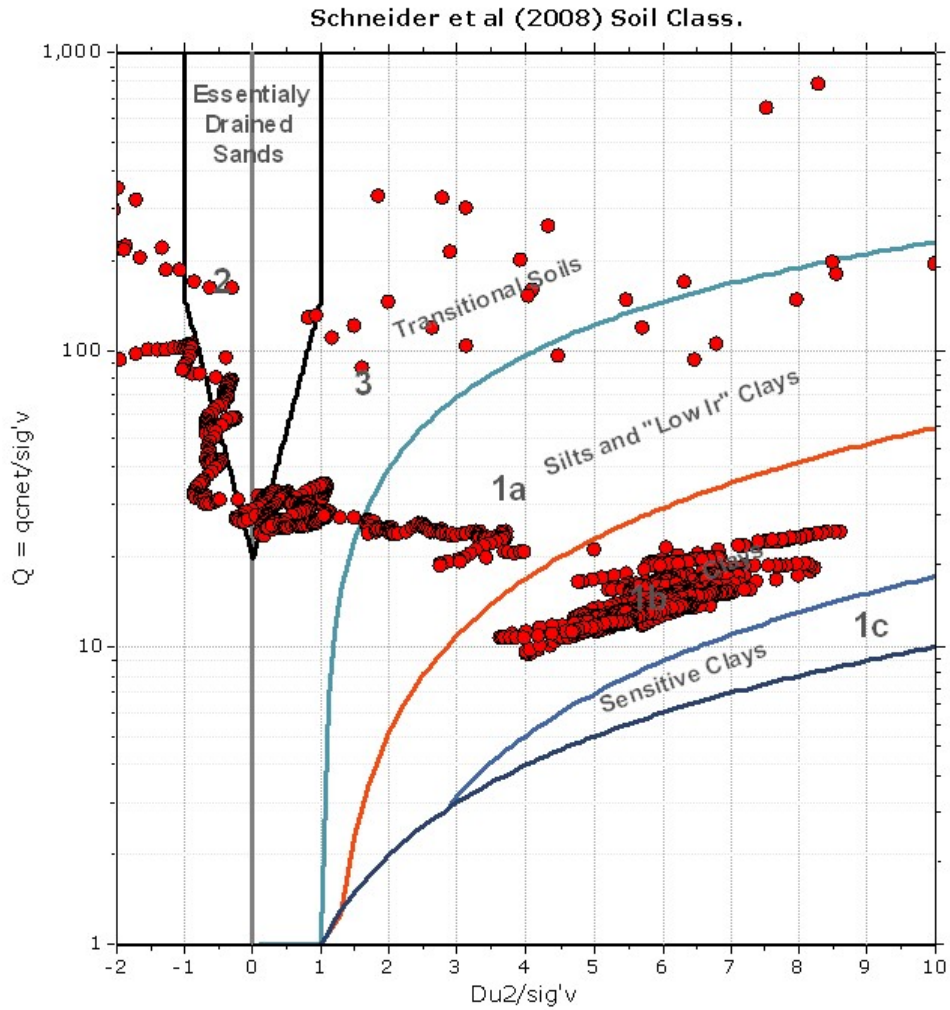
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

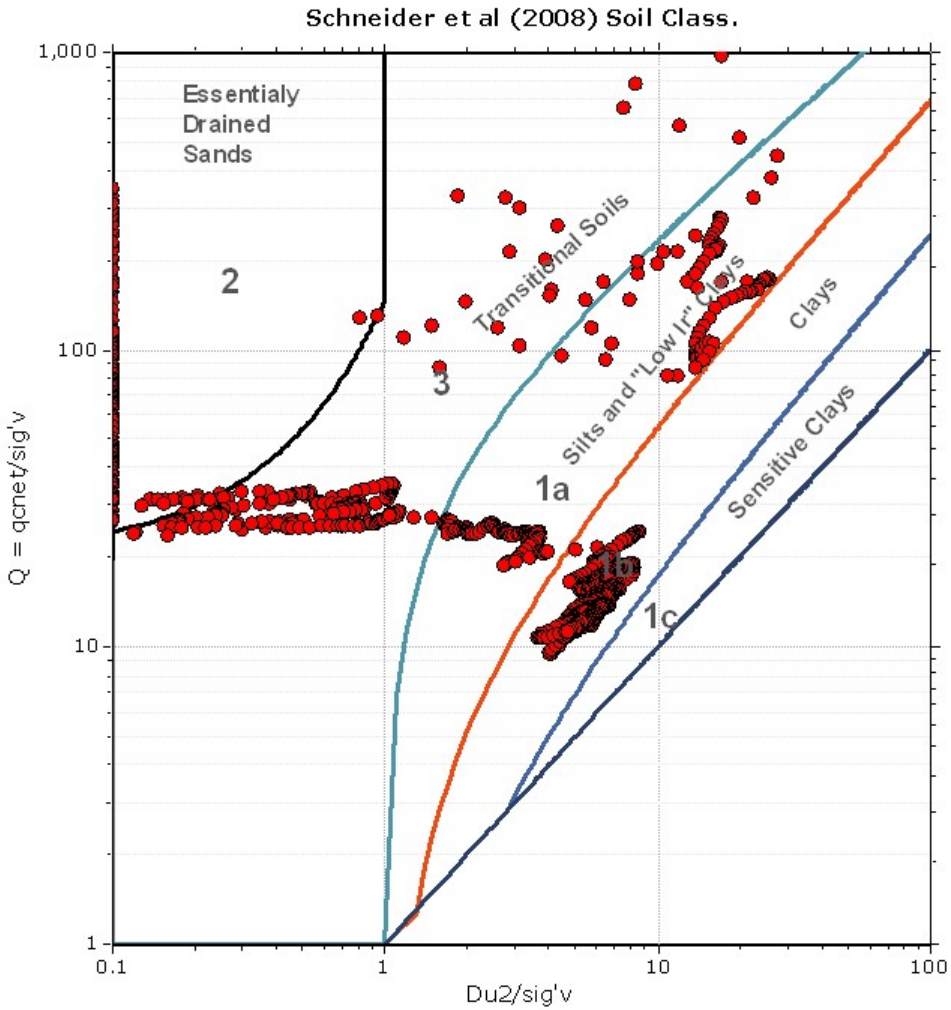
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

Bq plots (Schneider)



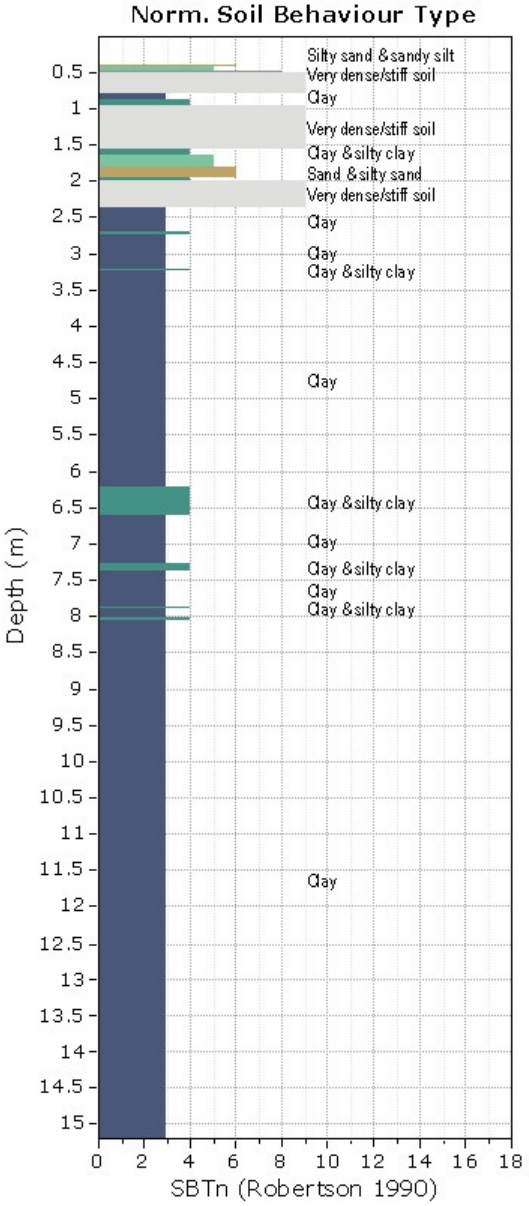


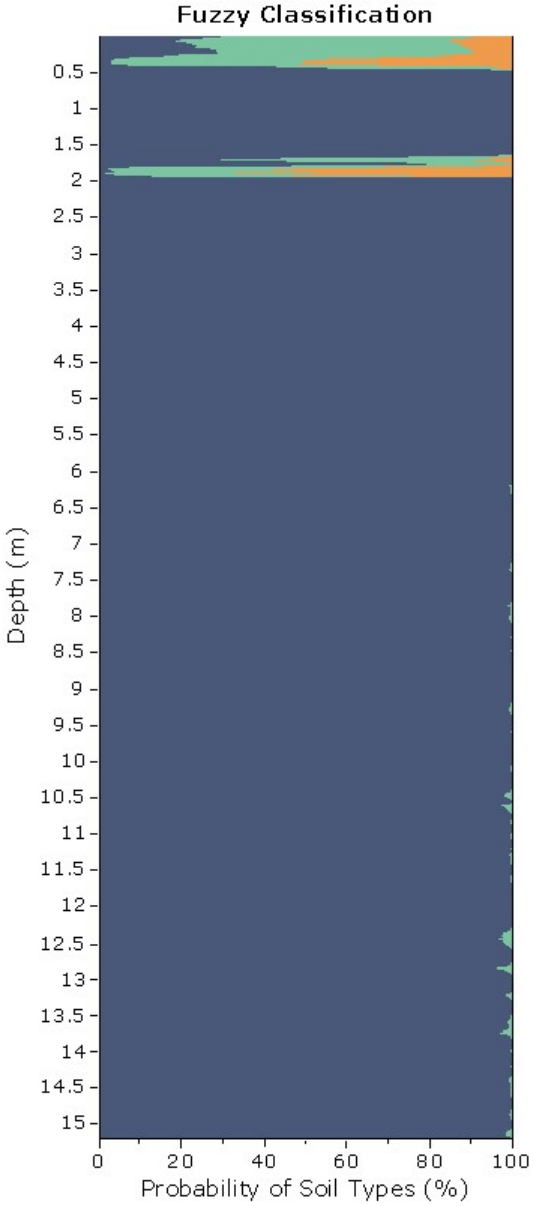
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-12

Project: **A1B2CH**
Location: **Birtley to Coal House**

Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

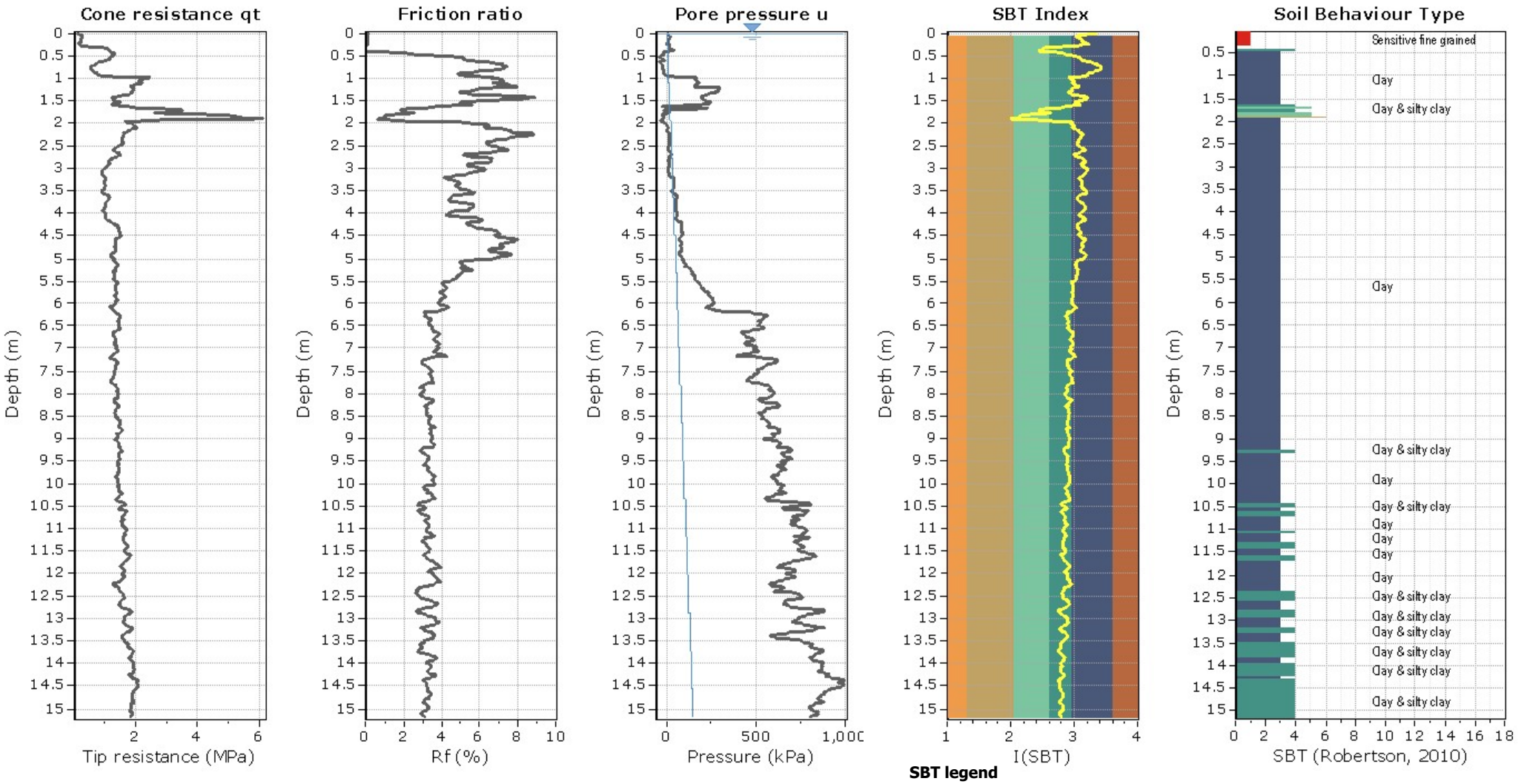




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

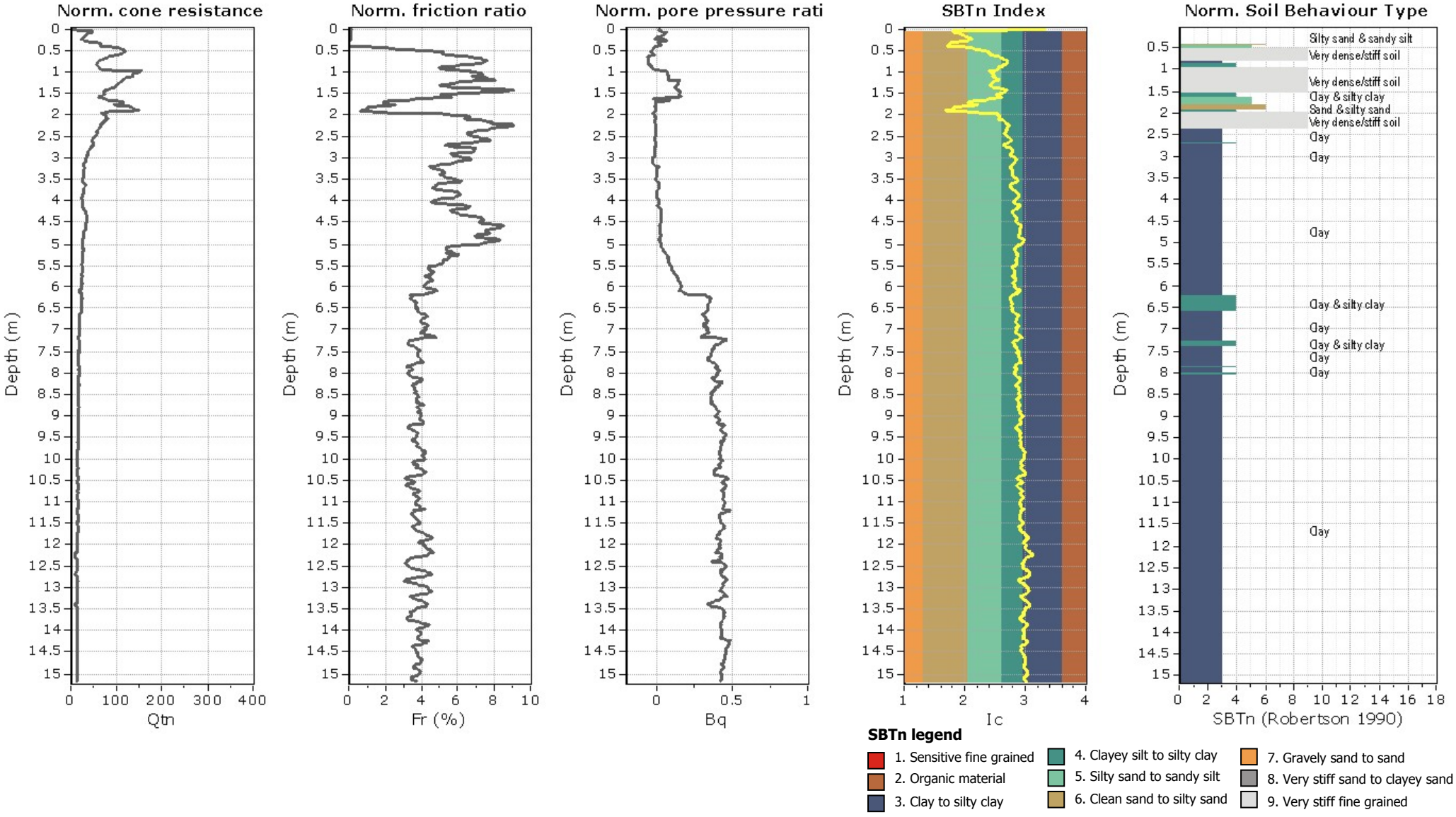
CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

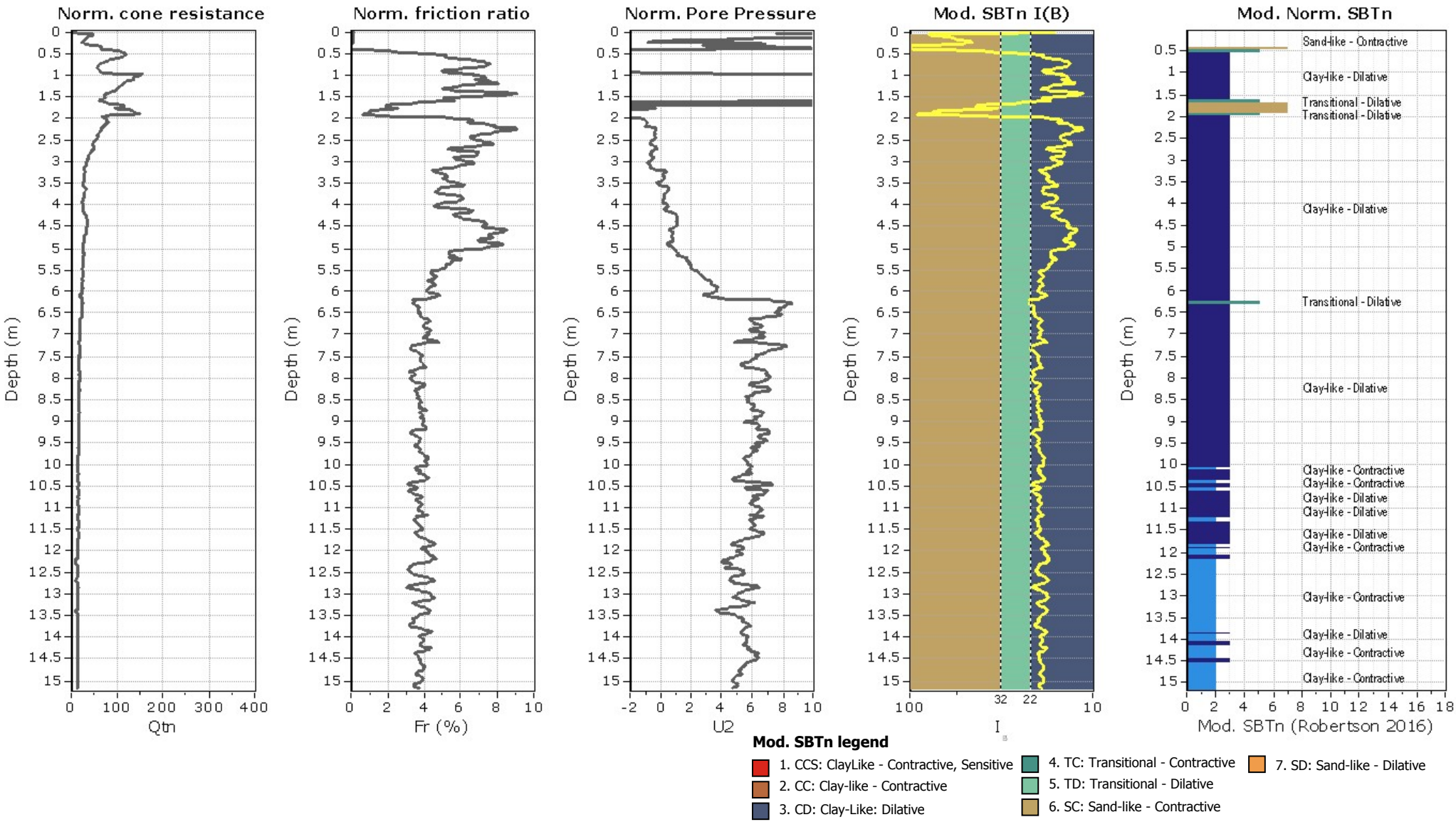
CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

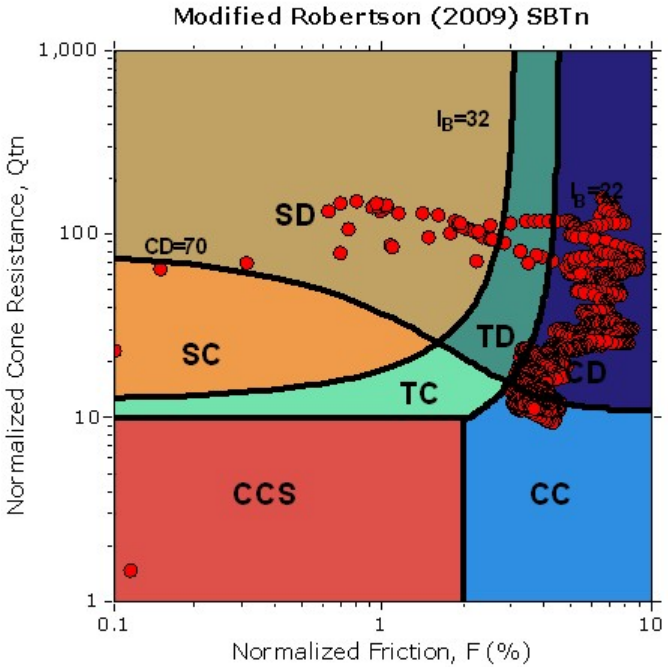


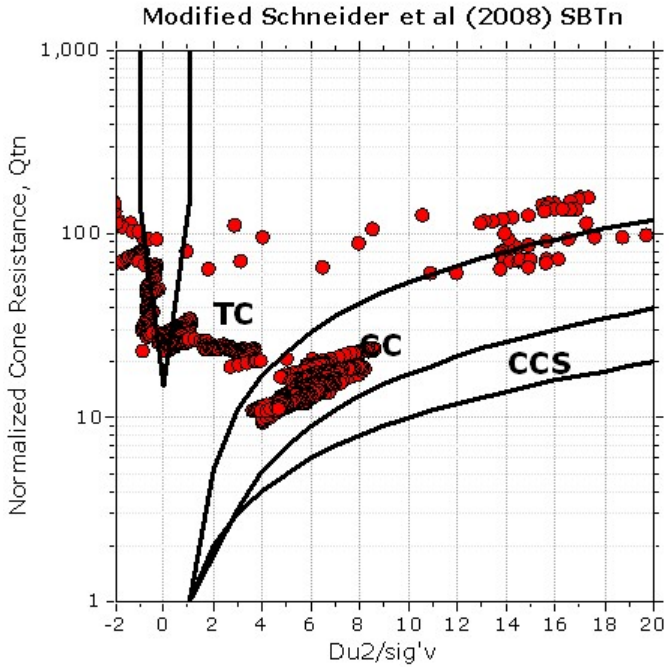
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

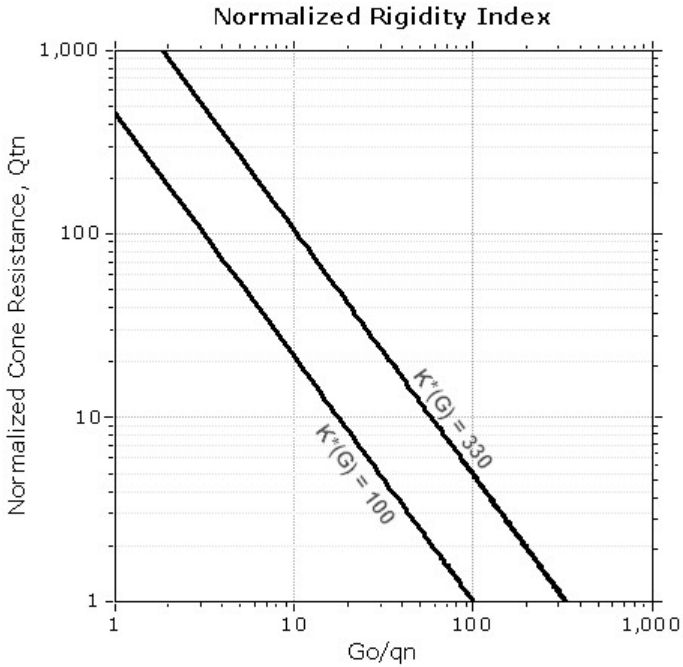
Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH

Updated SBTn plots







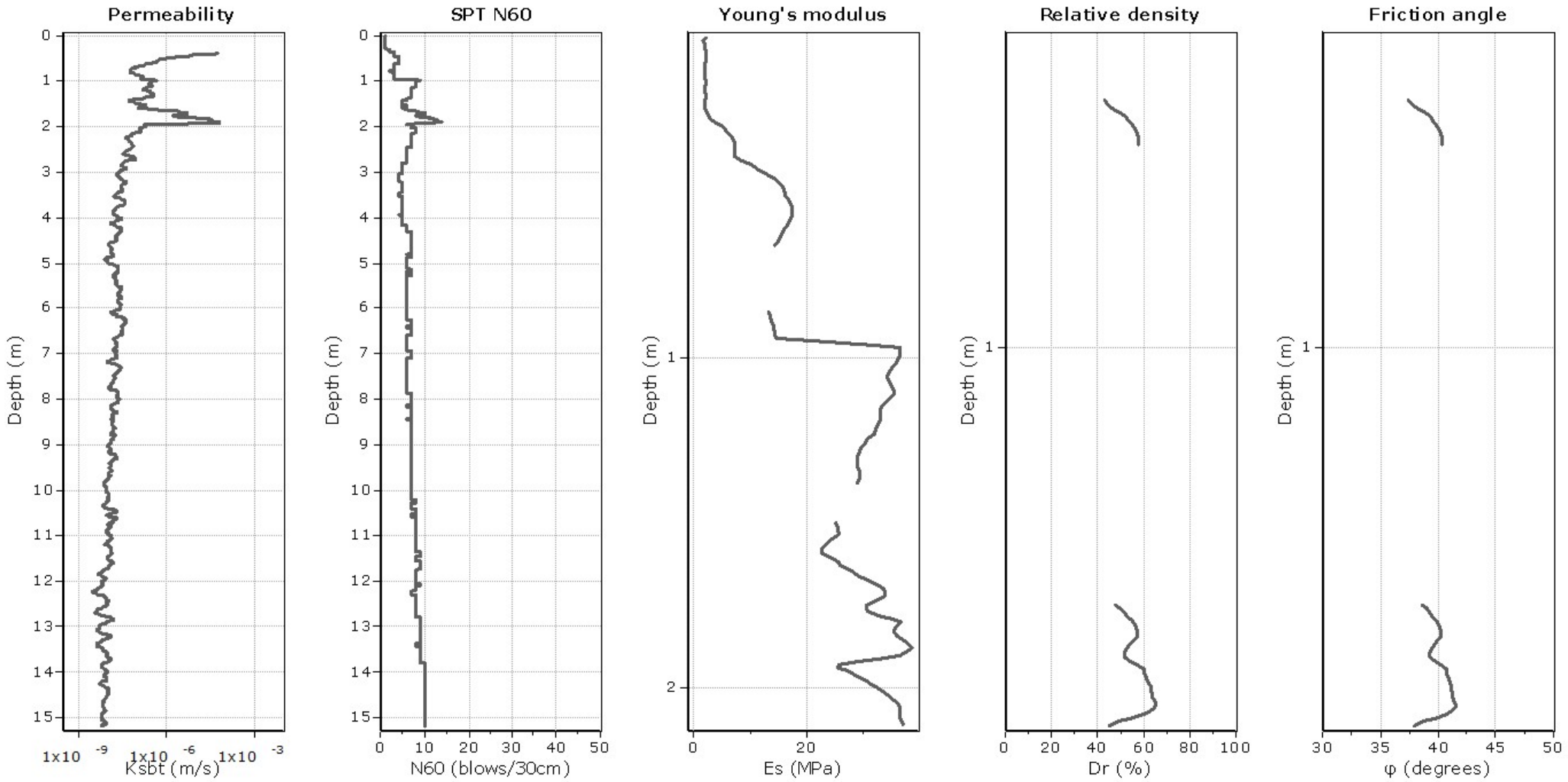
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



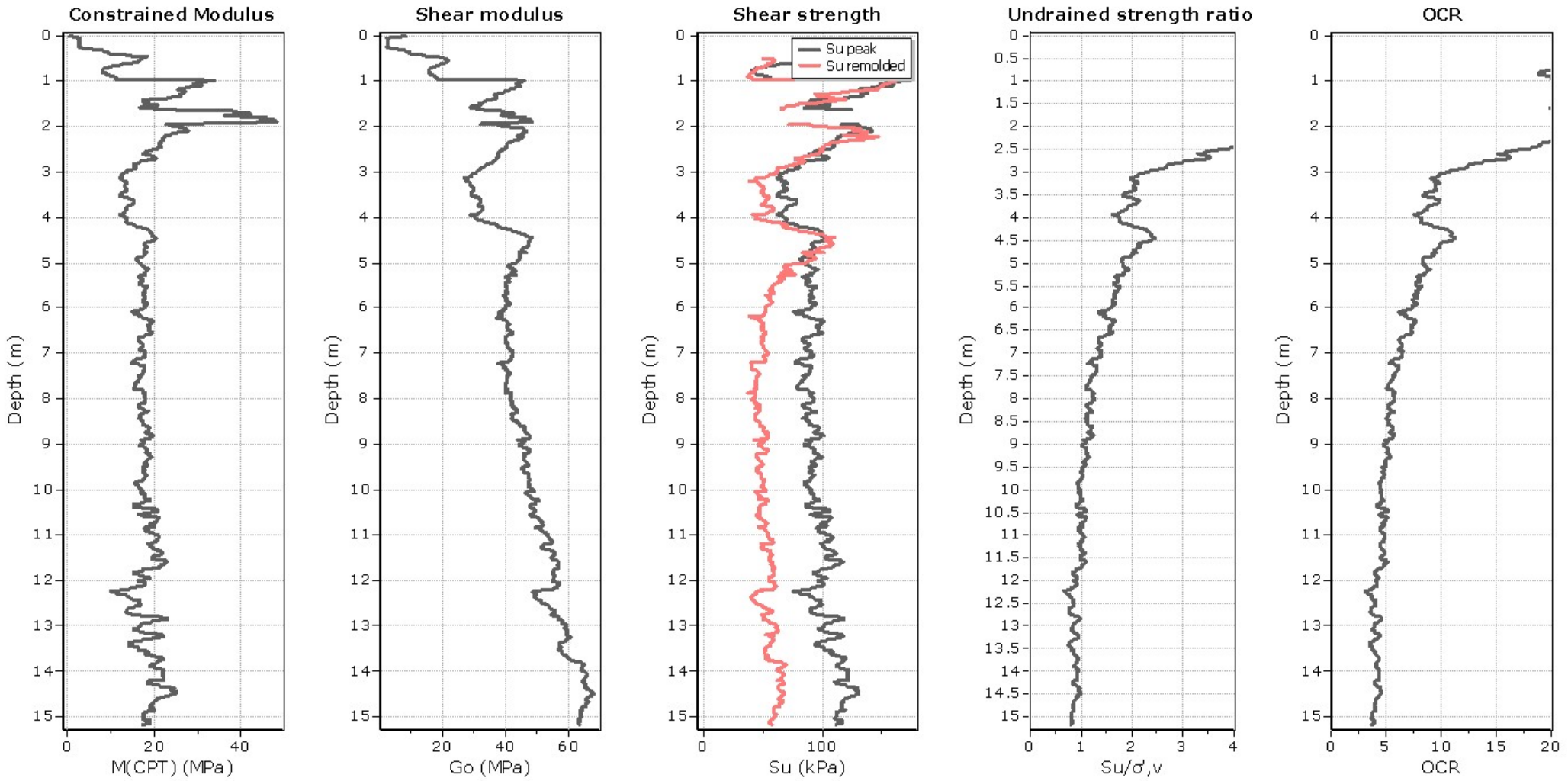
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



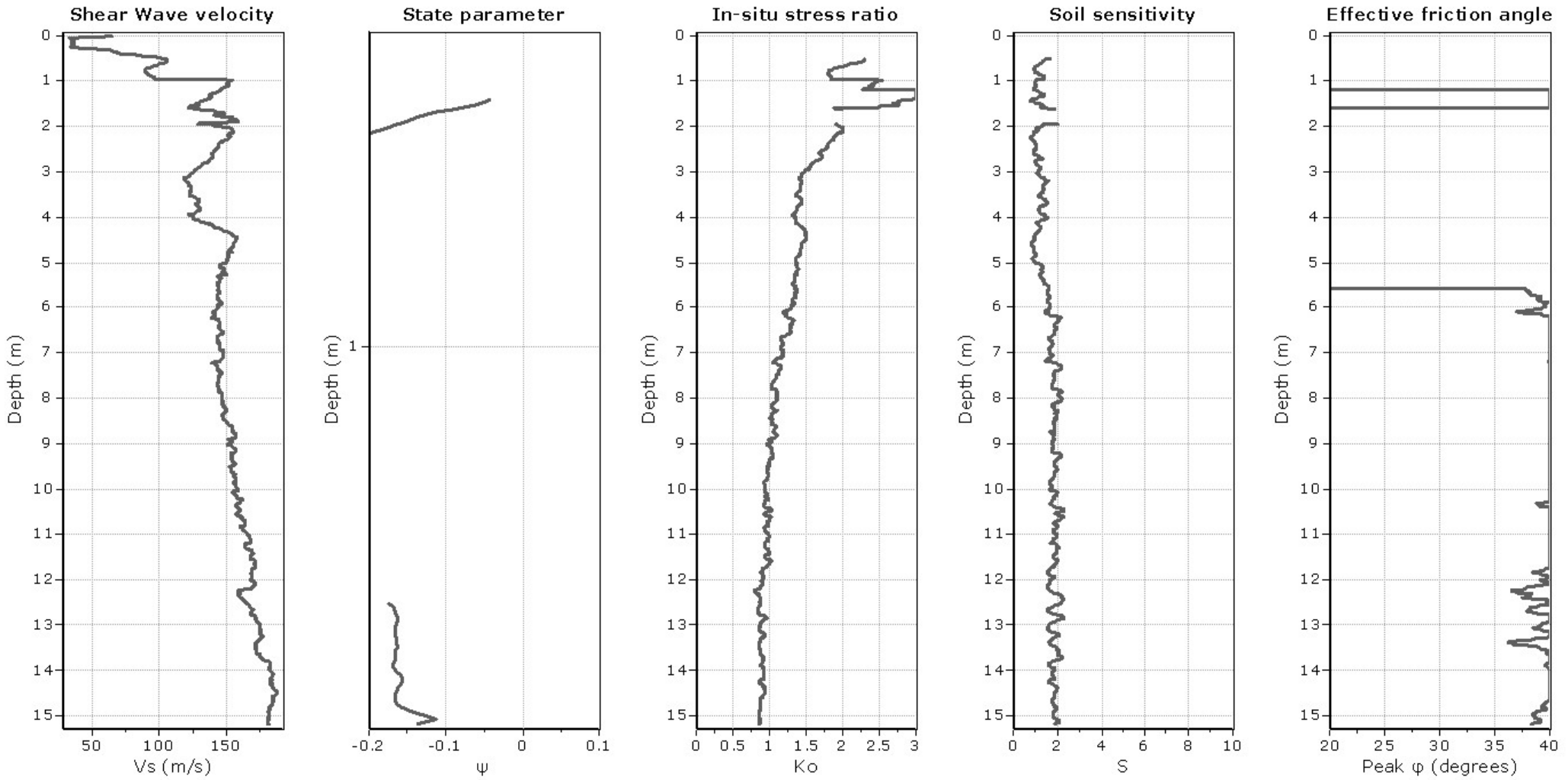
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **A1B2CH**
Location: **Birtley to Coal House**

CPT: CPT17-12
Total depth: 15.18 m, Date: 18/01/2018
Cone Operator: JG CH



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

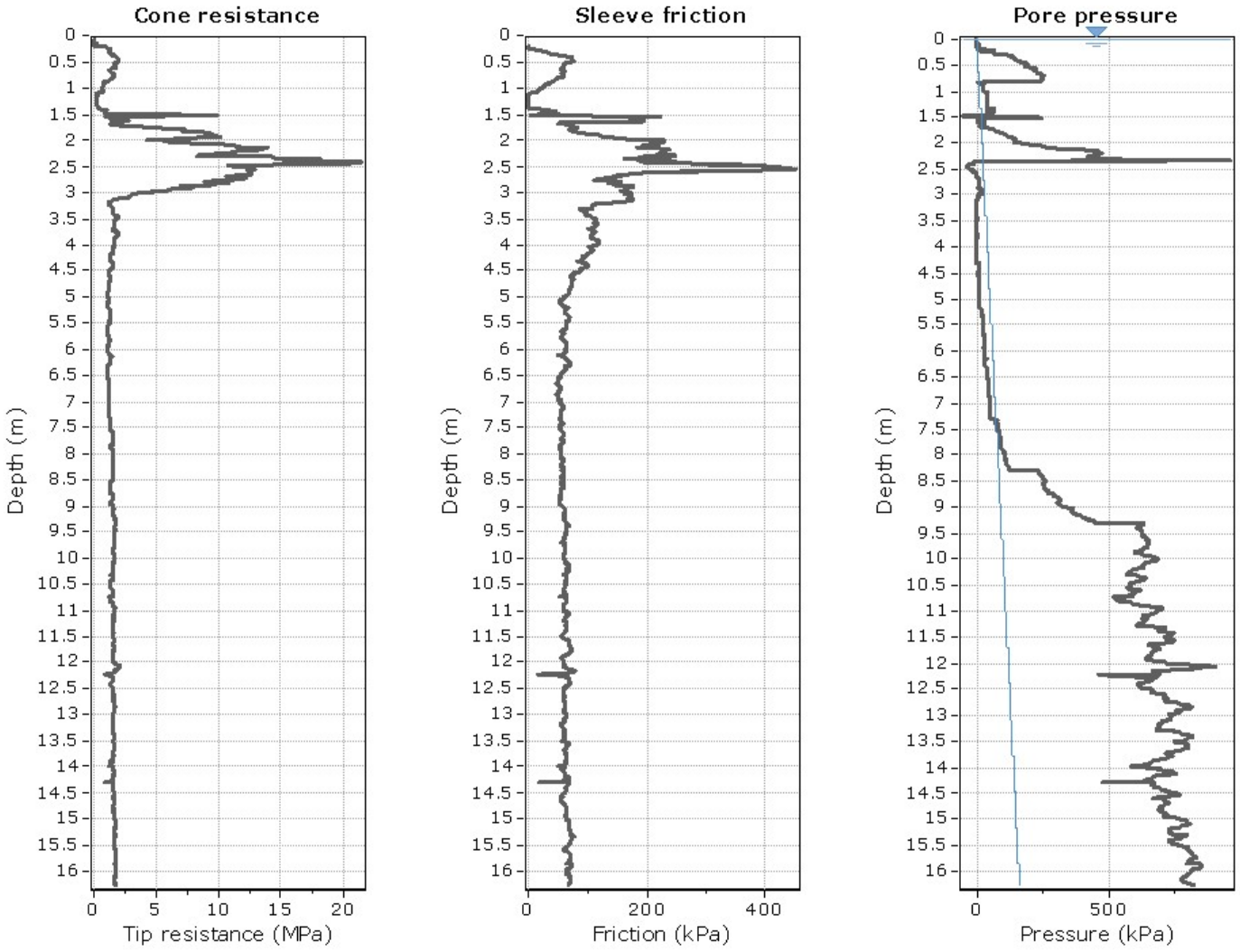
• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

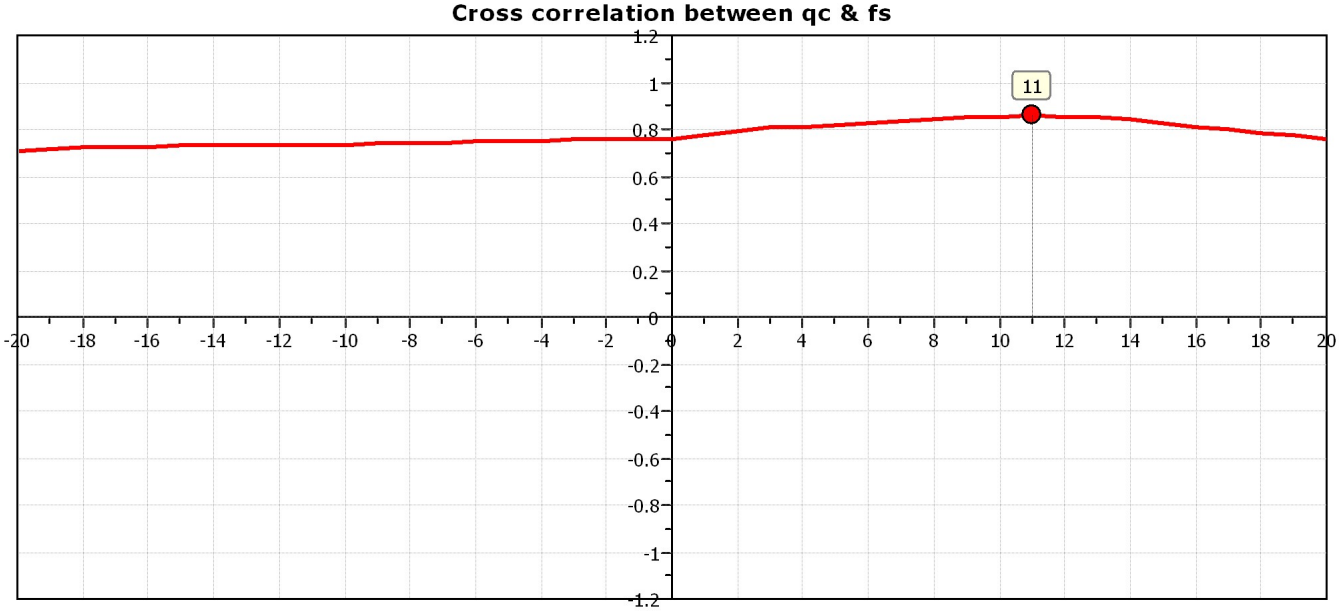
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

Project: **CA3043**
Location: **A1B2CH**



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

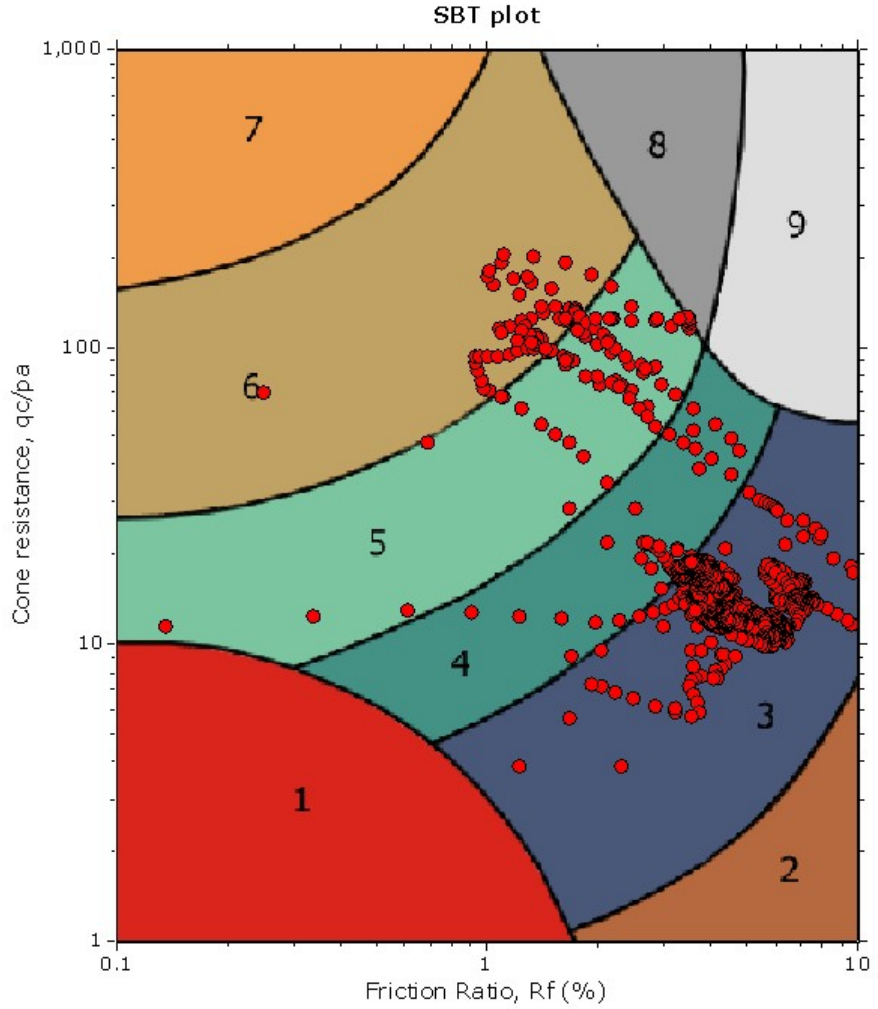


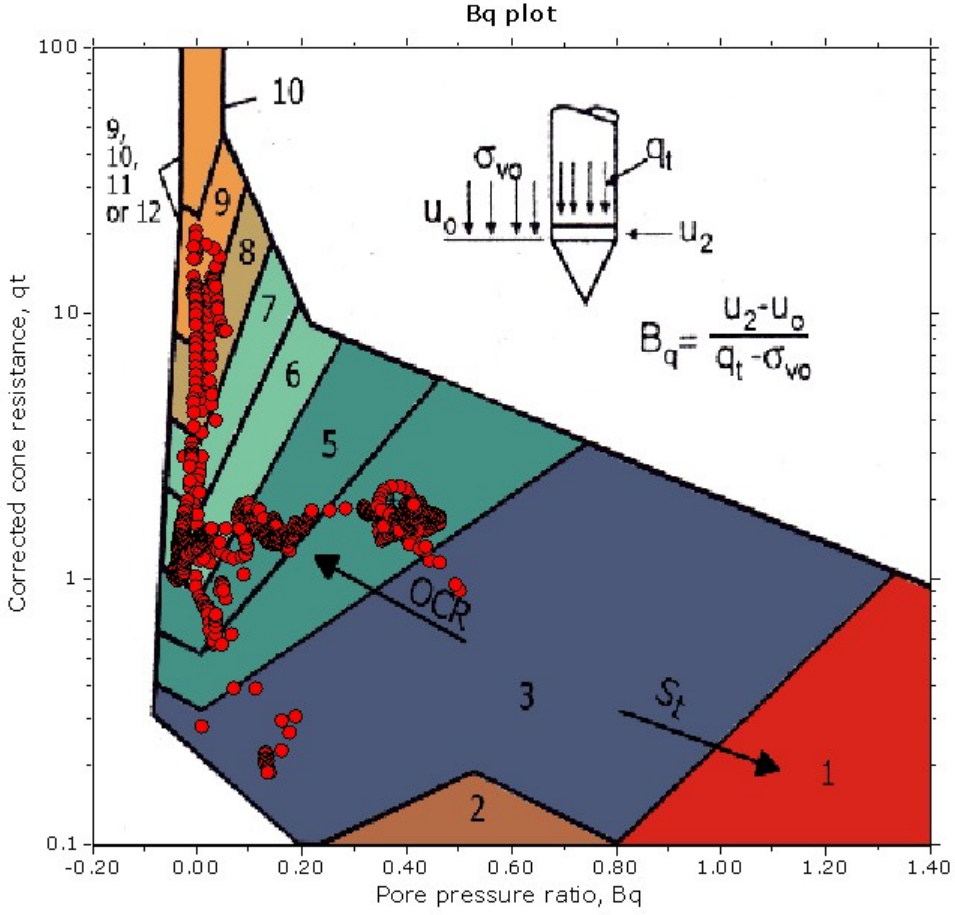
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

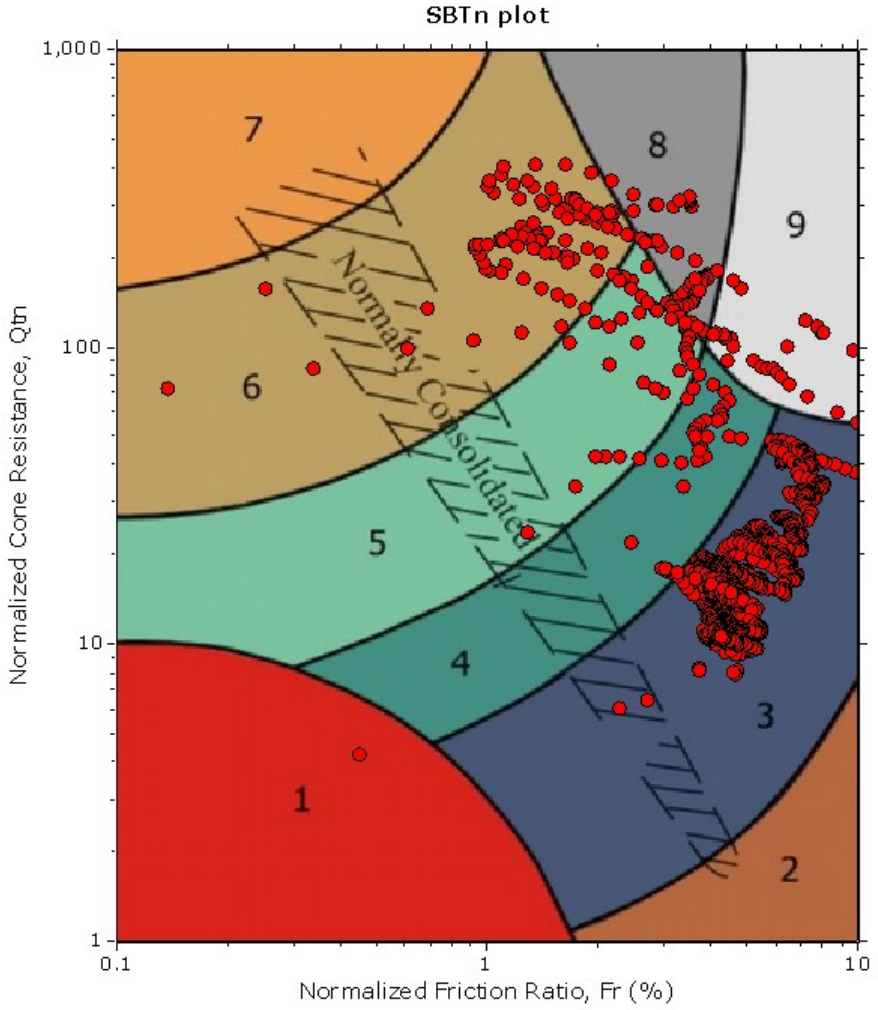
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

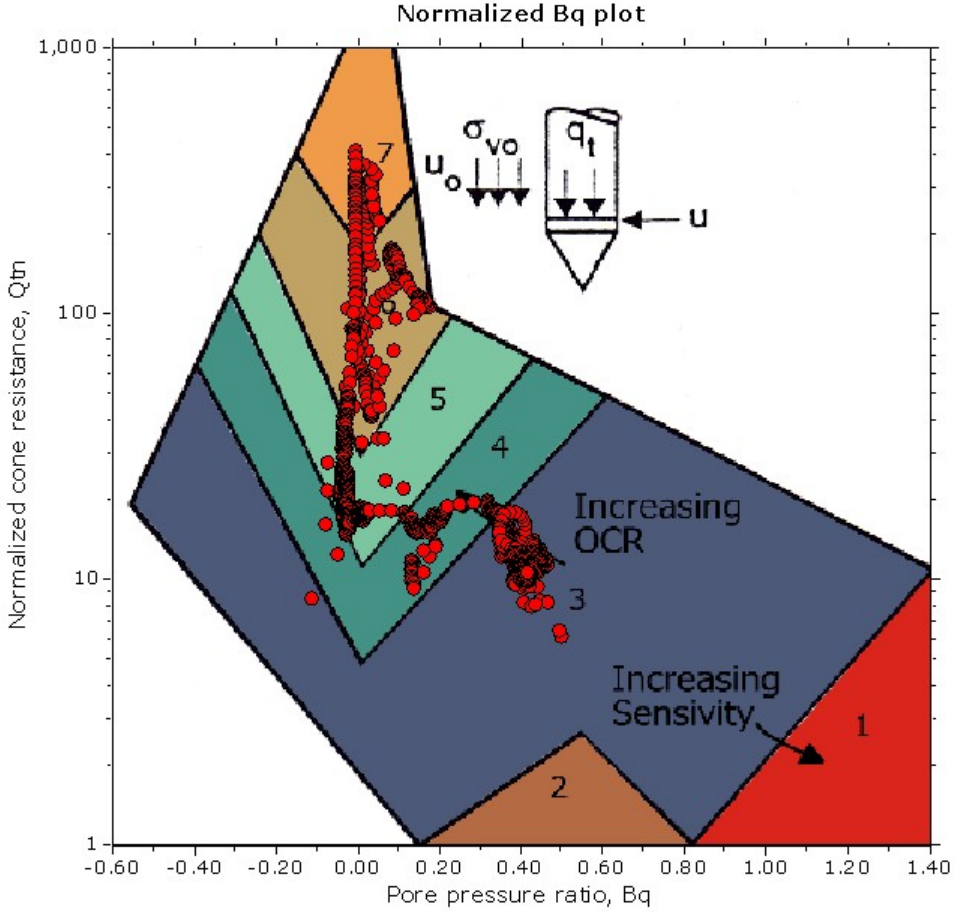
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

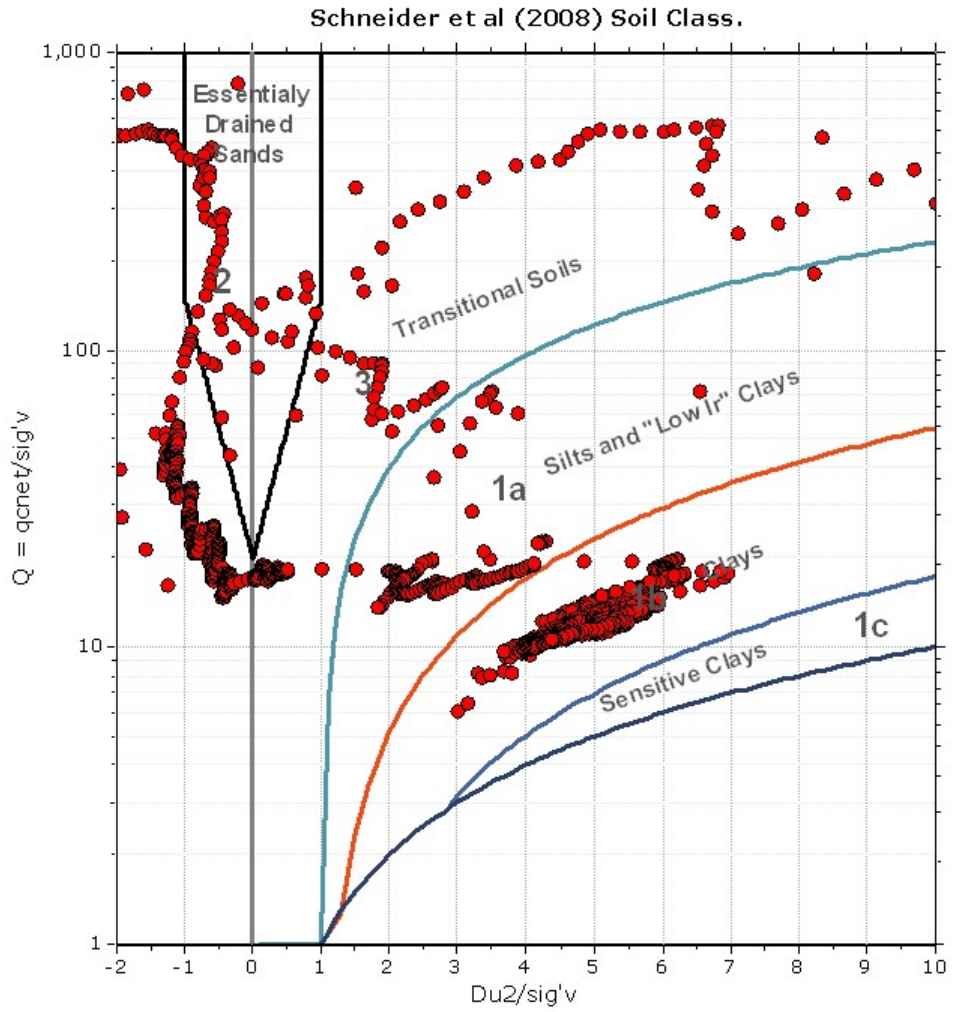
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

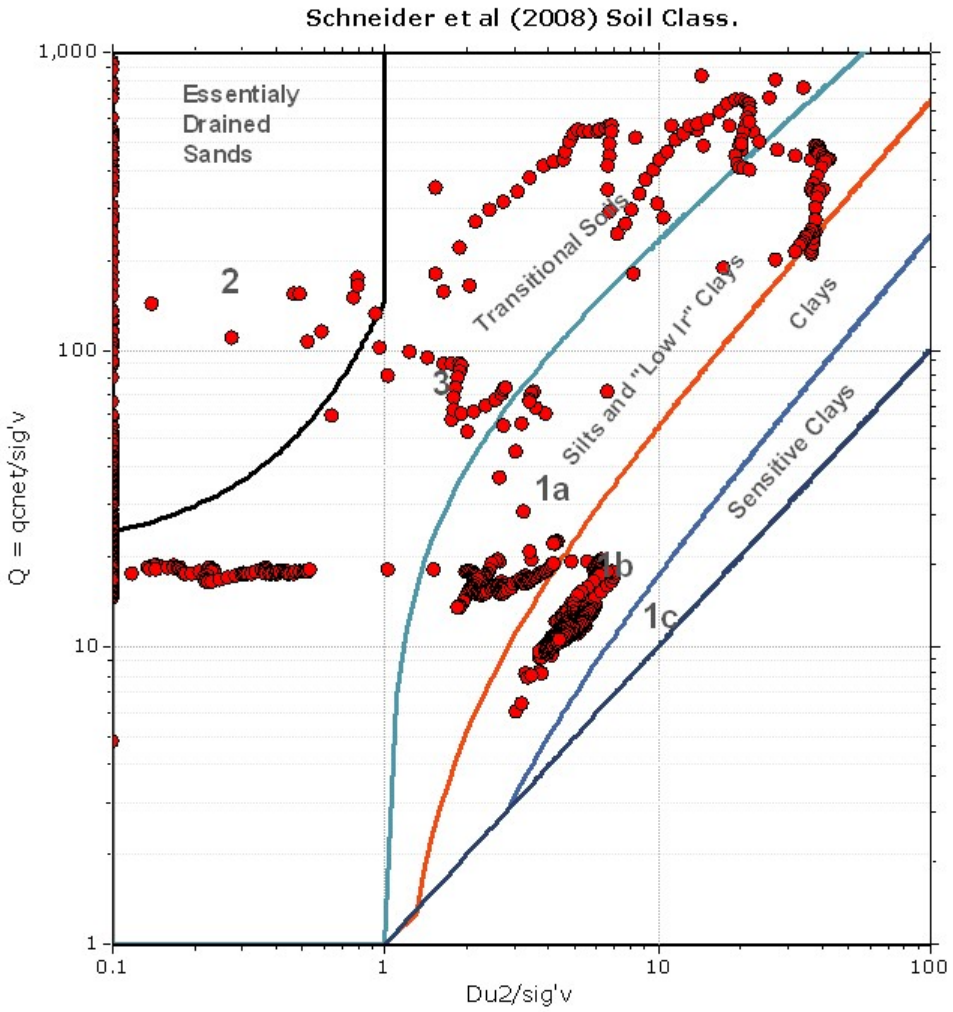
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



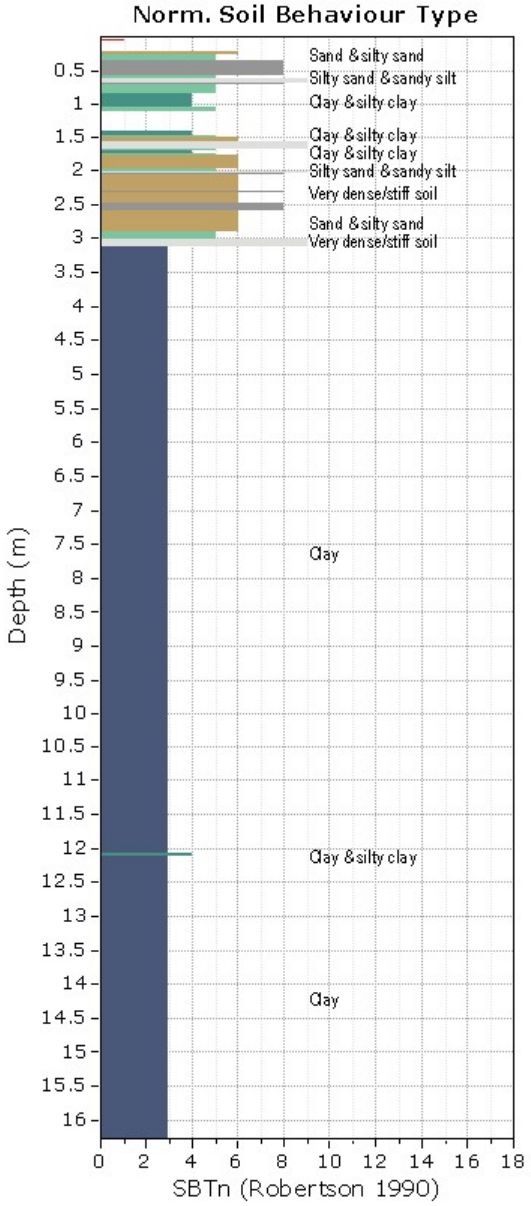


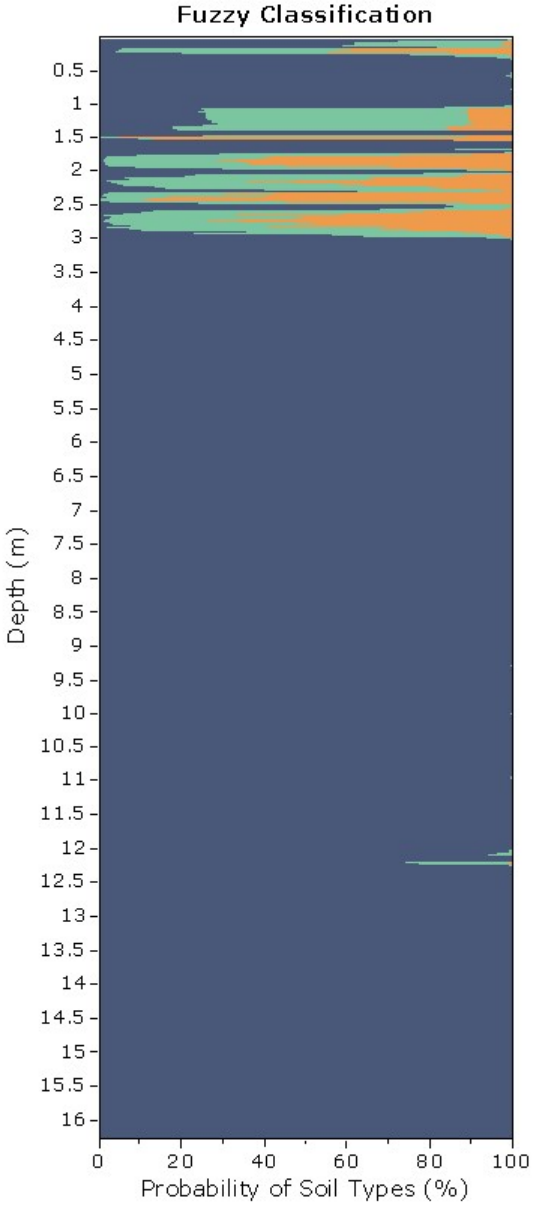
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-13

Project: CA3043
Location: A1B2CH

Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

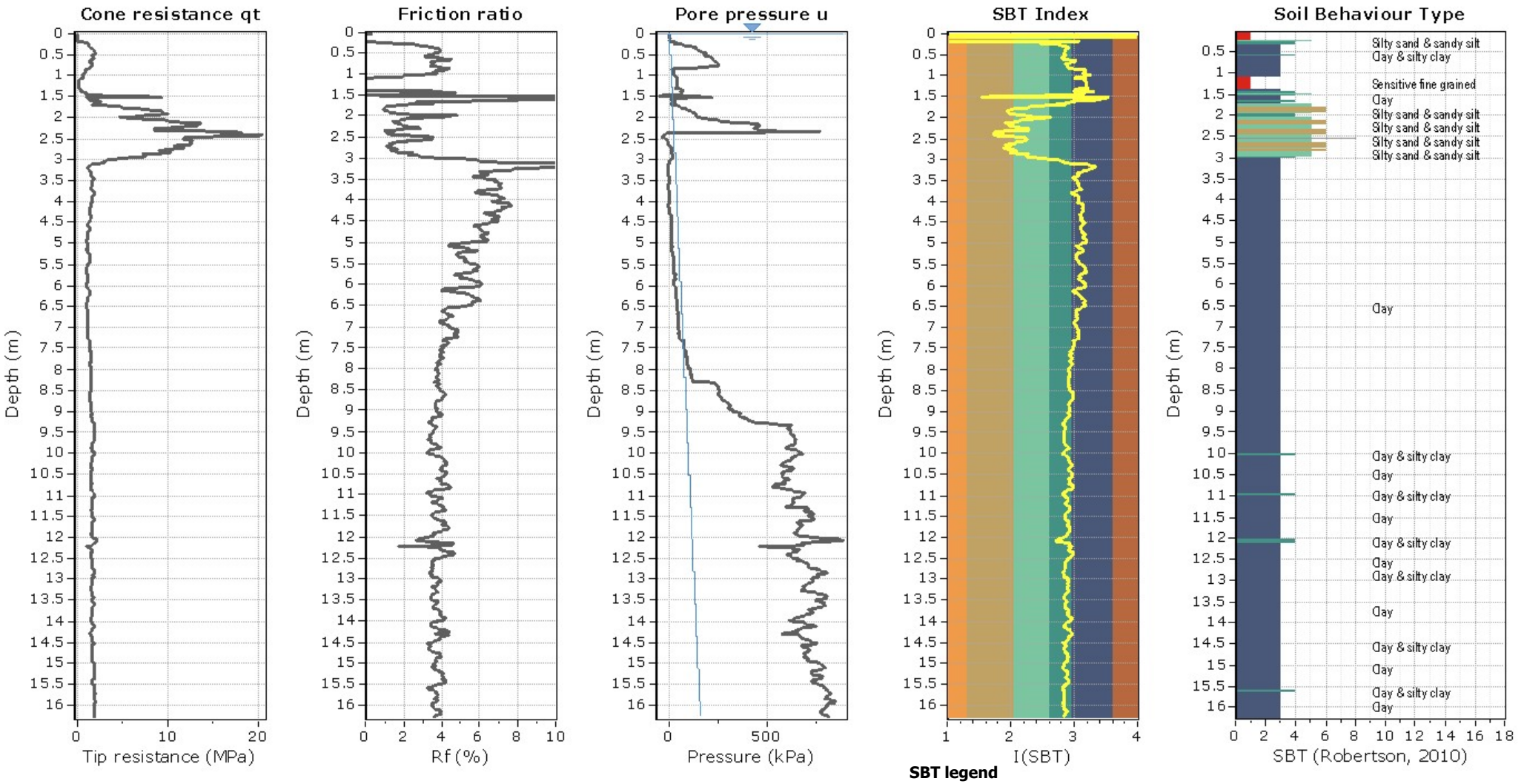




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

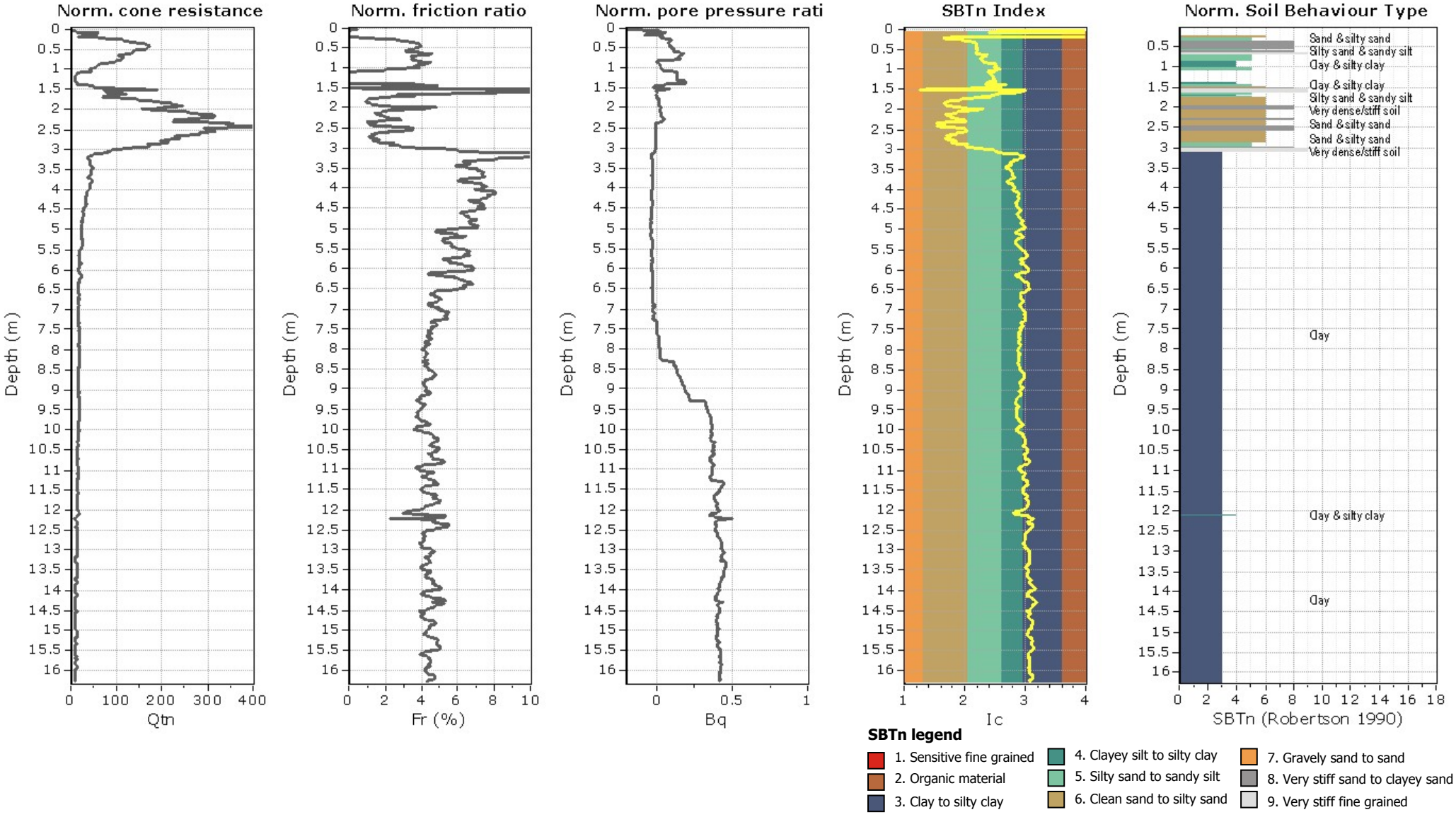
CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

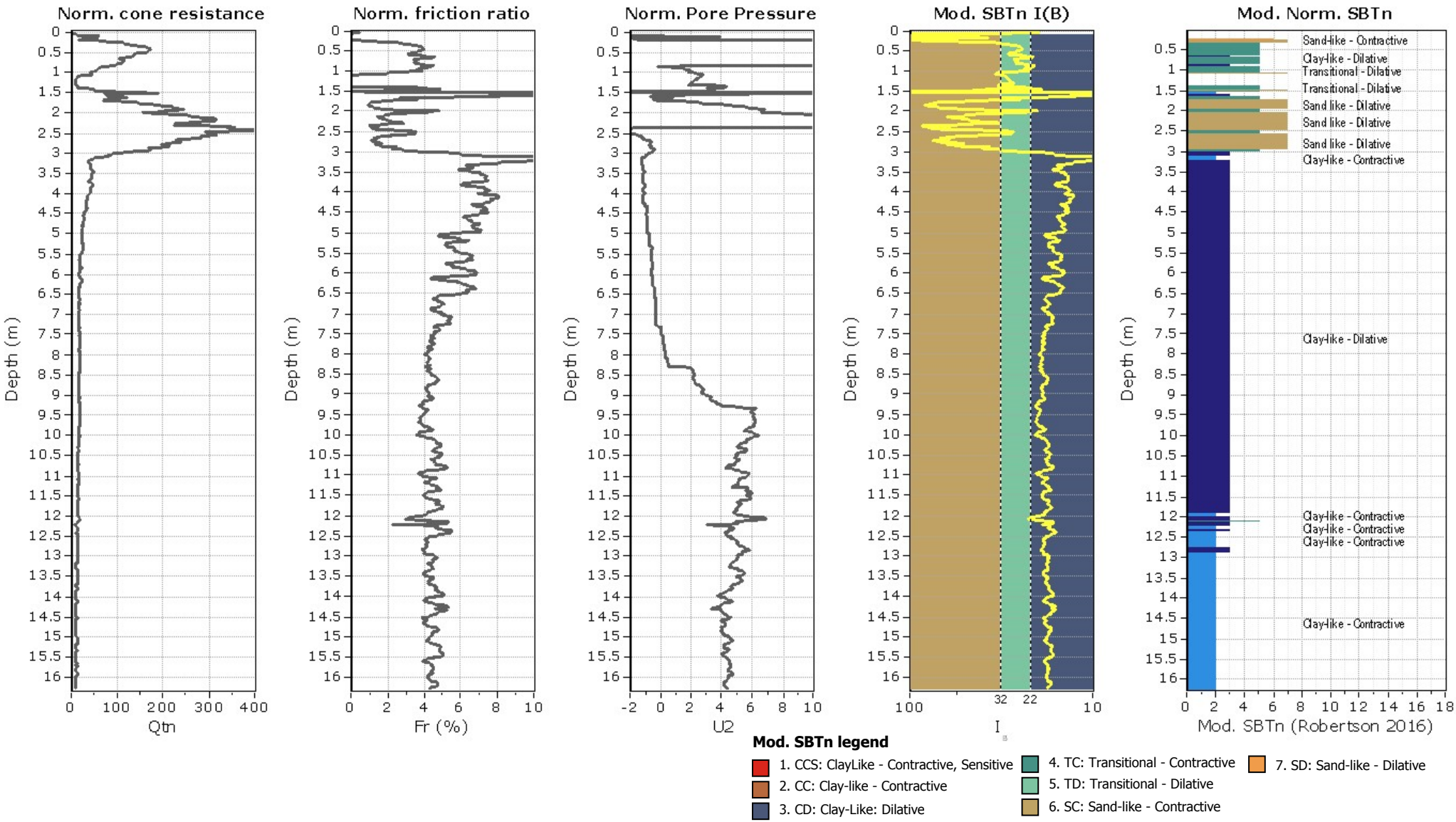
CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

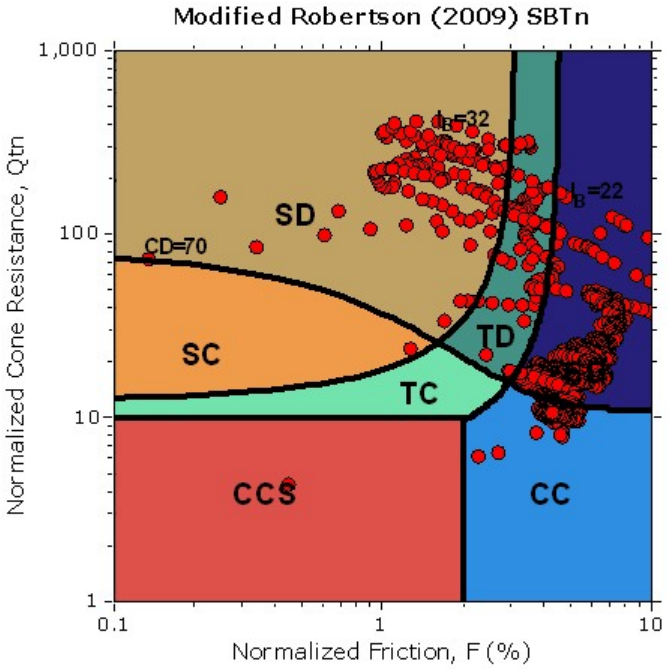


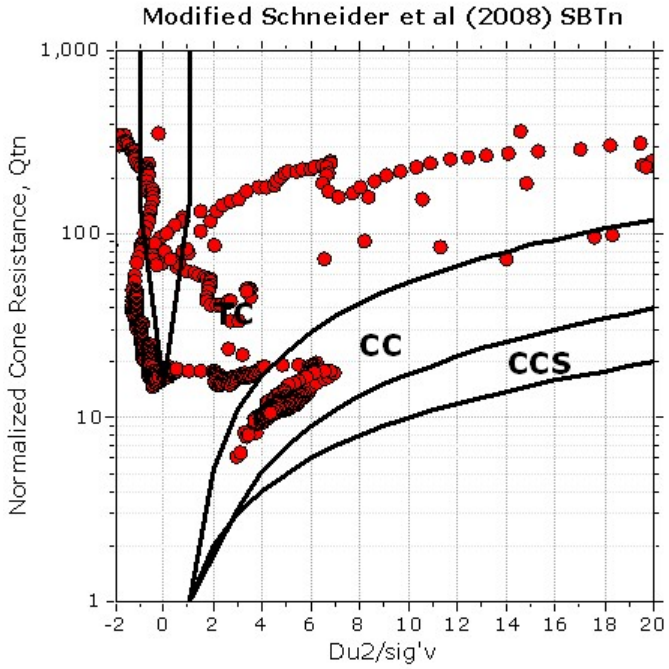
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

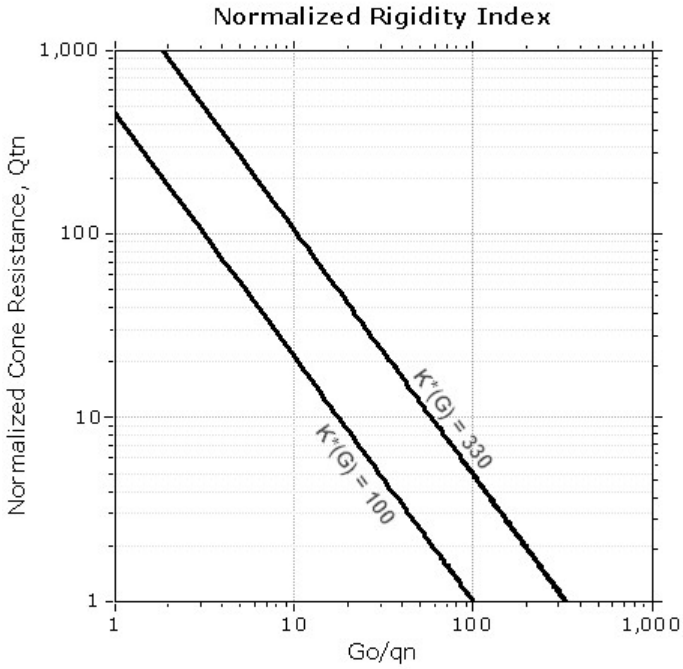
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







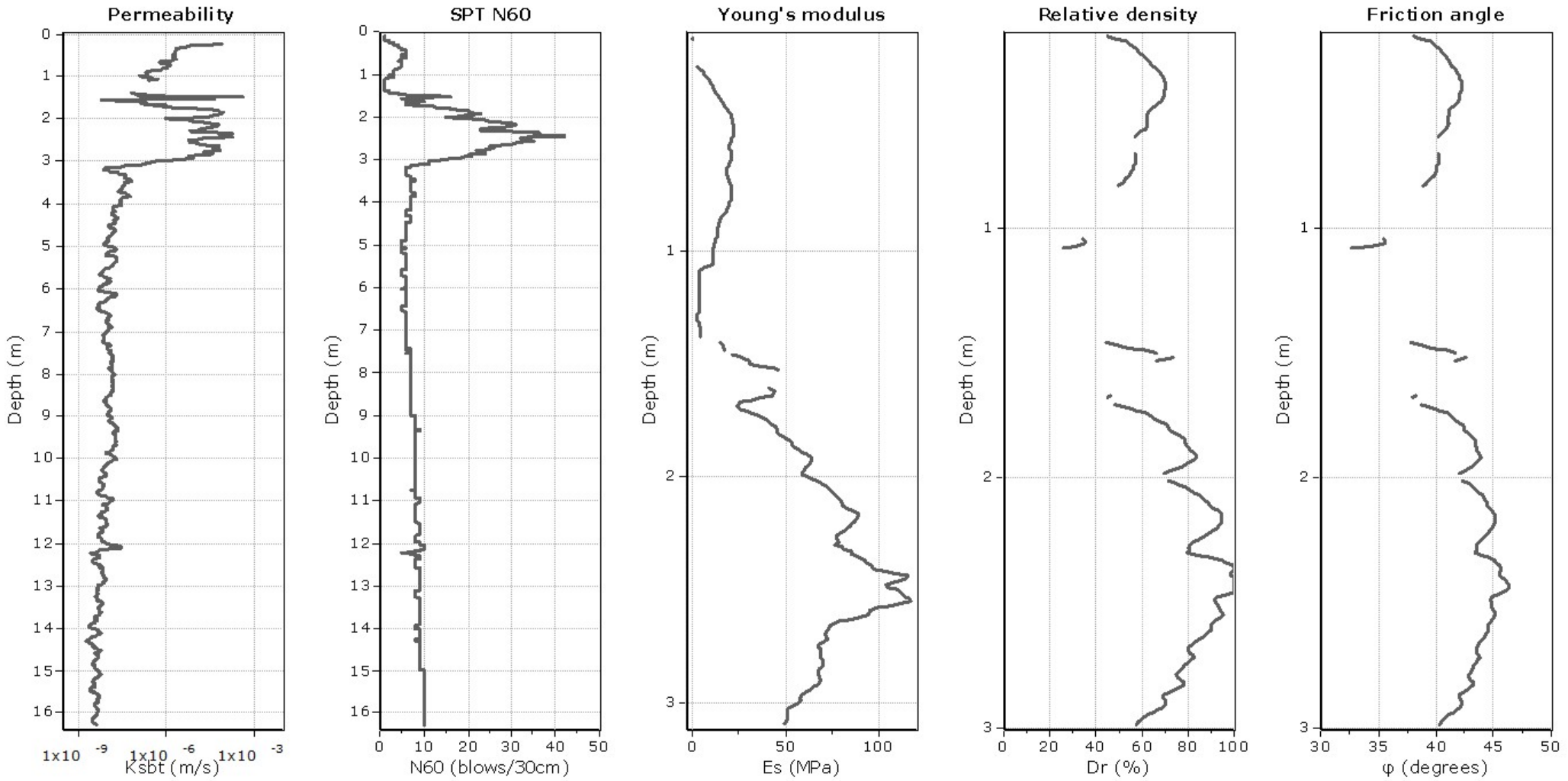
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown



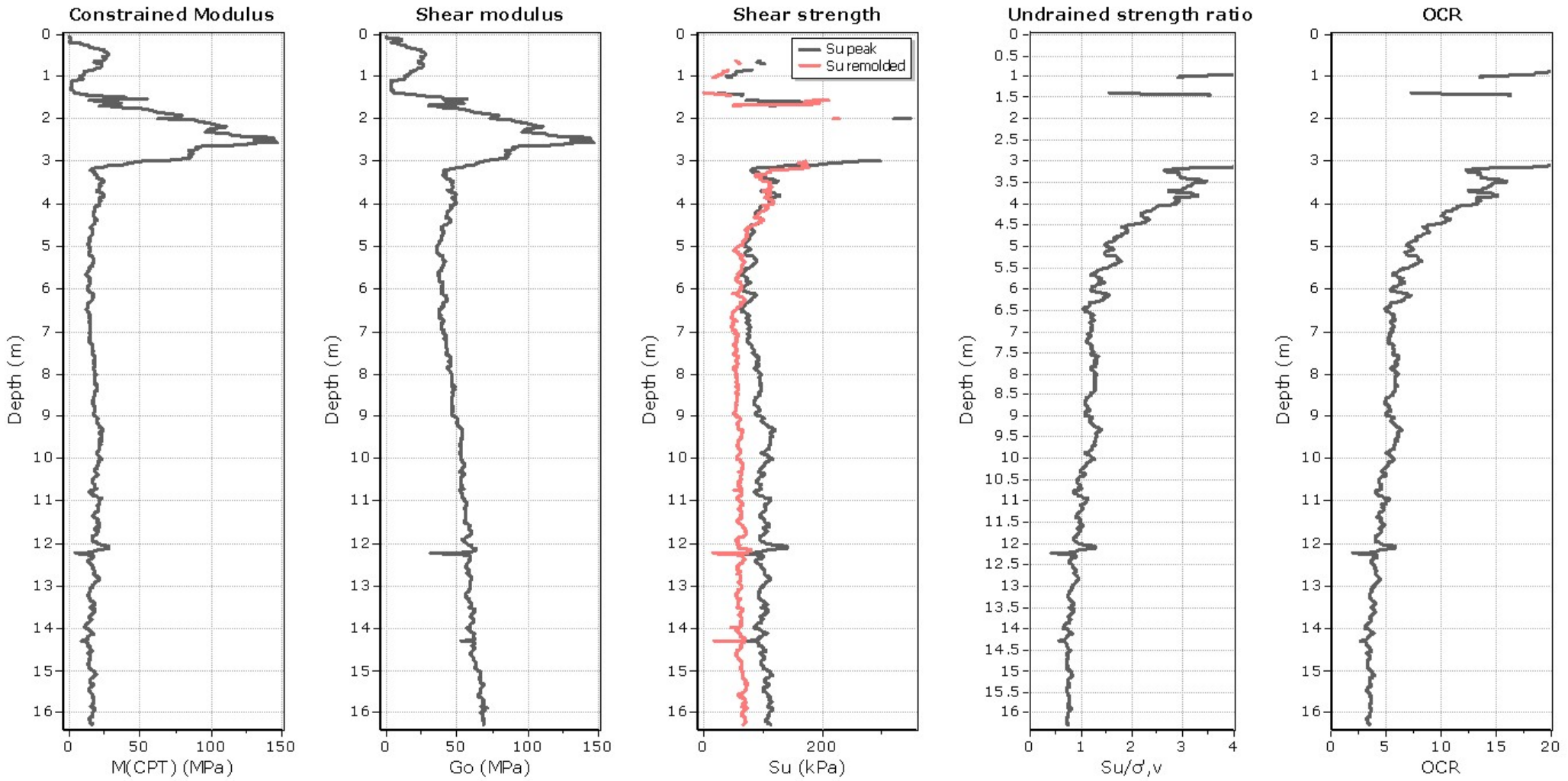
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown



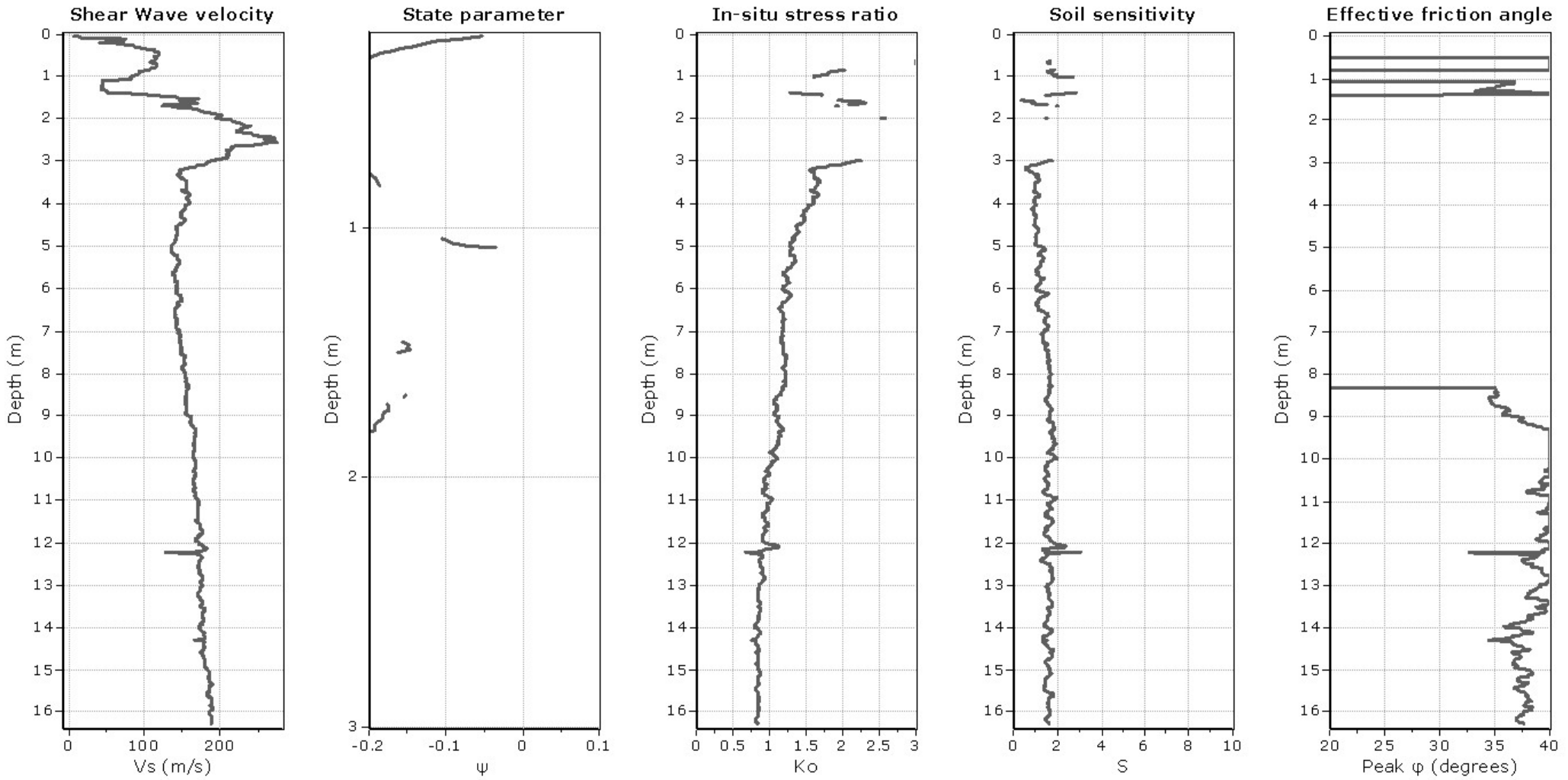
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-13
Total depth: 16.27 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

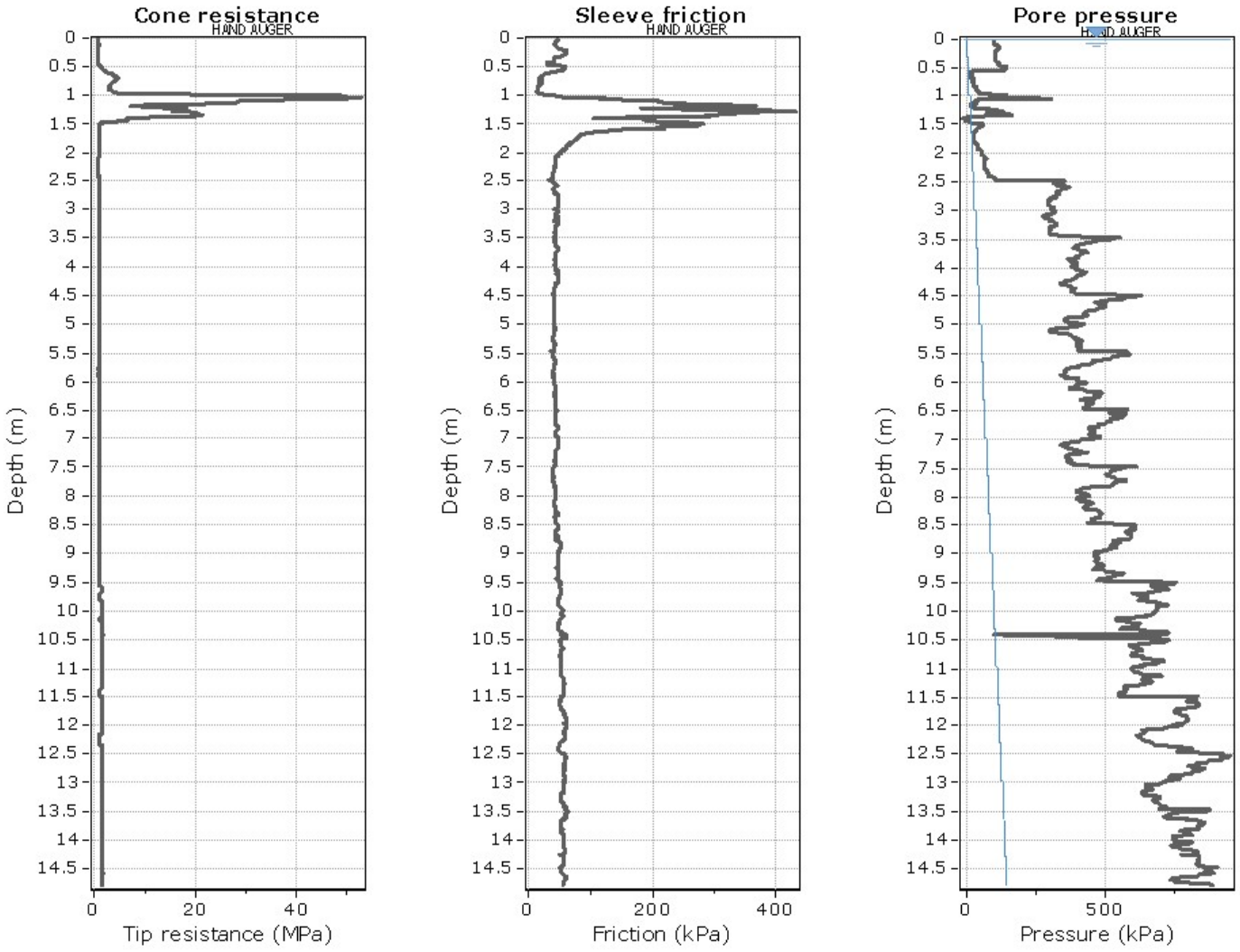
• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

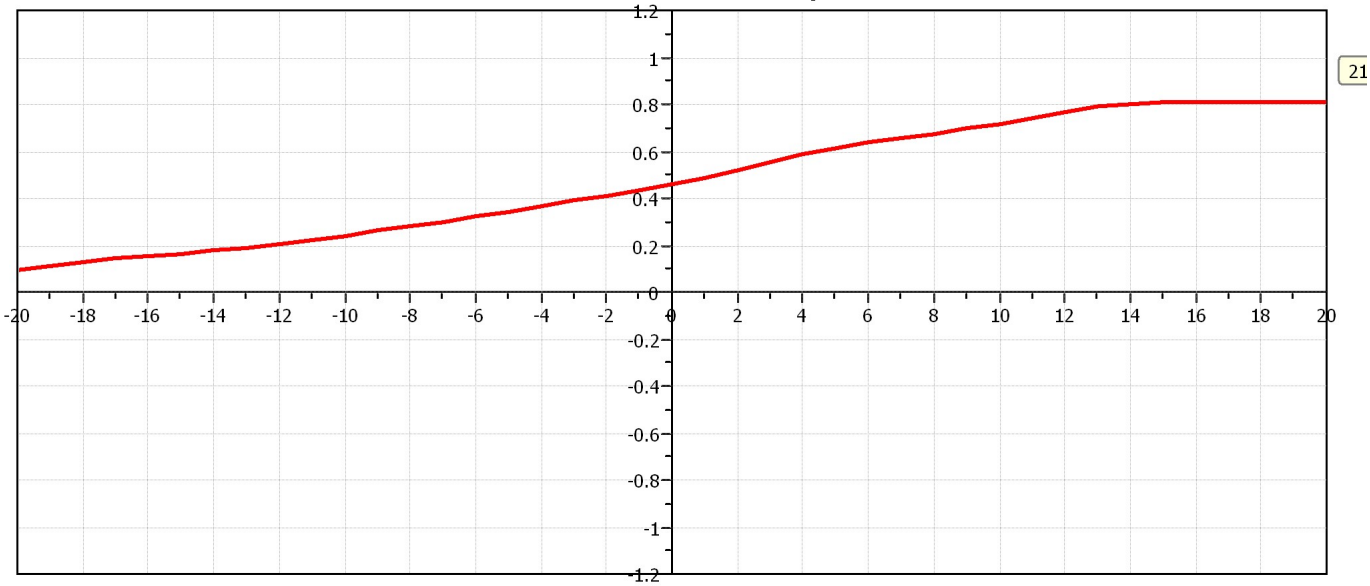
CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

Project: **CA3043**
Location: **A1B2CH**



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

Cross correlation between qc & fs

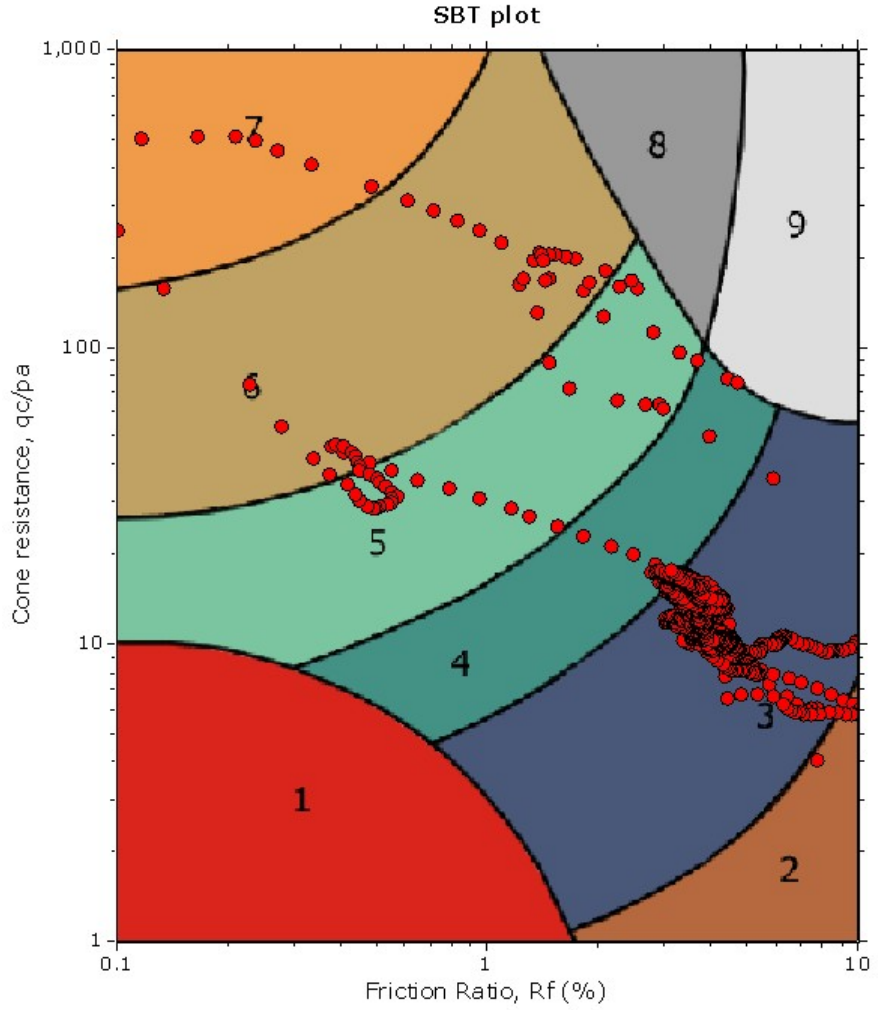


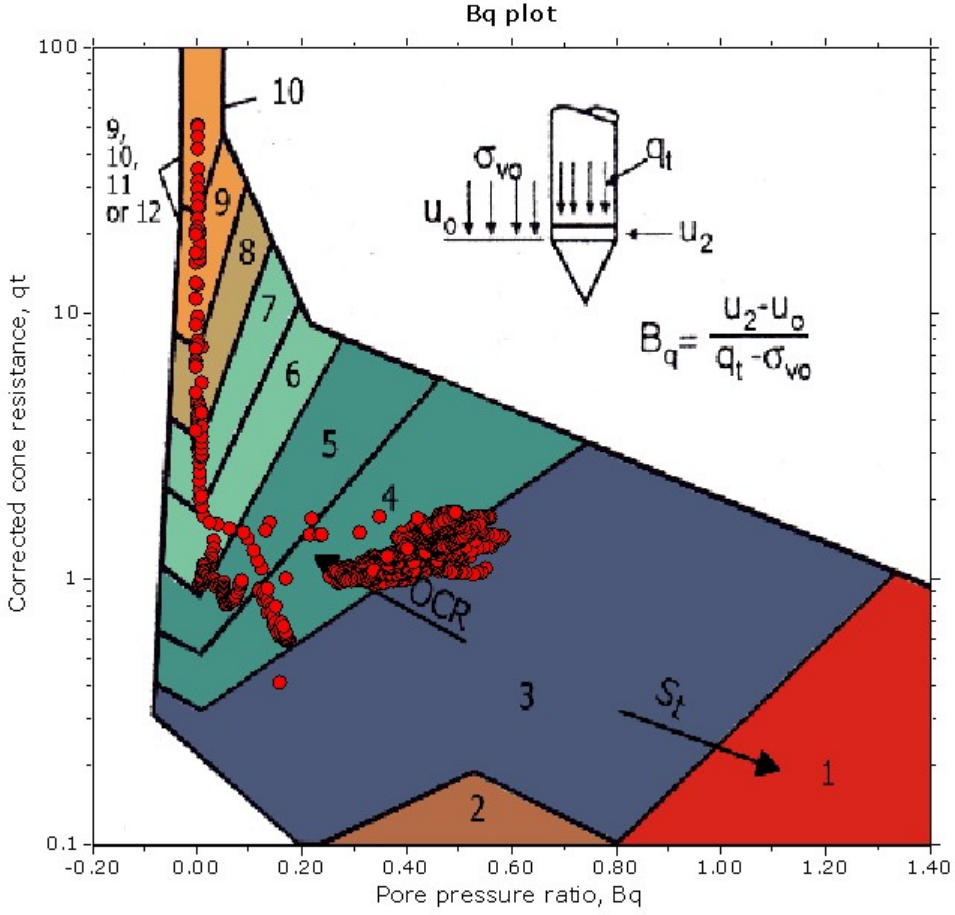
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

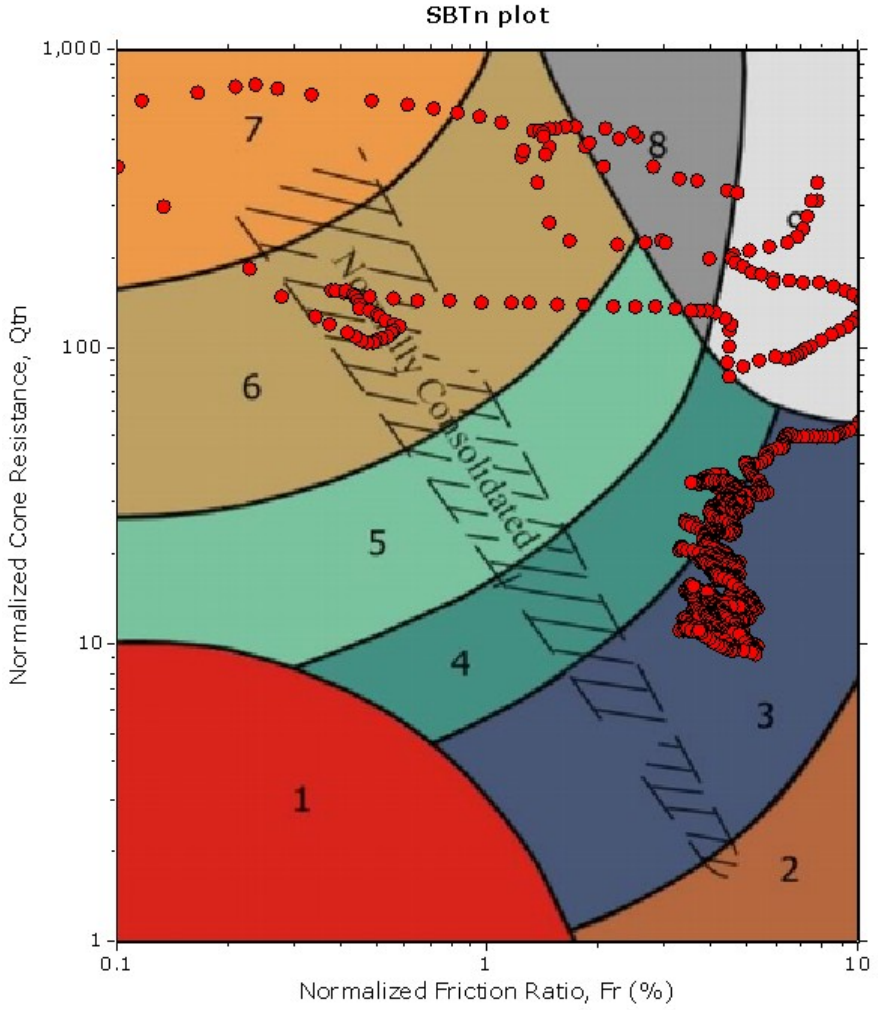
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

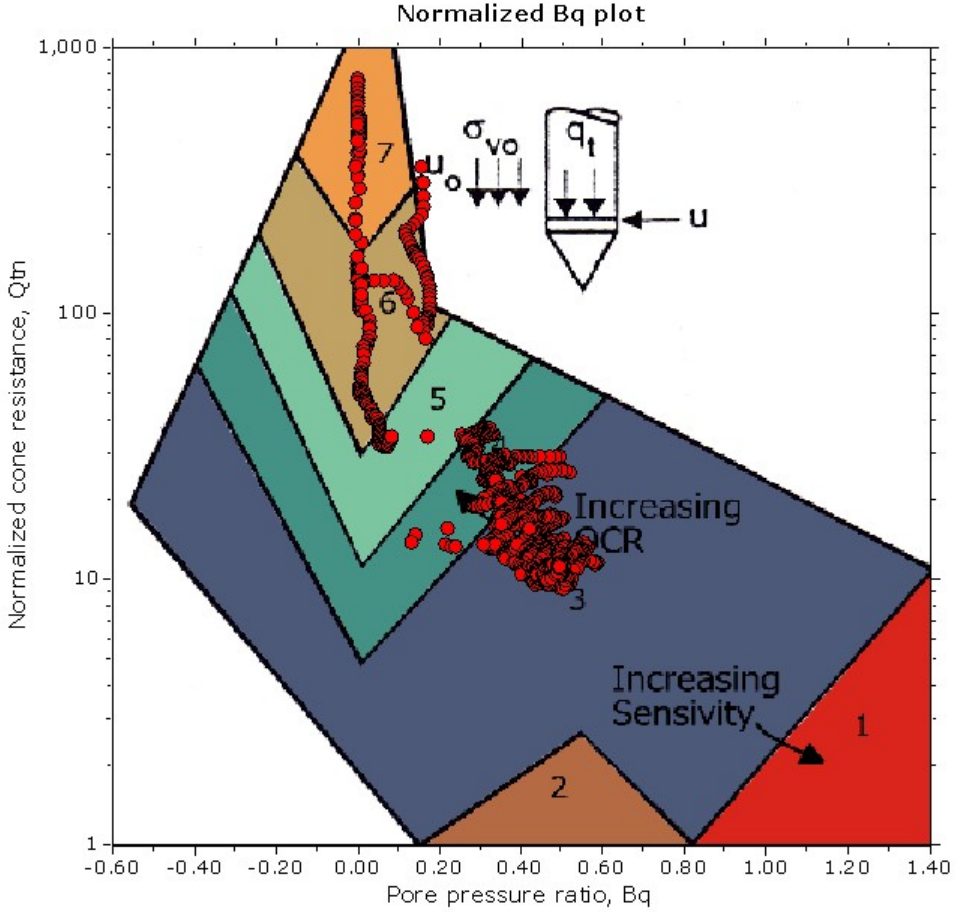
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

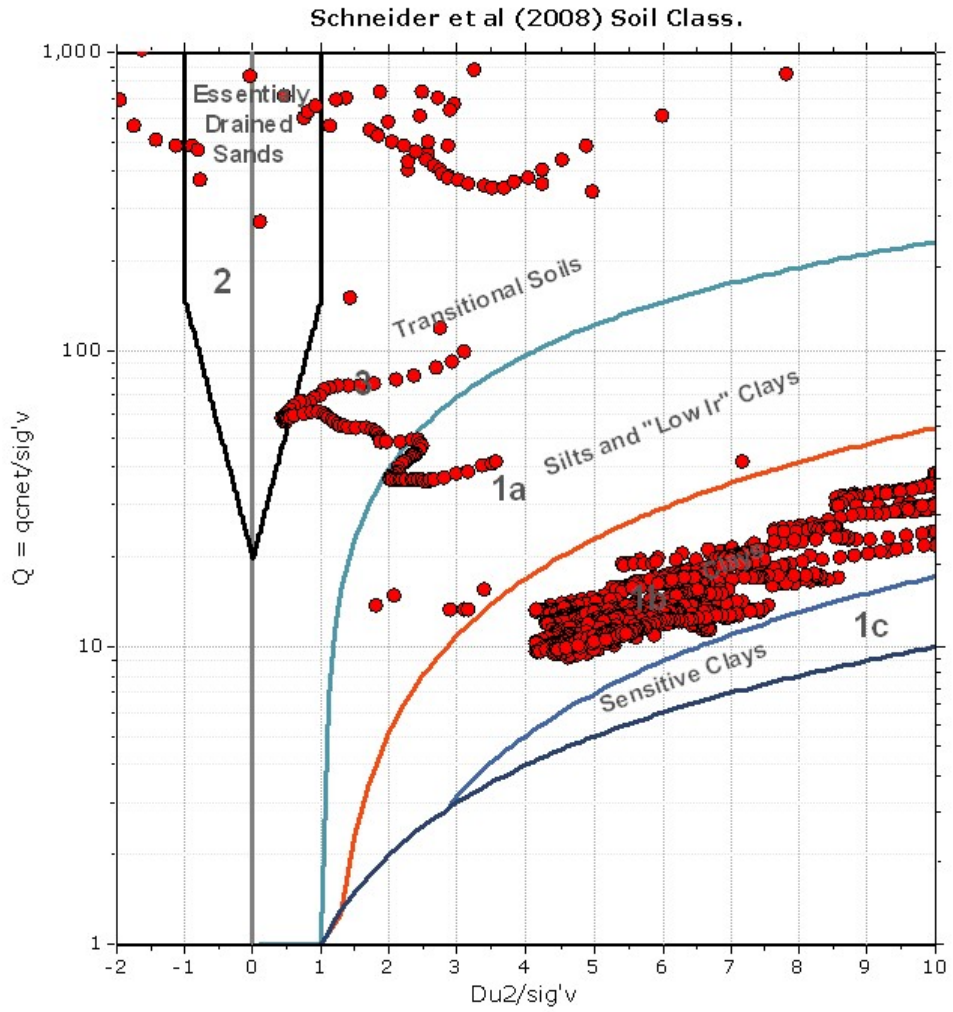
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

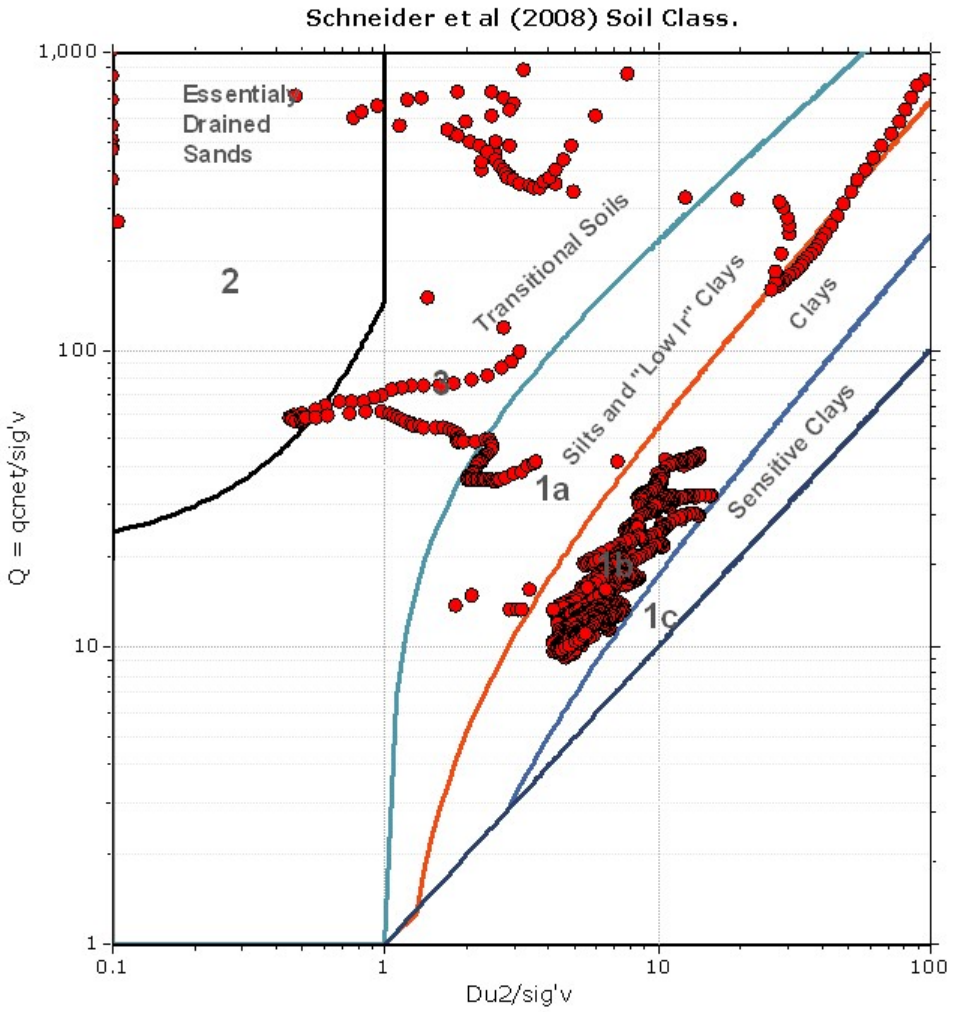
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



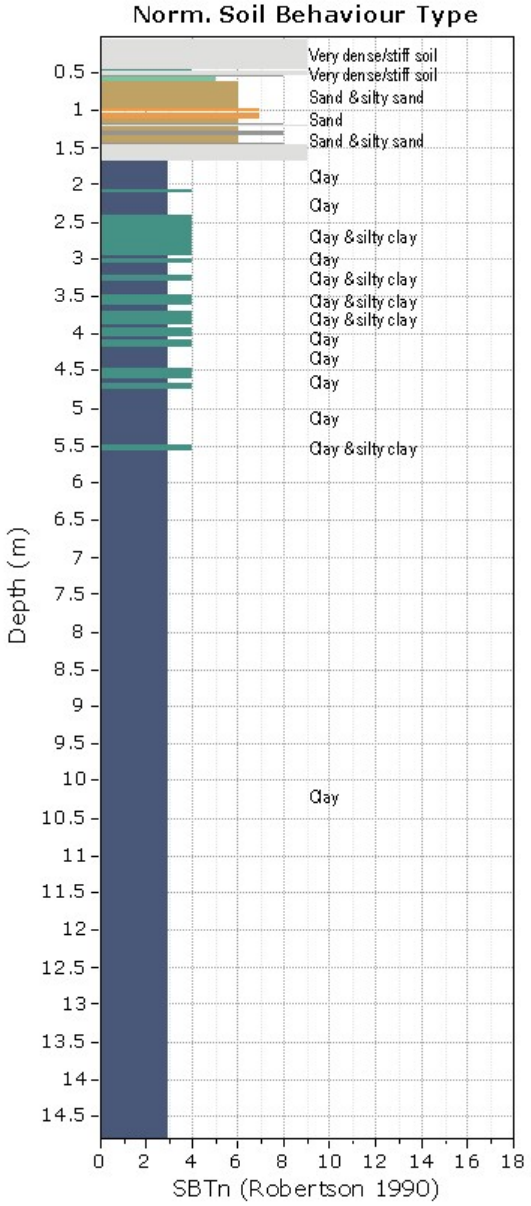


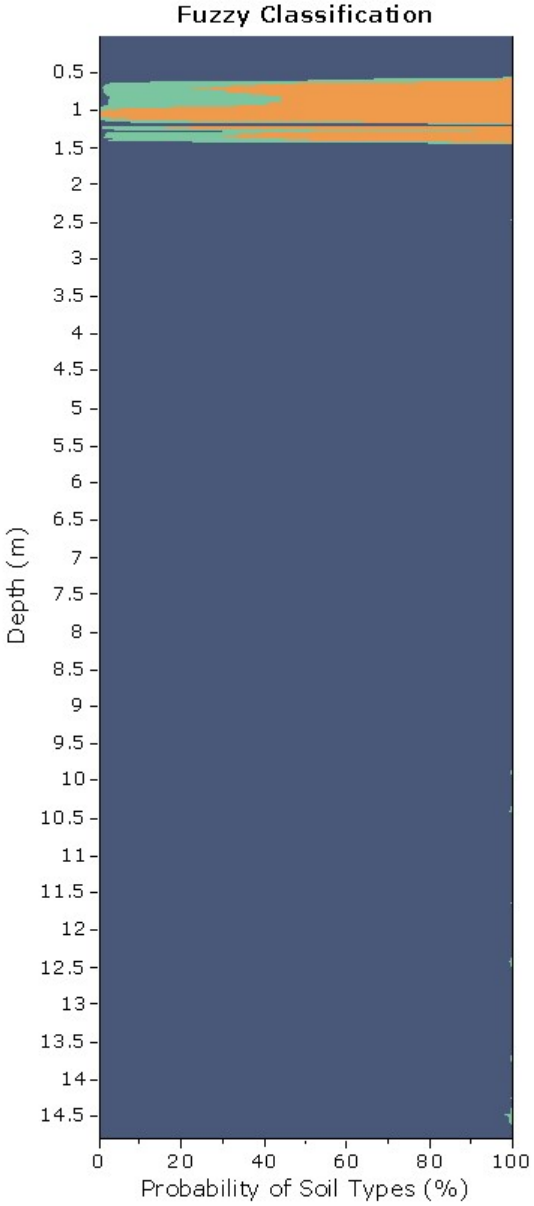
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-14

Project: **CA3043**
Location: **A1B2CH**

Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

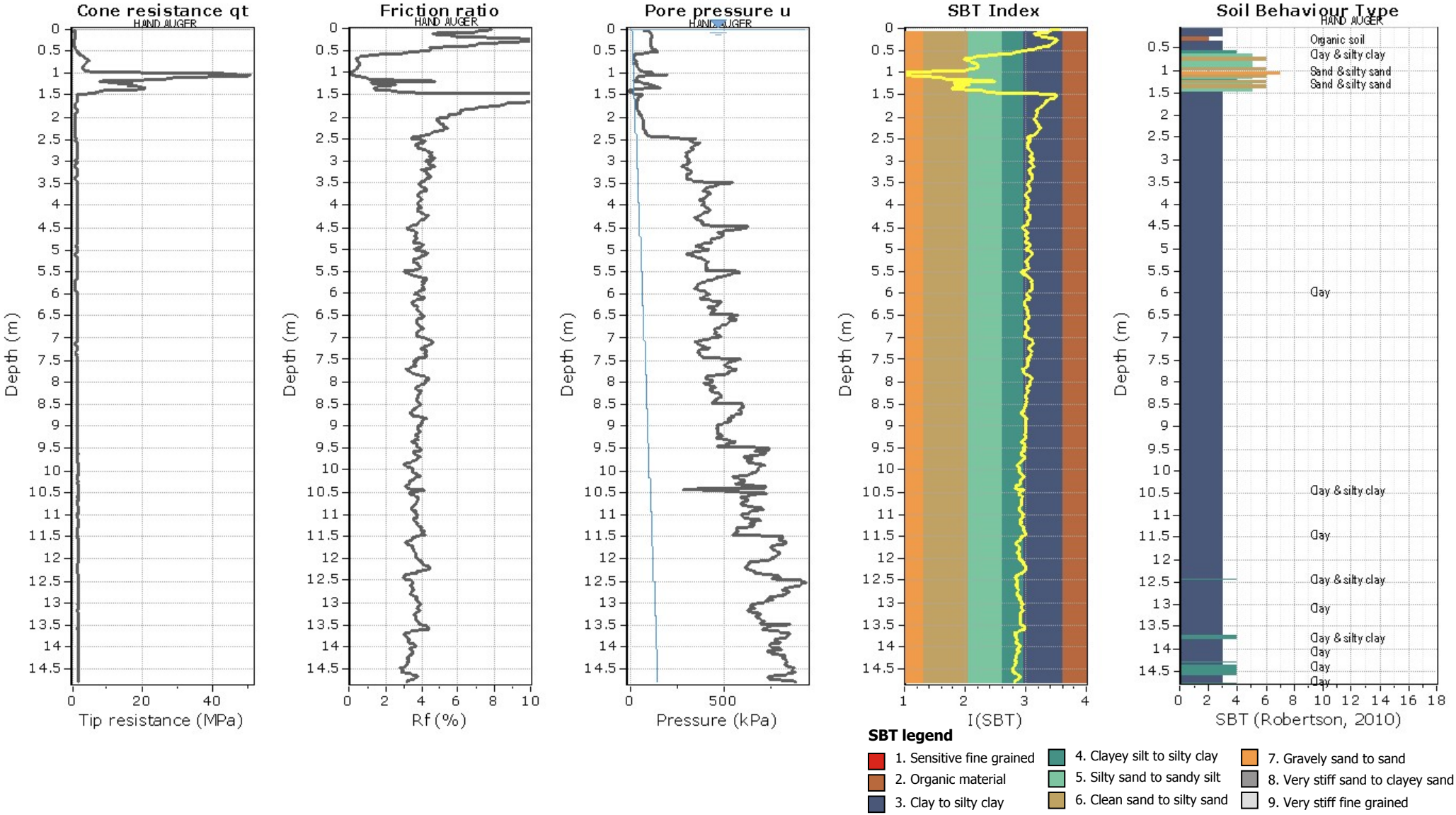




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

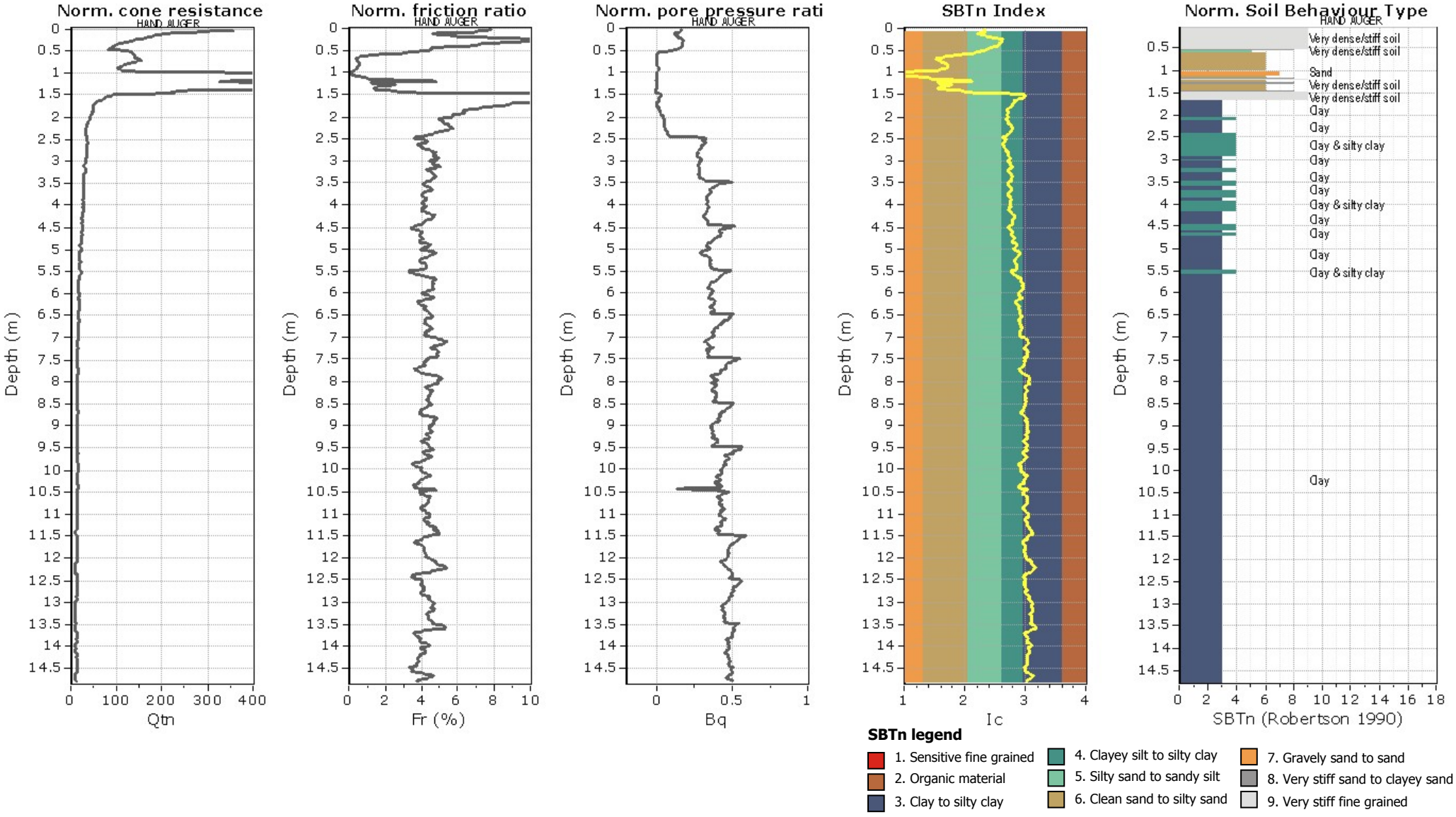
CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

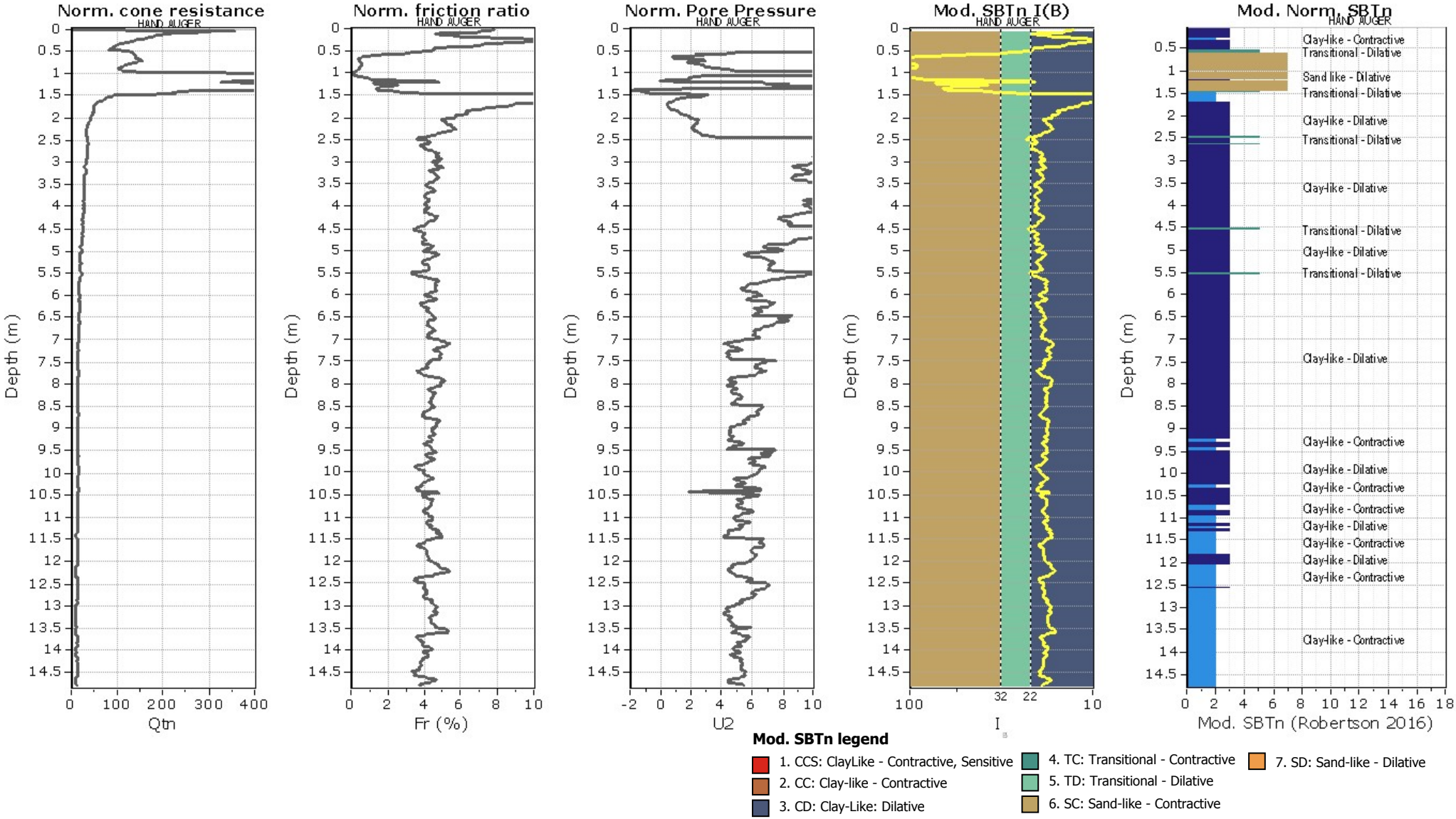
CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

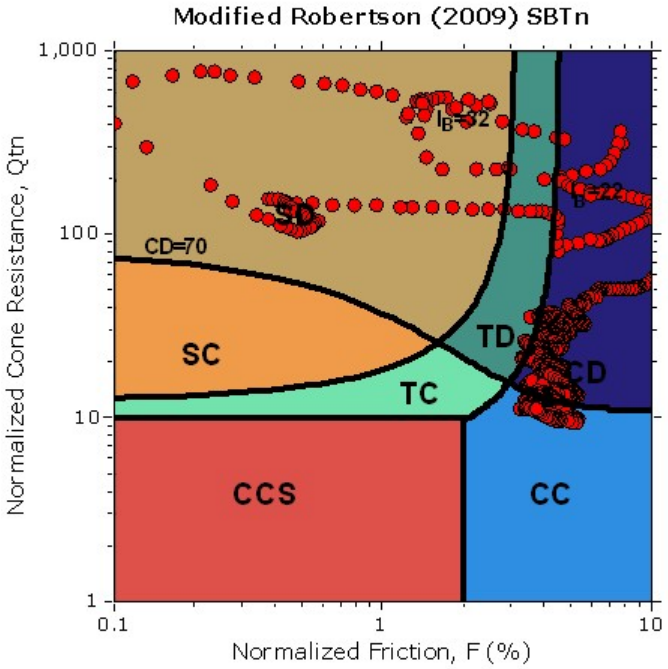


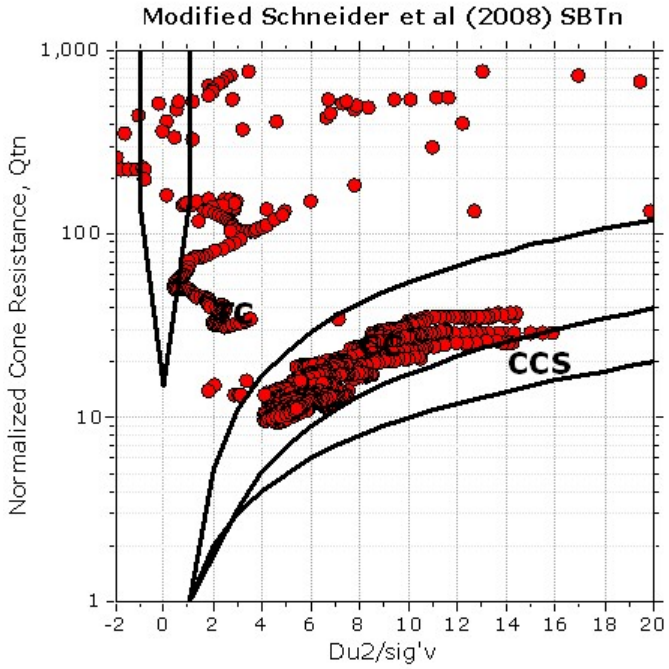
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

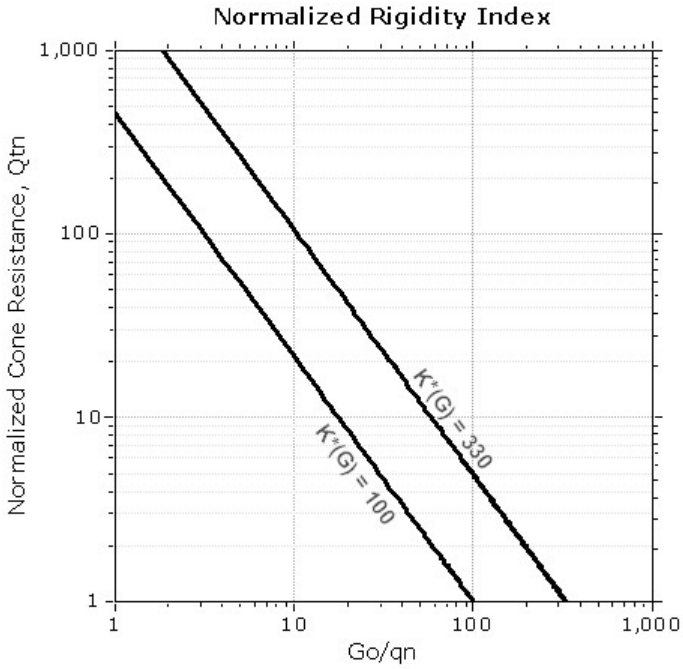
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







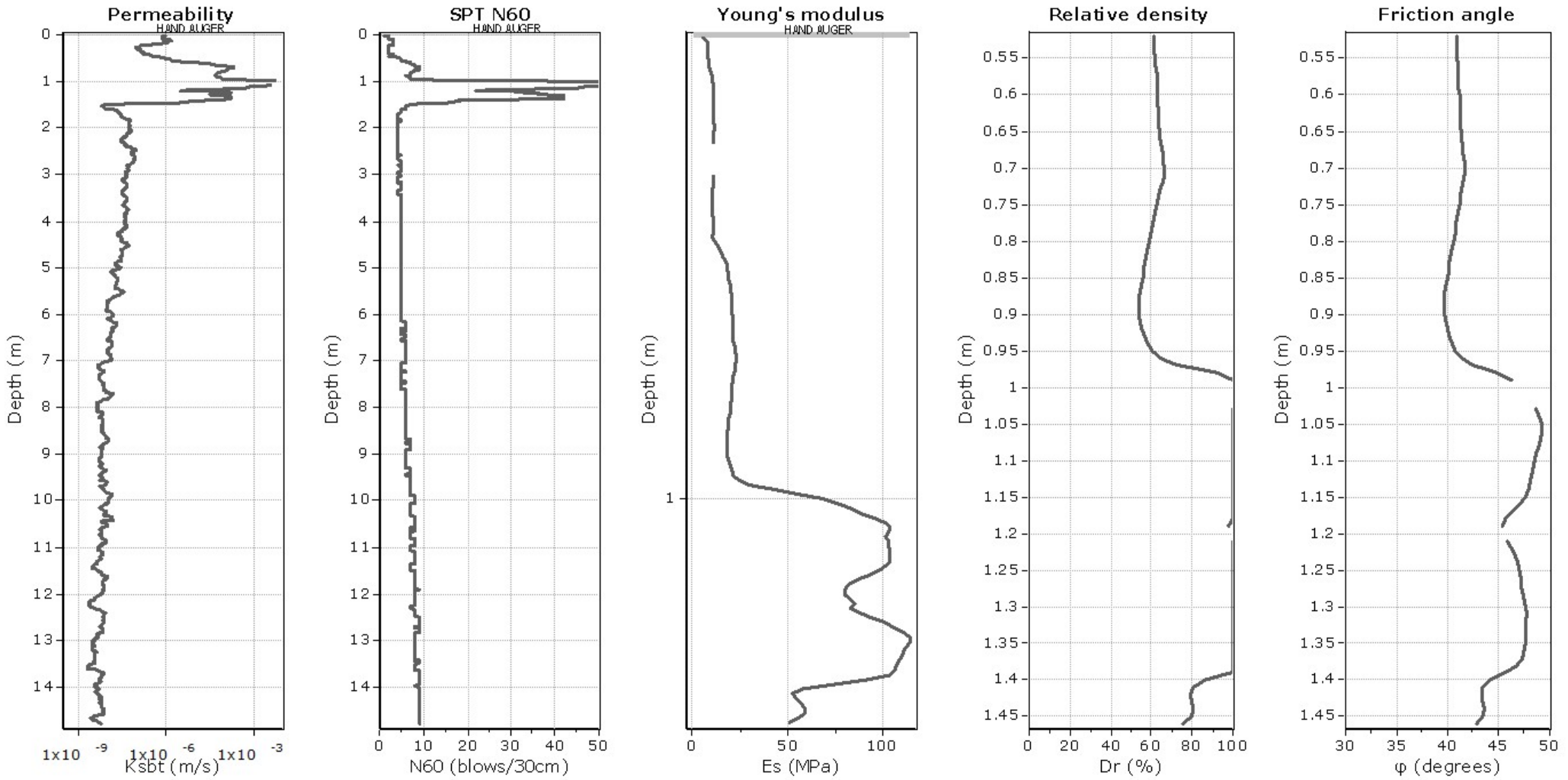
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown



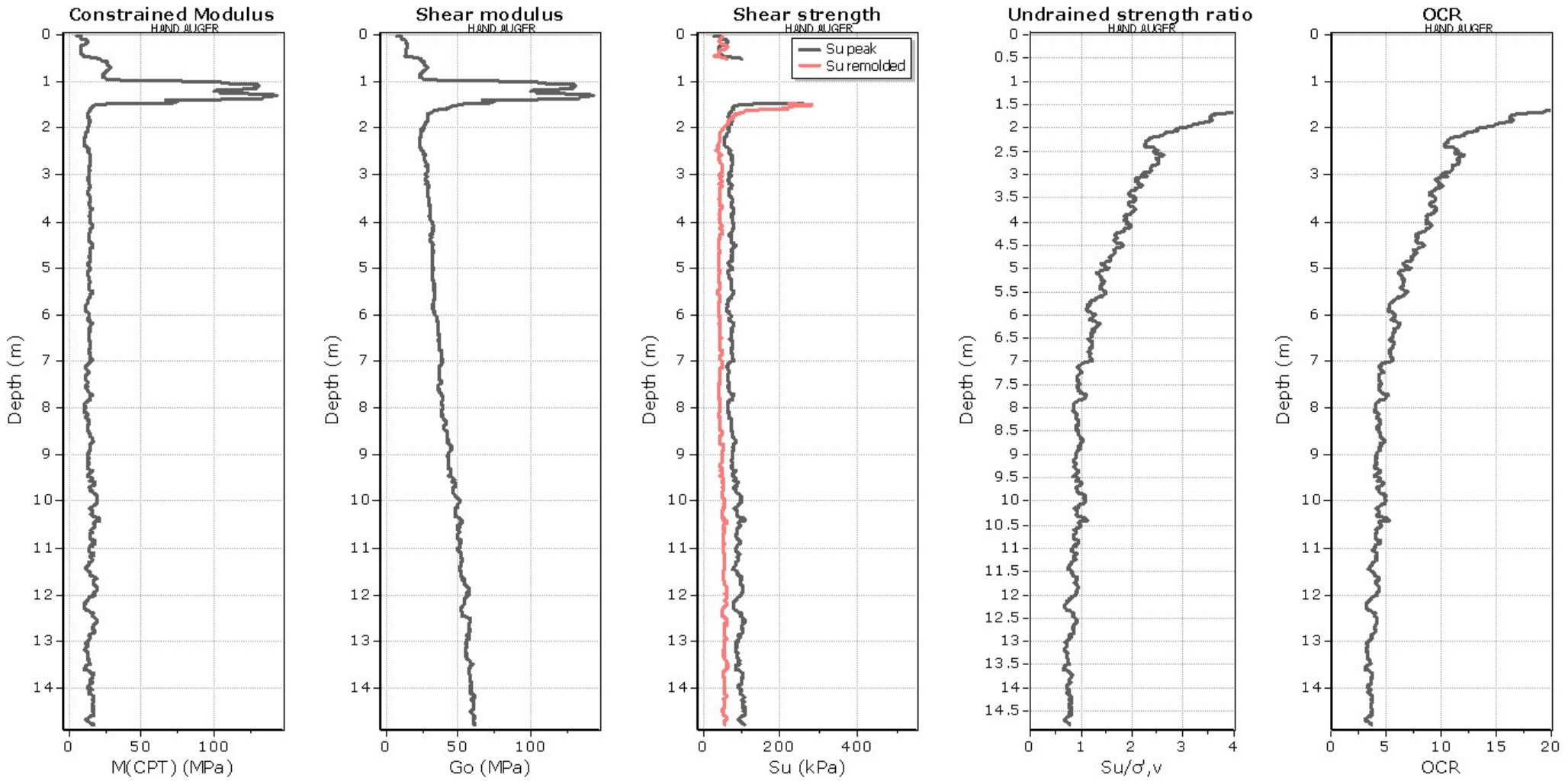
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown



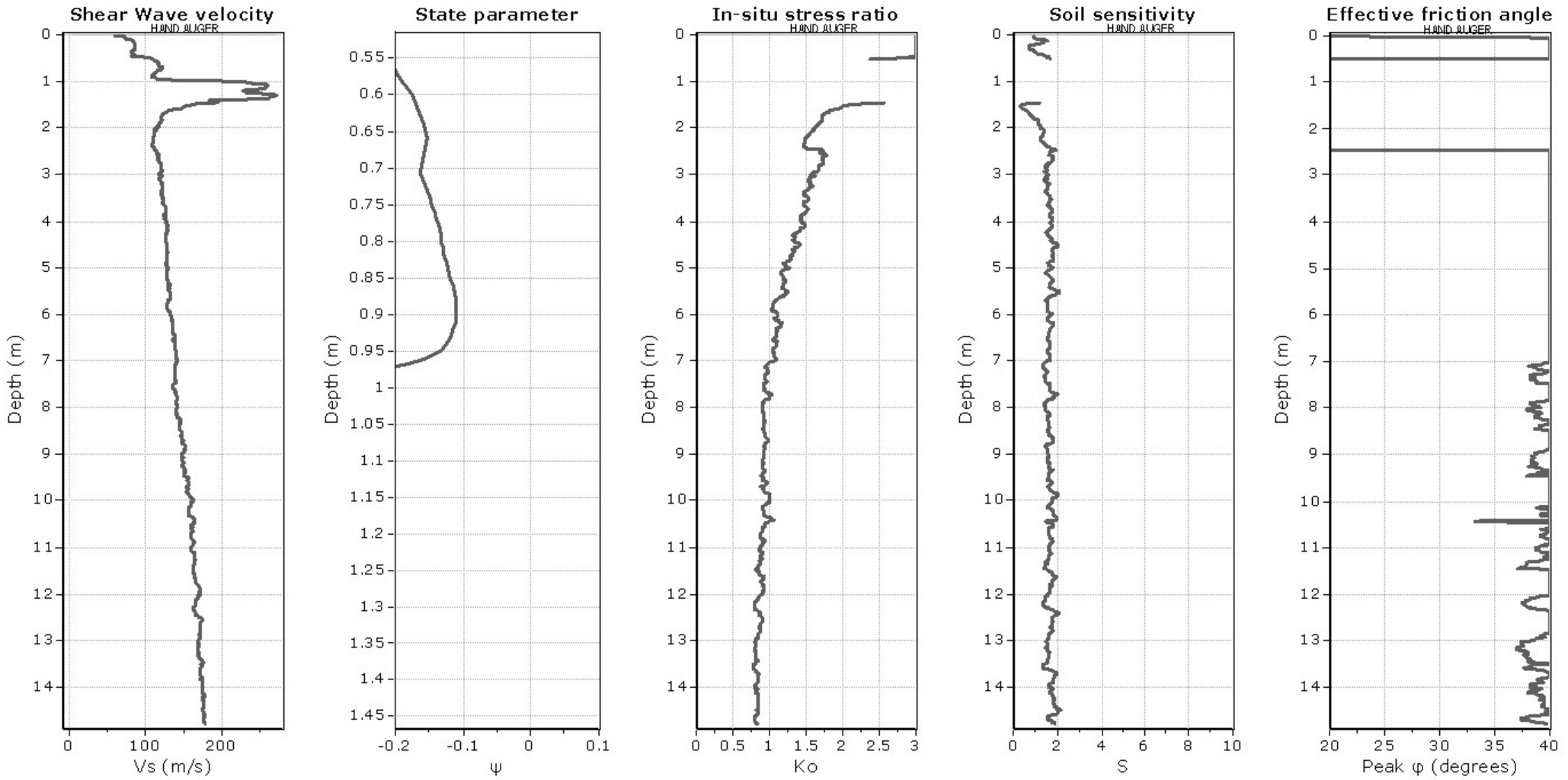
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-14
Total depth: 14.79 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

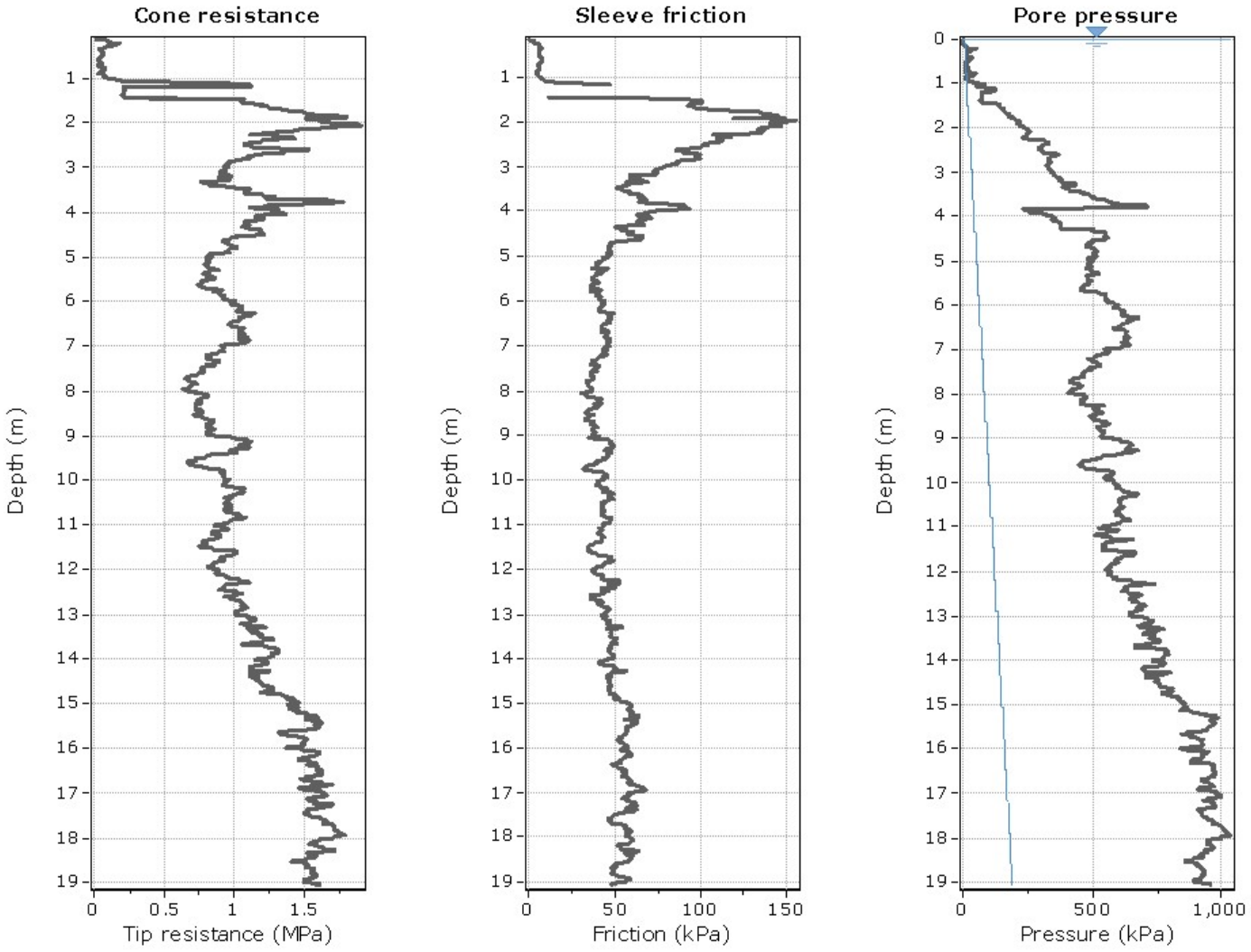
• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

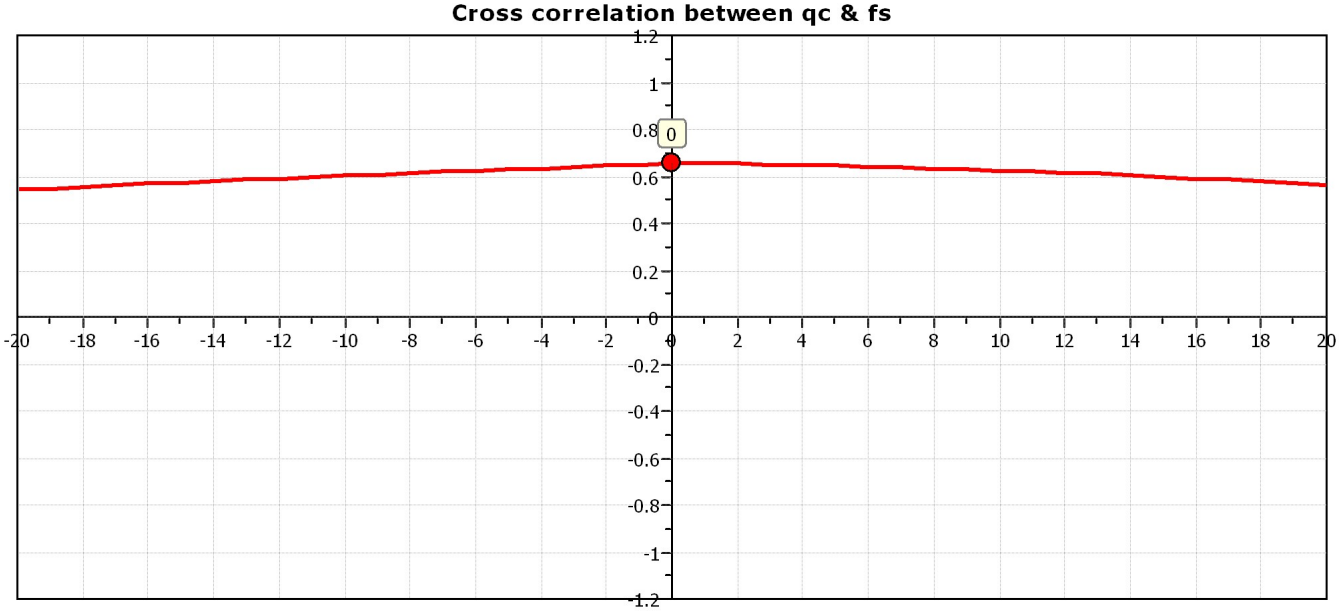
CPT: CPT17-15

Project: **CA3043**
Location: **A1B2CH**

Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

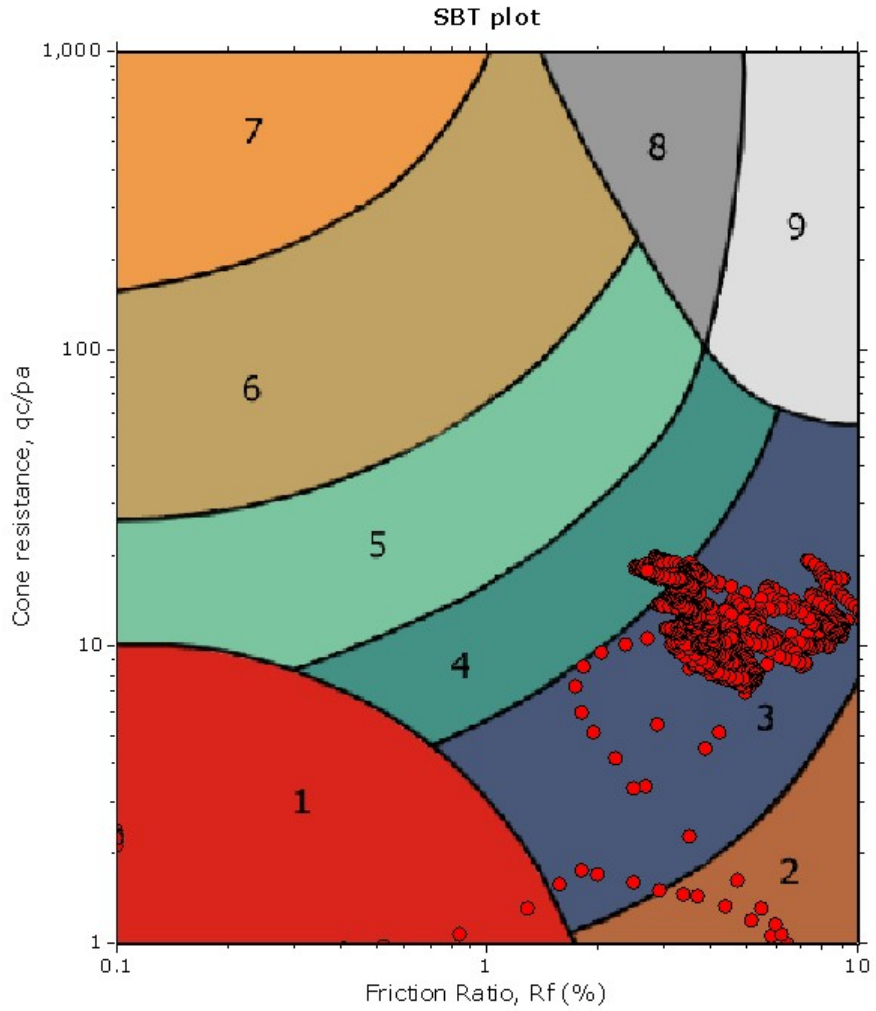


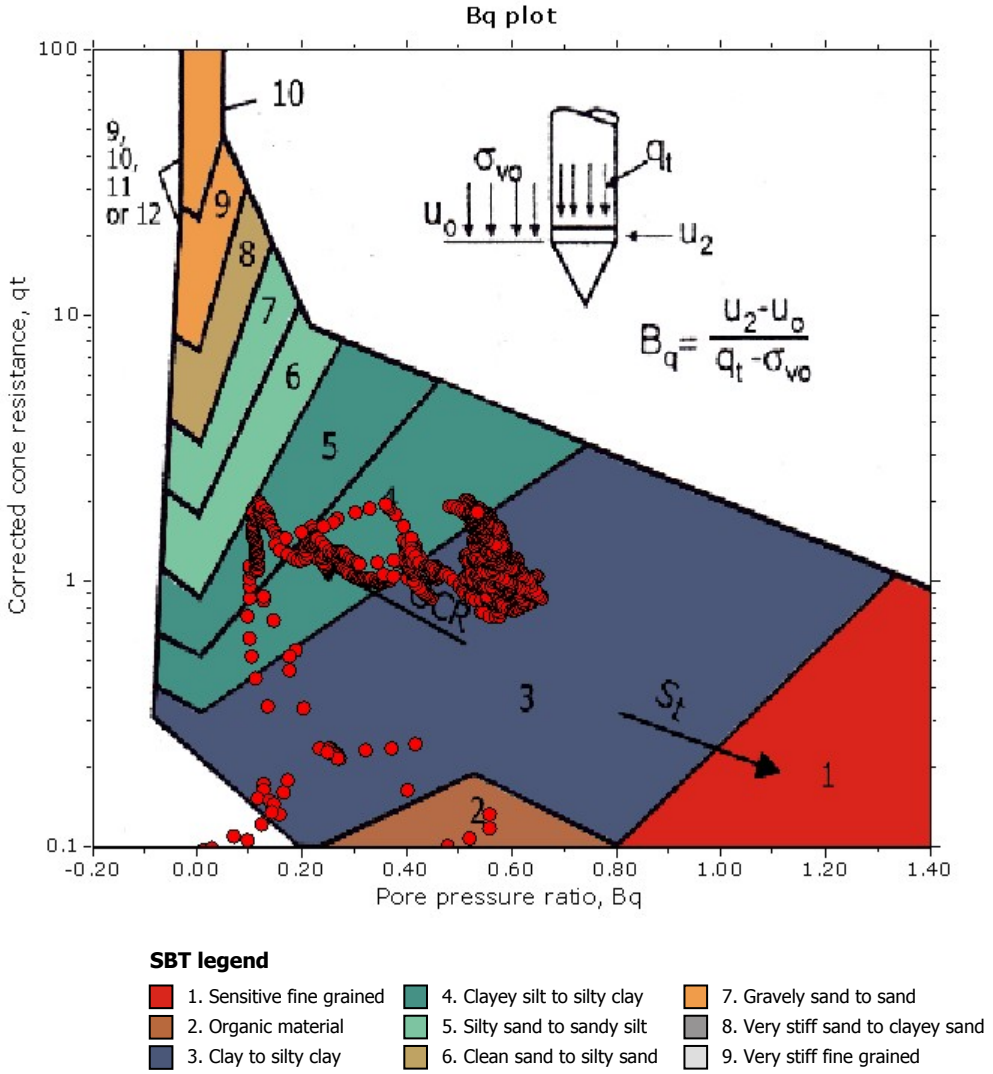
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots





SBT legend

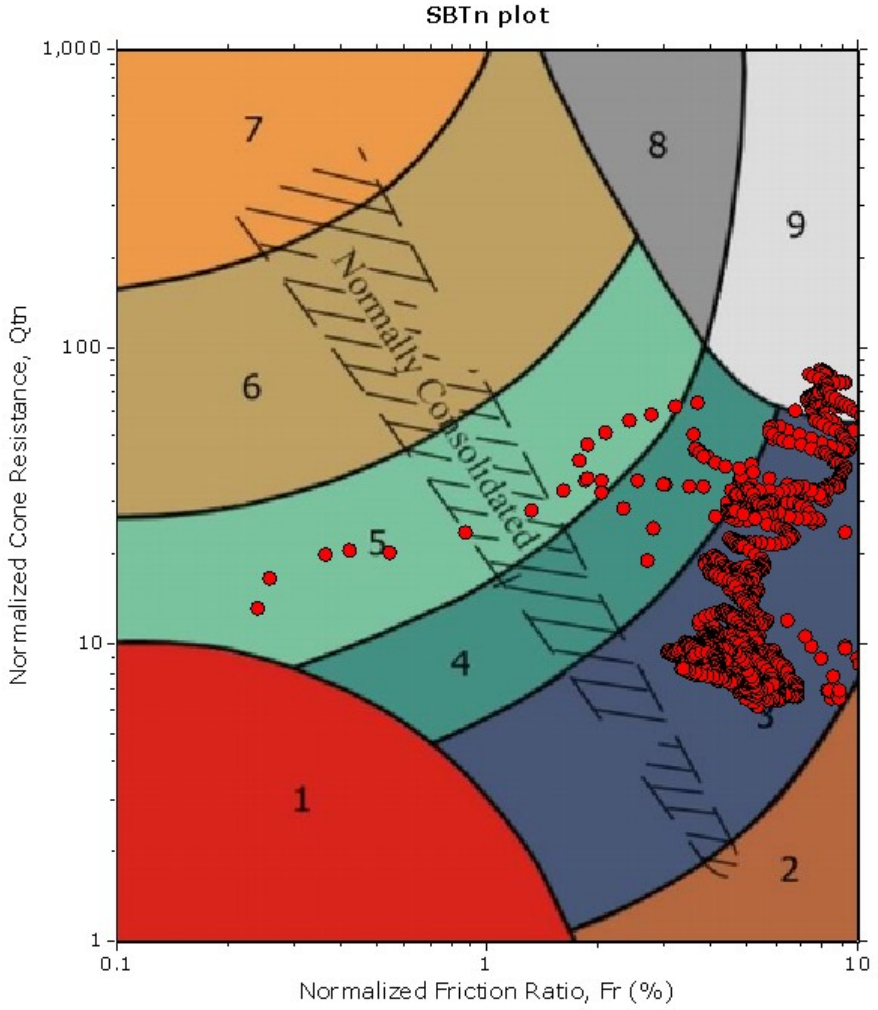
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

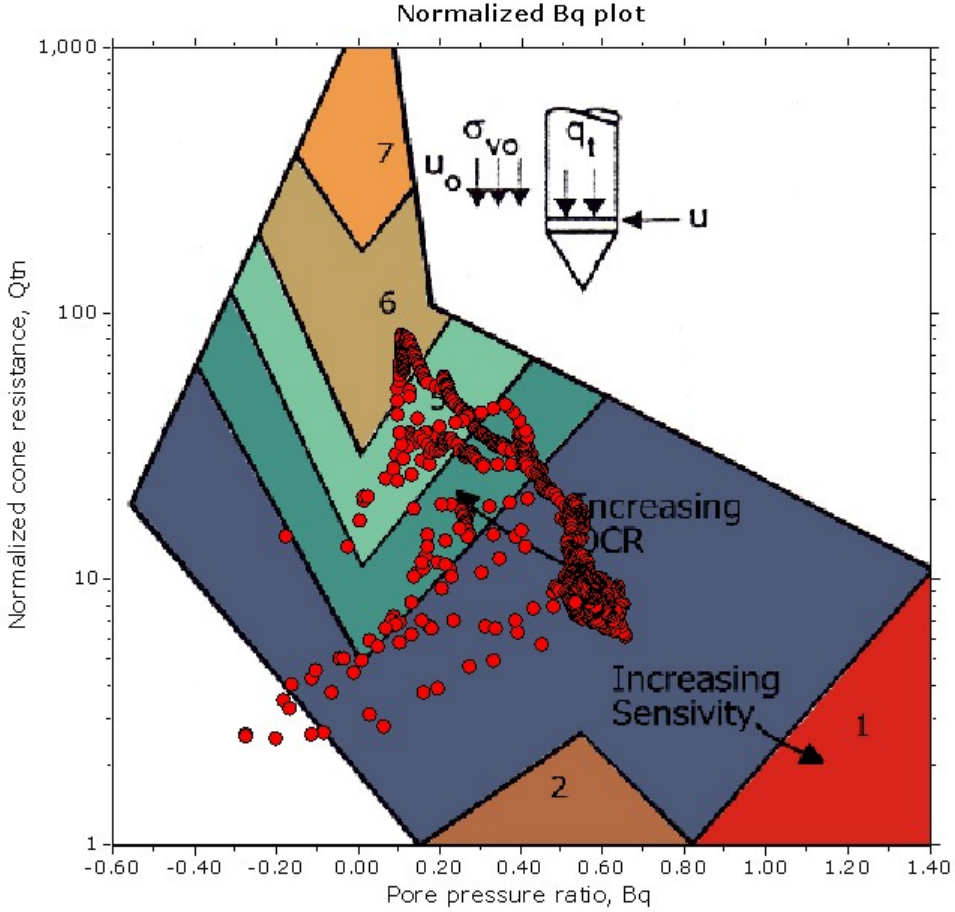
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

SBT - Bq plots (normalized)





SBTn legend

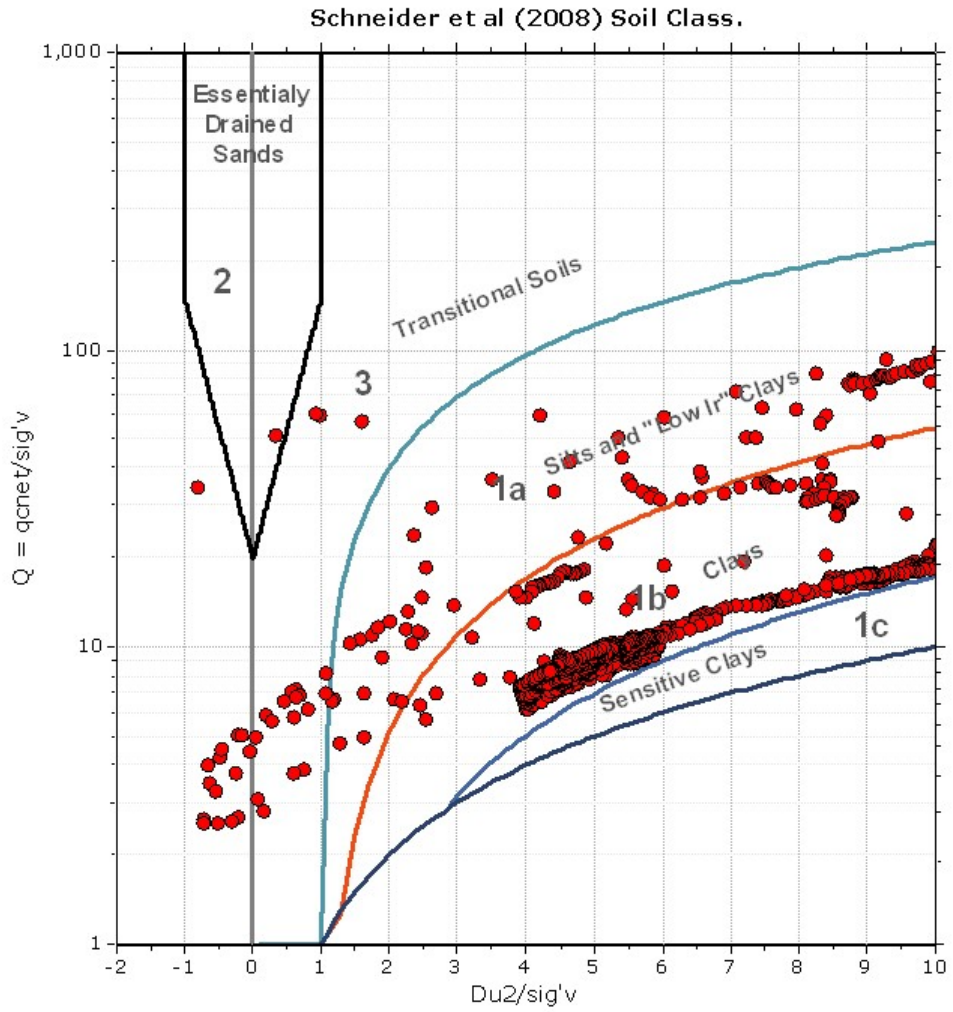
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

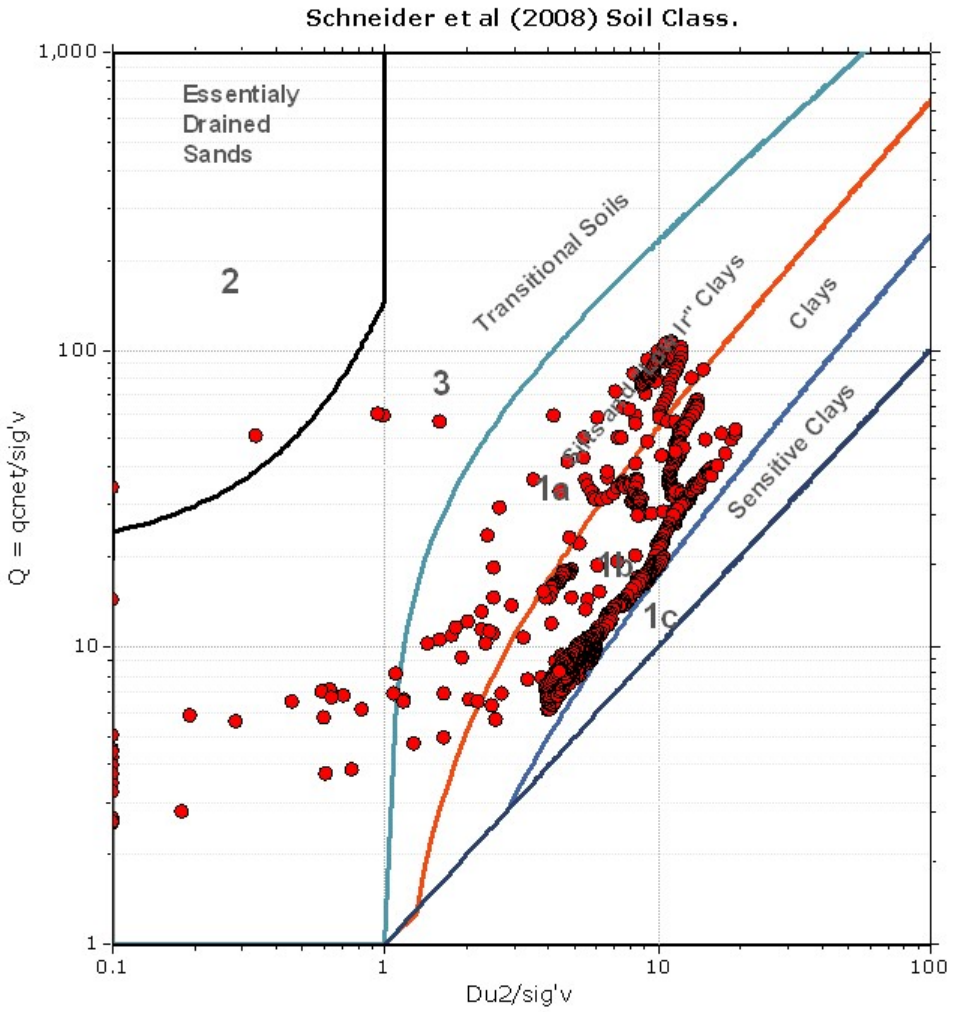
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

Bq plots (Schneider)



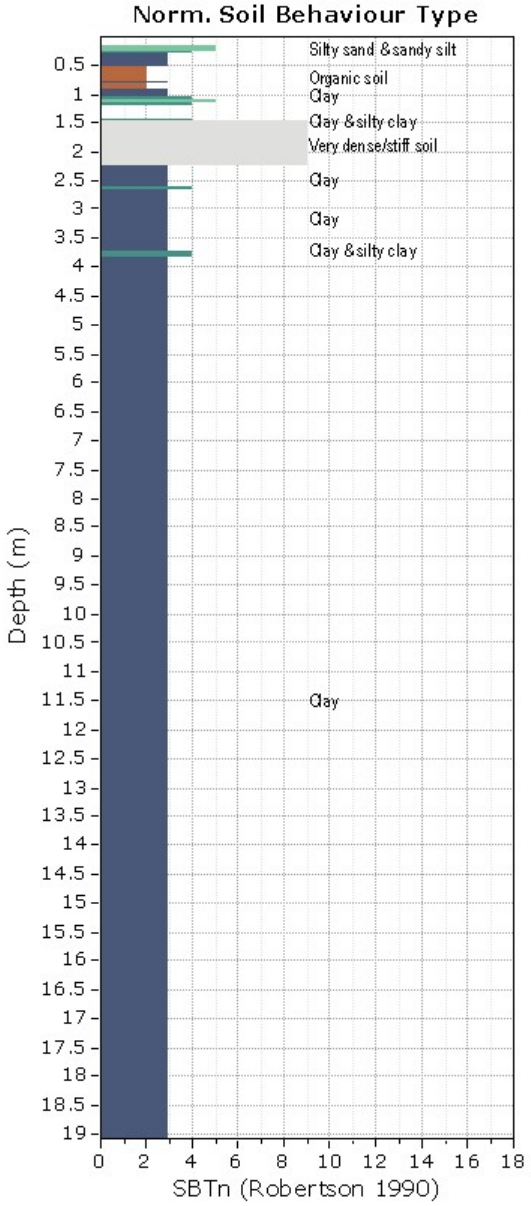


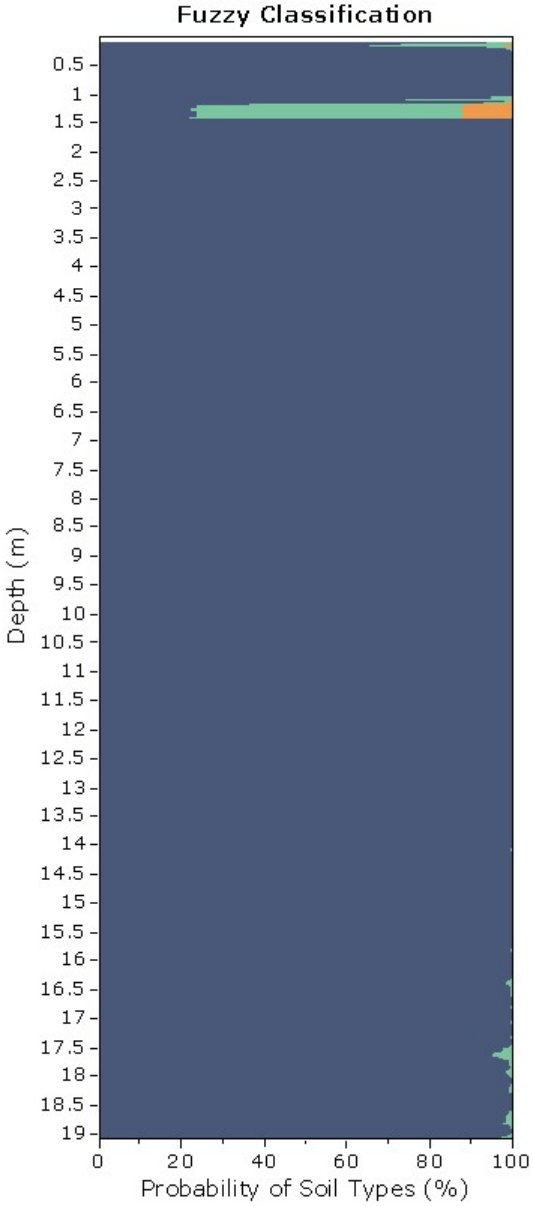
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

CPT: CPT17-15

Project: **CA3043**
Location: **A1B2CH**

Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

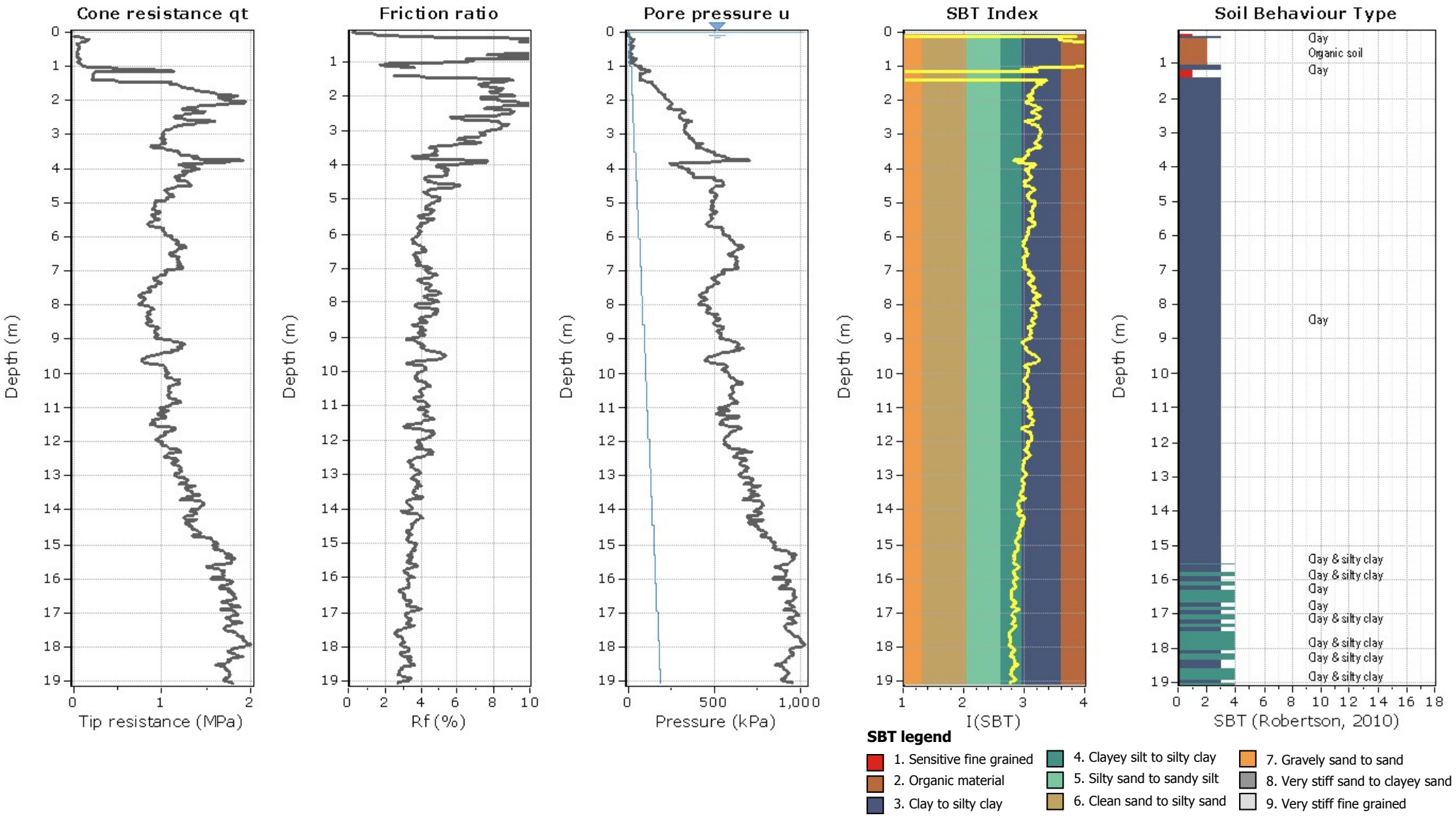




Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

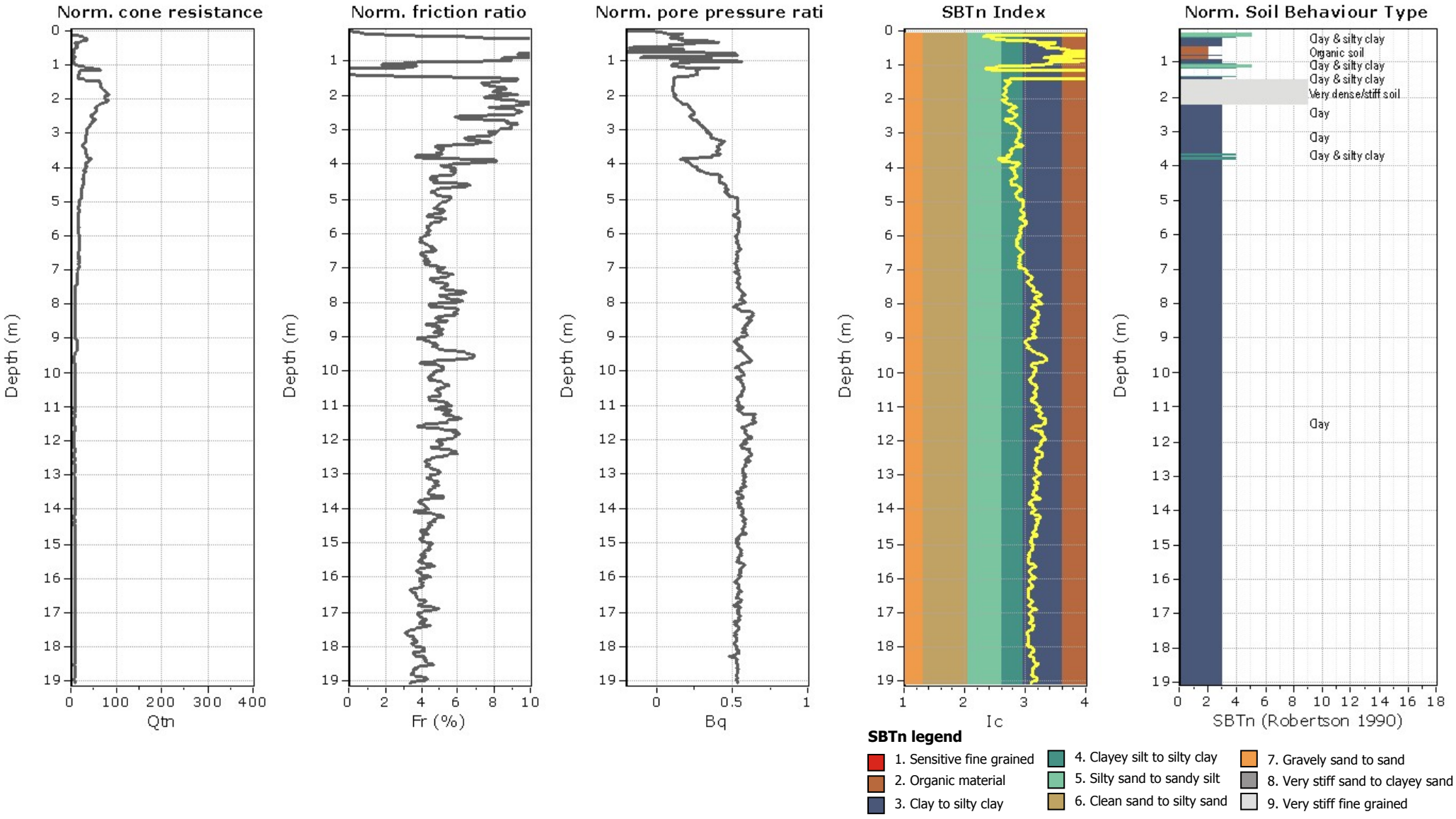
CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

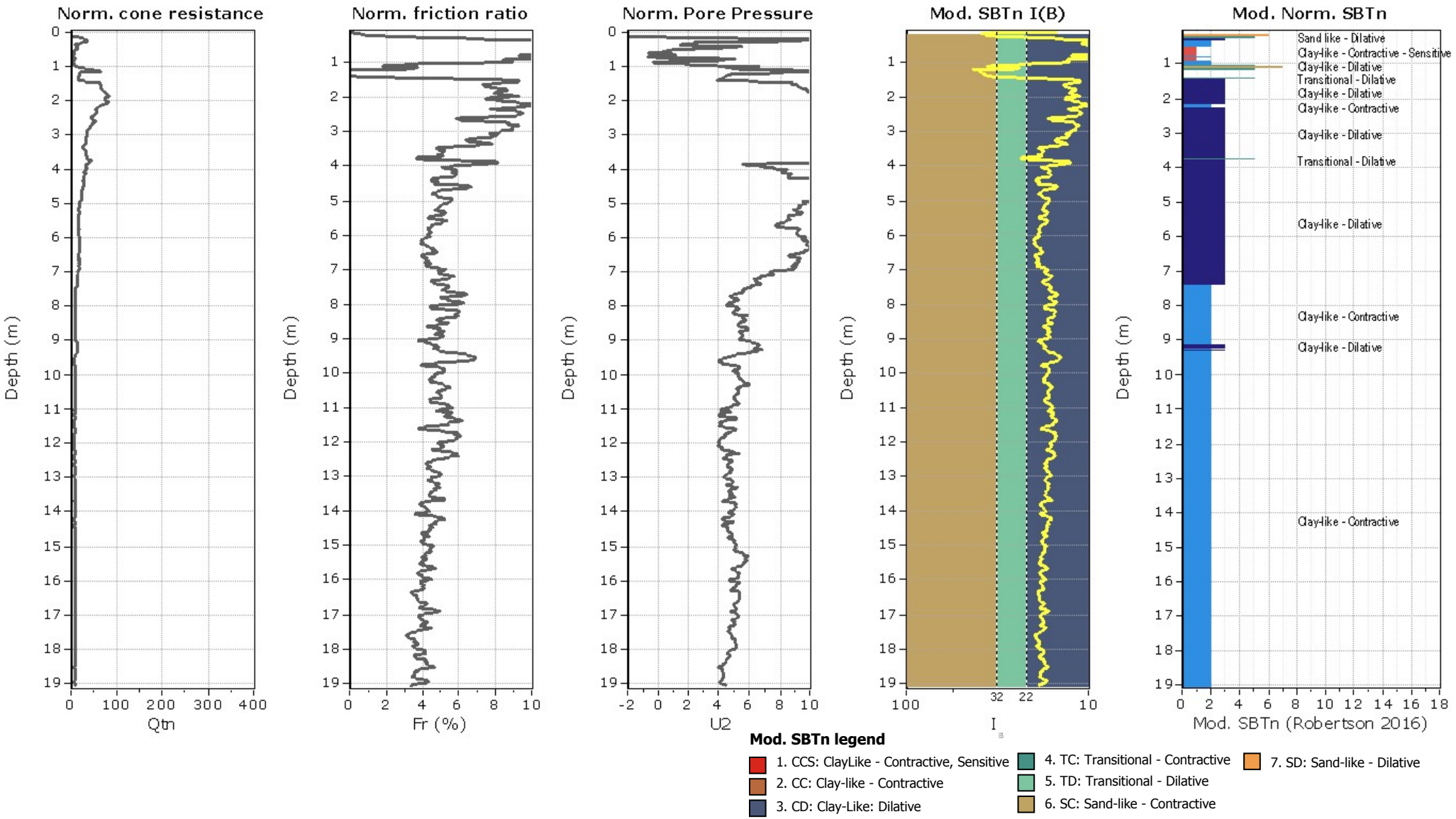
CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

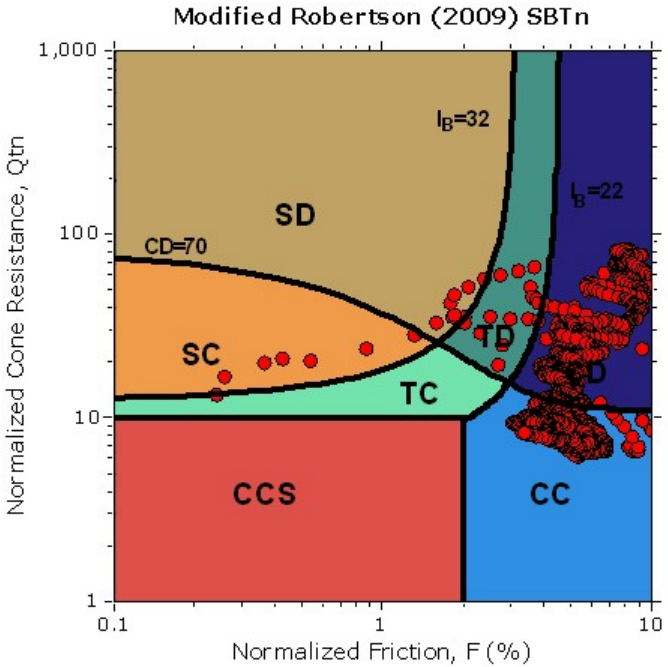


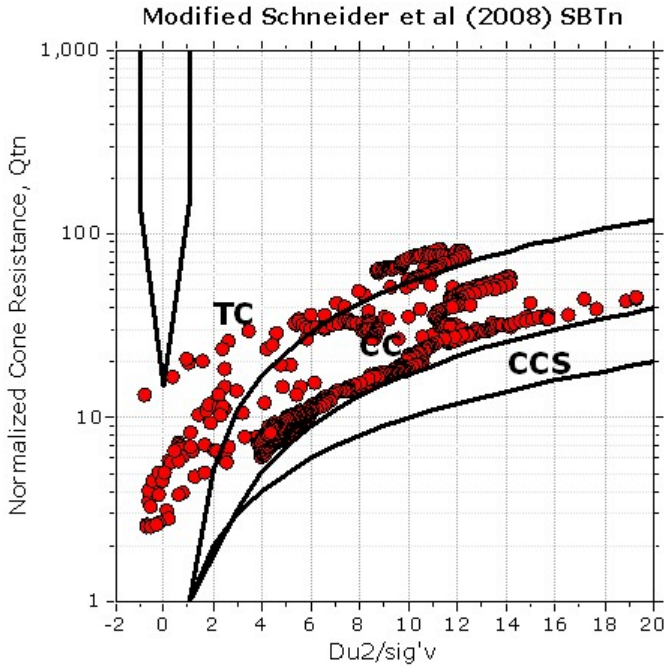
Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

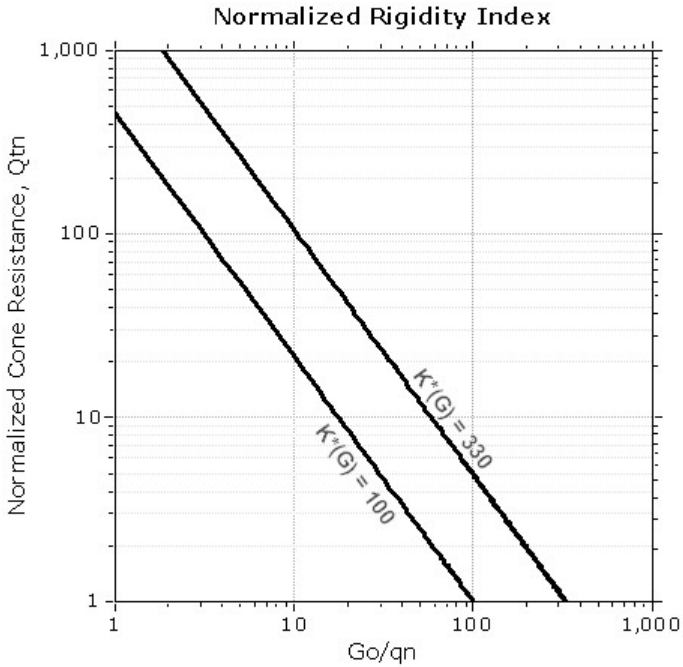
Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown

Updated SBTn plots







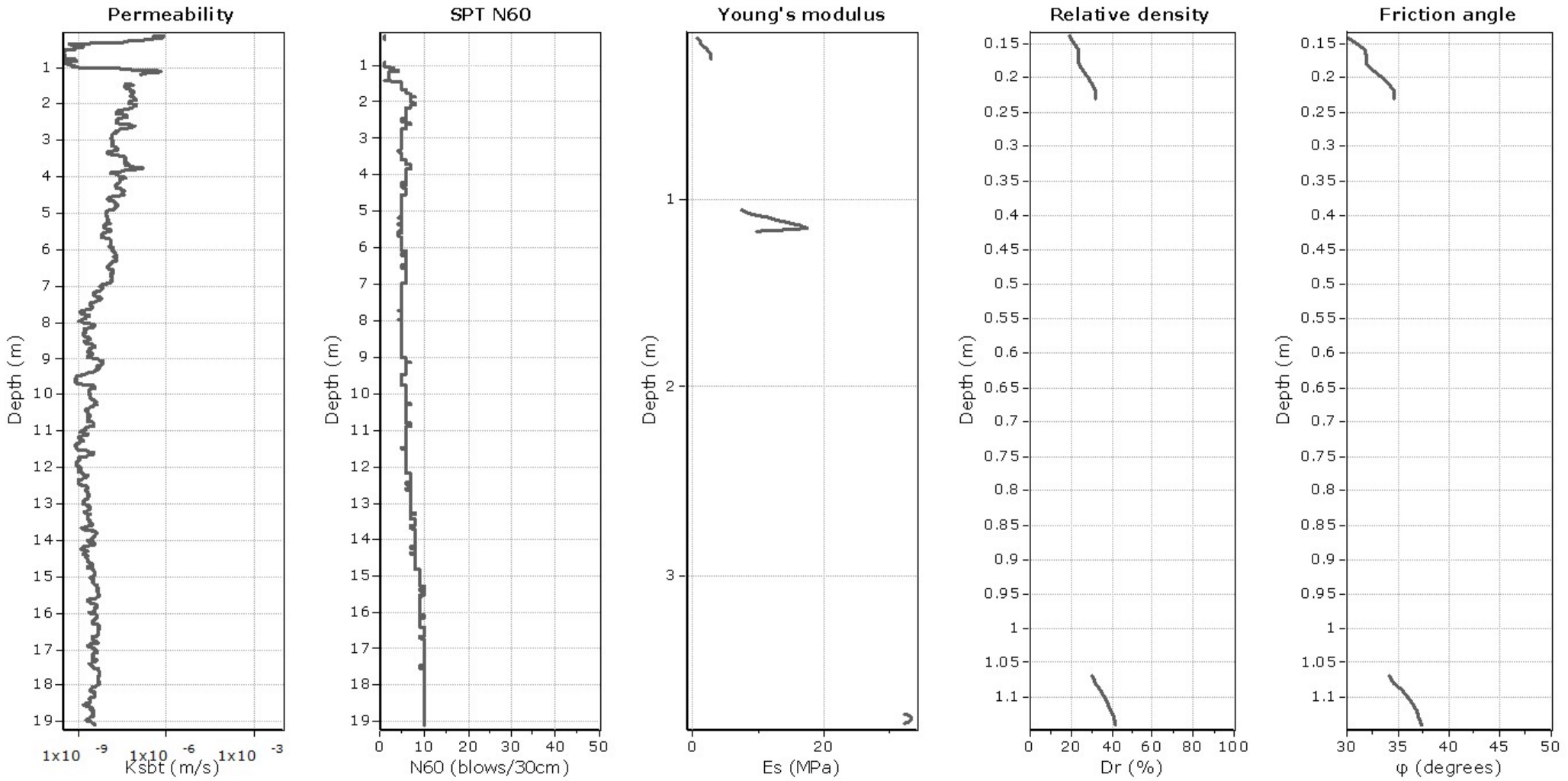
CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: **CA3043**
Location: **A1B2CH**

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



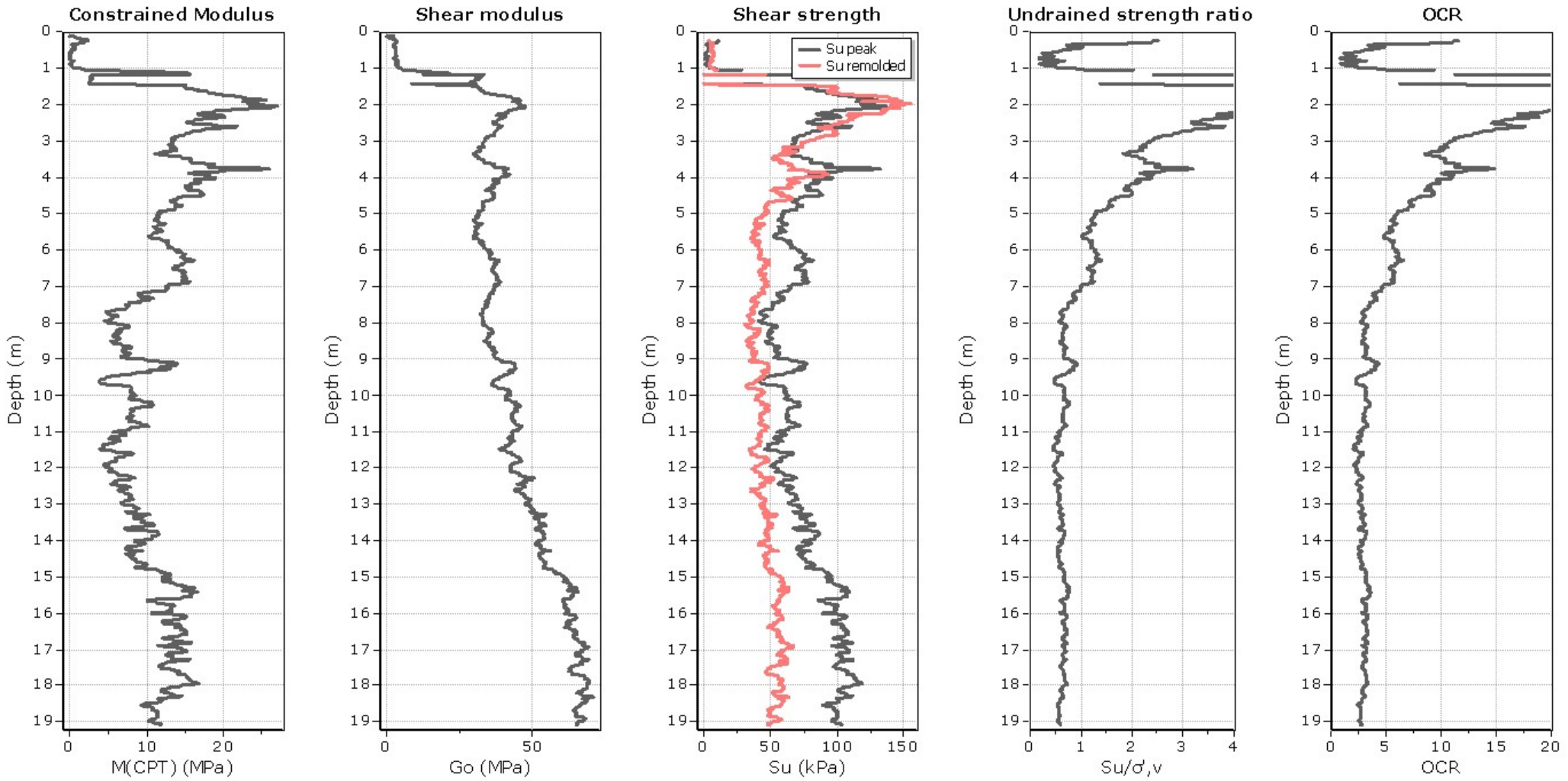
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



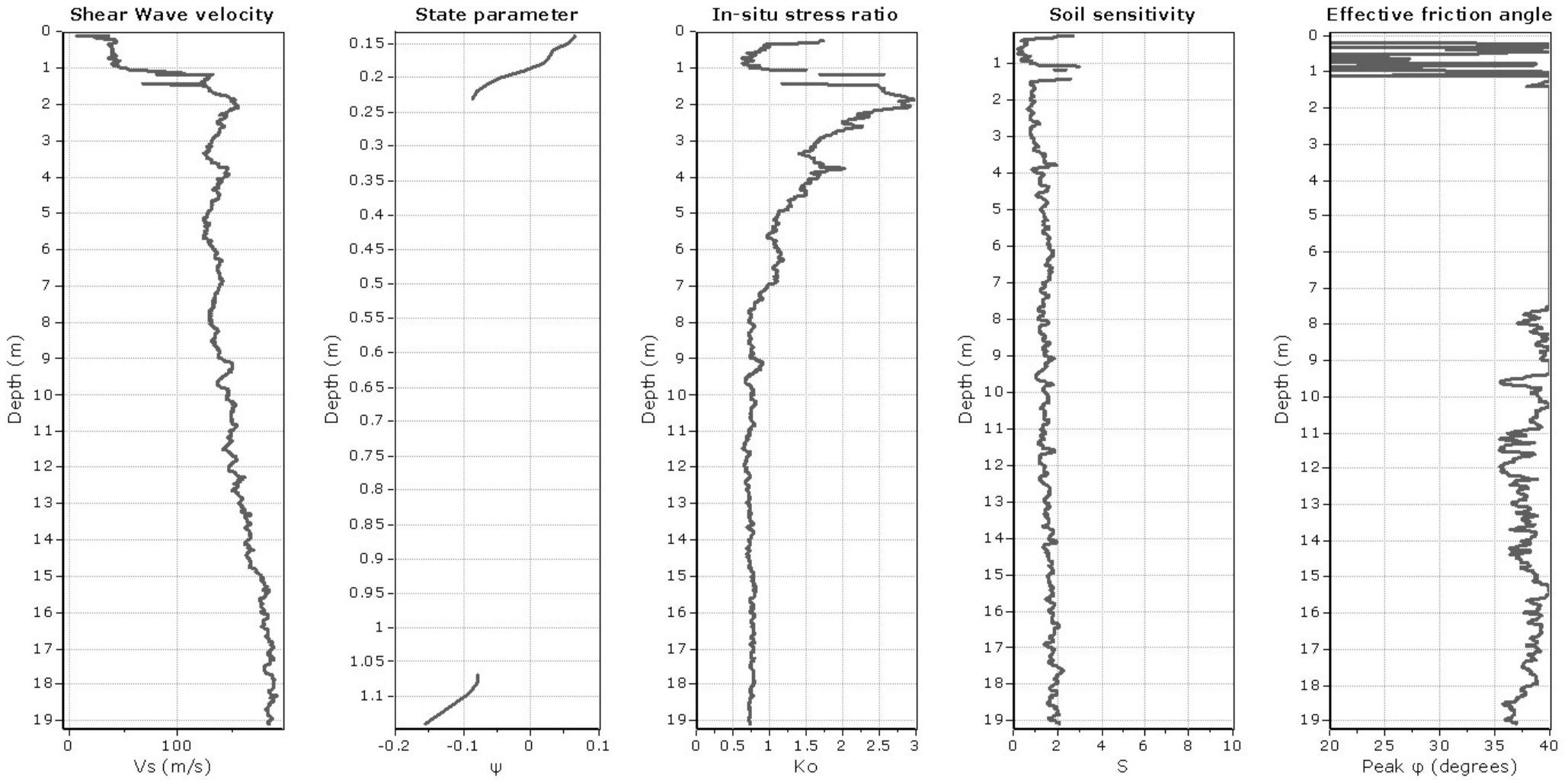
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Central Alliance Pre Construction Services Ltd
Alliance House, South Park Way
Wakefield WF2 0XJ
http://www.central-alliance.co.uk

Project: CA3043
Location: A1B2CH

CPT: CPT17-15
Total depth: 19.07 m, Date: 06/02/2018
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

A1 BIRTLEY TO COAL HOUSE IMPROVEMENT SCHEME

FACTUAL REPORT ON CONE PENETRATION TESTING

Report No M8012-18

May 2018

Carried out for:

Central Alliance Limited
Alliance House
Wakefield 41 Business Park
South Park Way
Wakefield
WF2 0XJ

SOCOTEC UK Limited

Askern Road, Carcroft,
Doncaster, South Yorkshire, DN6 8DG, UK
Tel: +44 (0) 1302 723456
email: geo.doncaster@socotec.com

Report No M8012-18

May 2018

Issue No Date	Status	Prepared by	Checked by	Approved by
1 May 2018	Final report	NAME and POSITION John Holt BSc (Hons) SIGNATURE	NAME and POSITION Peter Hepton BSc PhD SIGNATURE	NAME and POSITION Peter Hepton BSc PhD SIGNATURE

SOCOTEC UK Limited was formerly known as Environmental Scientifics Group Limited. The Certificate of Incorporation on Change of Name was filed on 16 October 2017.

C O N T E N T S

1 INTRODUCTION

In April 2018 SOCOTEC was commissioned by Central Alliance Limited to carry out cone penetration testing (CPT) as part of a ground investigation for the A1 Birtley to Coal House Improvement Scheme. The CPT positions were located in the village of Lamesley at National Grid Reference NZ 254 582.

The testing was required to provide information for a proposed improvement scheme for the A1 carriageway and replacement of the Allerdene railway bridge. Testing was carried out from 10 to 12 April 2018. The scope of the testing was specified by Central Alliance Limited.

This report presents the CPT fieldwork records together with an interpretation of the soils penetrated. The data are also presented separately in digital format following AGS (2017).

2 CONE PENETRATION TESTING

2.1 General

Sixteen CPTs were carried out at ten nominal locations to a maximum achievable depth of 21.15 m using an electric piezocone operated from an 8 tonne tracked mounted CPT unit. Each CPT location was hand excavated to 1.20 m depth by Central Alliance Limited with the test being carried out from the base of the service inspection pit. The programme of testing is summarised in Table 1.

The test locations were selected and set out by Central Alliance Limited.

Testing was carried out in accordance with the UKAS accreditation to Part 9 of BS 1377 (1990) and in general accordance with BS EN ISO 22476-1 (2012). The geometry and dimensions of the cone used conforms with BS EN ISO 22476-1 (2012).

The serial number of the cone used is indicated on the test plots. The calibration certificate is included in Appendix B and provides details of the manufacturer, cone dimensions, capacity and geometry.

Any opinions and interpretations presented are outside the scope of the UKAS accreditation for cone penetration testing.

2.2 Data Processing

Test control and data acquisition was carried out using CPTest, a proprietary software supplied by GeoMil Equipment BV of Holland. The measured cone end resistance, sleeve friction, dynamic porewater pressure and inclination were recorded at 1 cm intervals of penetration.

Interpretation of the CPT data was carried out using an in-house SOCOTEC data reduction spreadsheet. The interpretation follows the recommendations of Lunne et al (1997) to derive: friction ratio, pore pressure ratio, undrained shear strength (minimum and maximum range presented using typical cone factors of 20 and 12 respectively), relative density, angle of friction and soil type. The soil classification uses the soil behaviour type chart of Robertson (1990), see KeyCPT. A nominal groundwater level of 5.00m has been used in the data interpretation.

Explanation of the terms used and derivations of the cone and soil parameters are given in the Key, see KeyCPT. The data are presented graphically as plots relative to depth below ground level on the CPT logs in Appendix B.

2.3 Dissipation Testing

Two dissipation tests were carried out in conjunction with CPTs at positions and depths in general accordance with the Specification requirements as selected by the Central Alliance Limited, see Table 2.

Plots of measured and normalised excess pore pressure are presented in Appendix C. Due to insufficient response in pore pressure during the test period there has been no interpretation carried out on the recorded data.

REFERENCES

AGS: 2017 : Electronic transfer of geotechnical and geoenvironmental data (Edition 4.0.4). Association of Geotechnical and Geoenvironmental Specialists.

BS 1377 : 1990 : Methods of test for soils for civil engineering purposes. British Standards Institution.

BS EN ISO 22476-1 : 2012 : Geotechnical investigation and testing – Field testing – Part 1 : Cone penetration tests. British Standards Institution

Lunne T, Robertson PK and Powell JJM : 1997 : Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional.

Robertson P K : 1990 : Soil classification using the cone penetration test. Canadian Geotechnical Journal, 27(1), 151-8.

Summary of Cone Penetration Tests

SOCOTEC

CPT ID	Hole Depth, (m)	Start Date	Eastings, (m)	Northings, (m)	Ground Level, (m AOD)	Remarks	No. of Sheets
CPT16	15.01	10/04/2018	425545.14	558410.88	22.68	Test carried out using 10cm2 S10-CFIP.361 Terminated due to total thrust Dissipation test carried out at 15.01m	2
CPT17	21.15	10/04/2018	425565.39	558378.99	28.16	Test carried out using 15cm2 S10-CFIP.361 Terminated due to total thrust	3
CPT18	4.96	11/04/2018	425591.80	558385.55	27.15	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT19	0.96	11/04/2018	425551.01	558419.71	25.06	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT19A	12.64	11/04/2018	425550.16	558420.25	25.30	Test carried out using 15cm2 S10-CFIP.361 Terminated due to excessive inclination	2
CPT20	4.52	10/04/2018	425583.53	558374.22	24.52	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT20A	20.55	10/04/2018	425584.27	558374.90	24.52	Test carried out using 10cm2 S10-CFIP.361 Terminated due to total thrust Dissipation test carried out at 20.55m	3
CPT21	5.47	10/04/2018	425613.36	558367.83	27.55	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT21A	8.65	10/04/2018	425612.65	558368.54	27.58	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT22	3.07	12/04/2018	425555.19	558386.84	21.93	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT22A	3.04	12/04/2018	425555.78	558386.03	24.30	Test carried out using 15cm2 S10-CFIP.361 Terminated due to excessive inclination	1
CPT23	1.99	11/04/2018	425644.84	558345.50	28.26	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT23A	5.99	12/04/2018	425643.89	558345.19	28.29	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1
CPT24	7.17	11/04/2018	425667.73	558326.98	28.46	Test carried out using 15cm2 S10CFIP.361 Terminated due to obstruction	1
CPT24A	0.89	11/04/2018	425667.03	558327.70	28.54	Test carried out using 15cm2 S10CFIP.361 Terminated due to obstruction	1
CPT25	1.96	12/04/2018	425698.64	558296.56	27.38	Test carried out using 15cm2 S10-CFIP.361 Terminated due to obstruction	1

- Piezocones fitted with polypropylene pore pressure filter located in the shoulder (U2) position
- Tests carried out with a friction reducer
- No backfilling of CPT holes

Project A1 BIRTLEY TO COAL HOUSE CPT
Project No. M8012-18
Carried out for Central Alliance Limited

Table 1

Summary of Dissipation Test Results

SOCOTEC

Dissipation Test Ref	Cone size (cm^2)	Filter location	Depth (mbgl)	Groundwater level used for analysis (mbgl)	Degree of consolidation	Time to reach reported degree of consolidation t (secs)	Modified time factor T*	Horizontal coefficient of consolidation c_h (m^2/year)	Remarks
CPT16 D01	10	u_2	15.01	-	-	-	-	-	Data unsuitable for interpretation, see result sheet
CPT20A D01	10	u_2	20.55	-	-	-	-	-	Data unsuitable for interpretation, see result sheet

Notes:
• See individual test interpretation sheets for details of analysis.

Project A1 BIRTLEY TO COAL HOUSE CPT
Project No. M8012-18
Carried out for Central Alliance Limited

Table 2

Key to Cone Penetration Test Records

SOCOTEC

Parameter	Unit	Description	Equation
Measured parameters			
q_c	MPa	Cone resistance	Measured parameter
f_s	MPa	Sleeve friction	Measured parameter
I	degrees	Inclination	Measured parameter
u	MPa	Dynamic pore pressure (Piezocone only)	Measured parameter. Denoted as u_1 and u_2 for pore pressure filter locations on cone face and cone shoulder respectively.
-	m, s	Penetration depth and corresponding time	Measured parameters
Derived cone parameters			
R_f	%	Friction ratio	f_s / q_c . 100 %
q_t	MPa	Corrected cone resistance (Piezocone only)	$q_c + (1 - a) . u_2$ where a = area ratio of cone = A_n/A_c; A_n = cross sectional areas of cone tip shaft; A_c = projected area of cone tip
f_t	MPa	Corrected sleeve friction (Piezocone only)	$(f_s – (u_2 . A_{sb} – u_3 . A_{st})) / A_s$ where b = area ratio of friction sleeve; A_{sb} and A_{st} are bottom and top cross sectional areas of friction sleeve
q_e	MPa	Effective cone resistance (Piezocone only)	$q_t – u_2$
q_n	MPa	Net cone resistance (Piezocone or using $q_t = q_c$)	$q_t - \sigma_{vo}$ where σ_{vo} = vertical total stress
R_t'	%	Corrected friction ratio (Piezocone only)	f_t / q_t . 100 %
Δu	MPa	Excess pore pressure (Piezocone only)	$u - u_0$ where u_0 = equilibrium pore water pressure
B_q	-	Pore pressure ratio (Piezocone only)	$(u - u_0) / (q_t - \sigma_{vo}) = \Delta u/q_n$
-	-	Dynamic pore pressure ratio (Piezocone only)	u / q_c
Q_t	-	Normalised cone resistance (Piezocone or using $q_t = q_c$)	$(q_t - \sigma_{vo}) / \sigma'_{vo} = q_n / \sigma'_{vo}$ where σ'_{vo} = vertical effective stress
F_r	%	Normalised local friction (Piezocone or using $q_t = q_c$)	$f_s / (q_t - \sigma_{vo}) = f_s / q_n$. 100 %

Notes:

Project A1 BIRTLEY TO COAL HOUSE CPT
Project No. M8012-18
Carried out for Central Alliance Limited

Key CPT

Key to Cone Penetration Test Records

SOCOTEC

Derived soil parameters		
Parameter	Description	Remarks
s_u Su(min) and Su(max)	Undrained Shear Strength (Clays)	Interpretation for fine soils only – soil types 3 and 4. Based on net cone resistance (corrected where pore pressure data available) and empirical cone factor $= (q_c - \sigma_{vo}) / N_k$ Plots of minimum and maximum strength presented using N_k of 20 and 12.
D_r RD	Relative Density	Interpretation for coarse soils only – soil types 5, 6 and 7. After Baldi et al (1986) for moderately compressible, unaged, uncemented, silica sand $= (1 / C_2) . Ln (q_c / C_0 (\sigma')^{C_1})$ For NC sands : $C_0 = 157$, $C_1 = 0.55$, $C_2 = 2.41$, $\sigma' = \sigma'_{vo}$ For OC sands : $C_0 = 181$, $C_1 = 0.55$, $C_2 = 2.61$, $\sigma' = \sigma'_m$ and mean effective stress = $\sigma'_m = (\sigma'_{vo} + 2\ \sigma'_{ho}) / 3$
ϕ IFA	Internal Friction Angle	Interpretation for coarse soils only – soil types 5, 6 and 7. After Robertson and Campanella (1983) for uncemented, moderately incompressible, predominately silica sands $= \text{Arctan} (0.105 + 0.16 . Ln (q_c / \sigma'_{vo}))$
N_{60}	Equivalent Standard Penetration Test (SPT) N value	$= (q_c / p_a) / 8.5 . (1 - I_c / 4.6))$ p_a – reference stress of 100 kPa

Soil Description			
Soil Type	Classification after Robertson (1990) using normalised cone resistance, normalised friction ratio and pore pressure ratio.		
Undrained shear strength description		Descriptive term	Strength, kPa
		Very soft Soft Firm Stiff Very stiff	<20 20 to 40 40 to 75 75 to 150 >150
Relative density description		Descriptive term	Cone resistance (q_c), MPa
		Very loose Loose Medium dense Dense Very dense	<2 2 to 4 4 to 12 12 to 20 >20

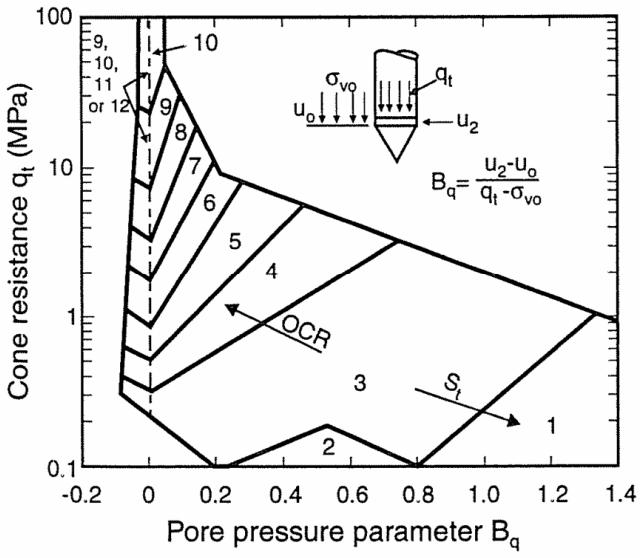
Notes:

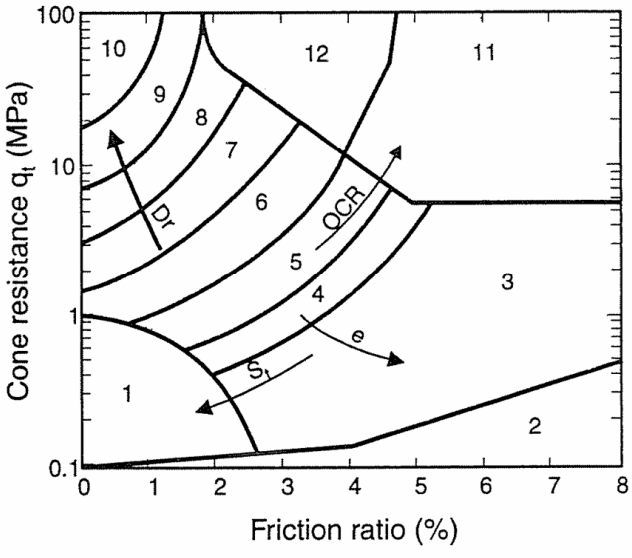
Project A1 BIRTLEY TO COAL HOUSE CPT
Project No. M8012-18
Carried out for Central Alliance Limited

Key CPT

Soil Behaviour Type Interpretation

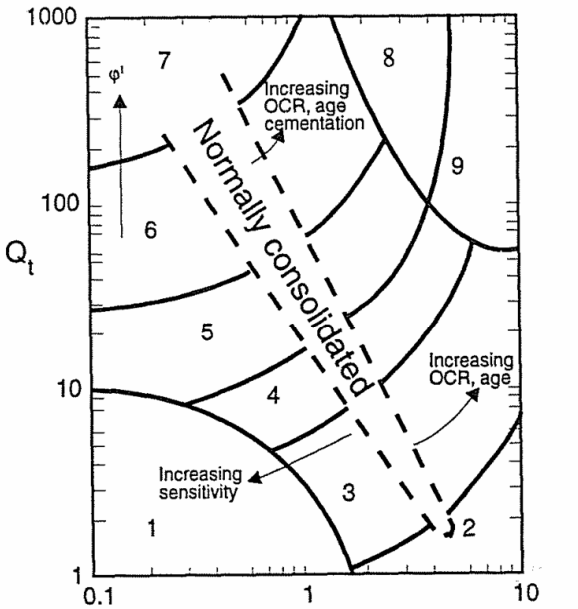
SOCOTEC

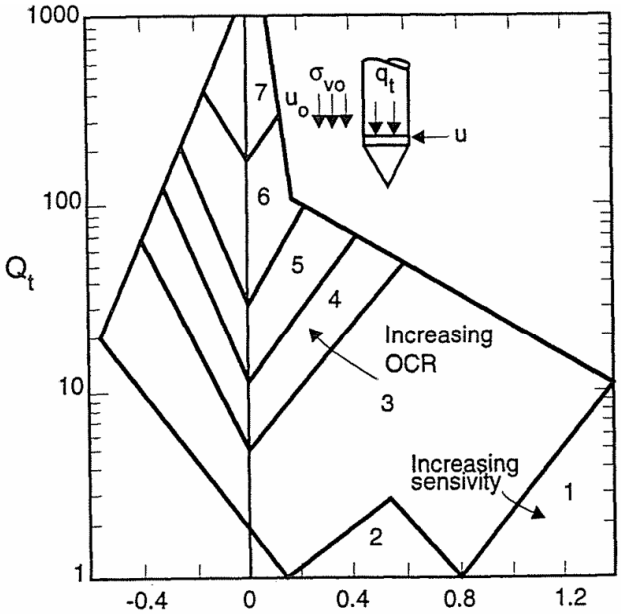




KEY TO SOIL BEHAVIOUR TYPES - after Robertson et al (1986)

ZONE	SOIL BEHAVIOUR TYPE	ZONE	SOIL BEHAVIOUR TYPE	ZONE	SOIL BEHAVIOUR TYPE
1	Sensitive fine grained	5	Clayey silt to silty clay	9	Sand
2	Organic material	6	Sandy silt to clayey silt	10	Gravelly sand to sand
3	Clay	7	Silty sand to sandy silt	11	Very stiff fine grained*
4	Silty clay to clay	8	Sand to silty sand	12	Sand to clayey sand*





KEY TO SOIL BEHAVIOUR TYPES – after Robertson (1990)

ZONE	SOIL BEHAVIOUR TYPE	ZONE	SOIL BEHAVIOUR TYPE	ZONE	SOIL BEHAVIOUR TYPE
1	Sensitive fine grained	4	Silt mixtures: clayey silt to silty clay	7	Gravelly sand to sand
2	Organic soils – peats	5	Sand mixtures: silty sand to sandy silt	8	Very stiff sand to clayey sand
3	Clays: clay to silty clay	6	Sands: clean sand to silty sand	9	Very stiff fine grained

Notes:

Project A1 BIRTLEY TO COAL HOUSE CPT
Project No. M8012-18
Carried out for Central Alliance Limited

Figure
Key CPT

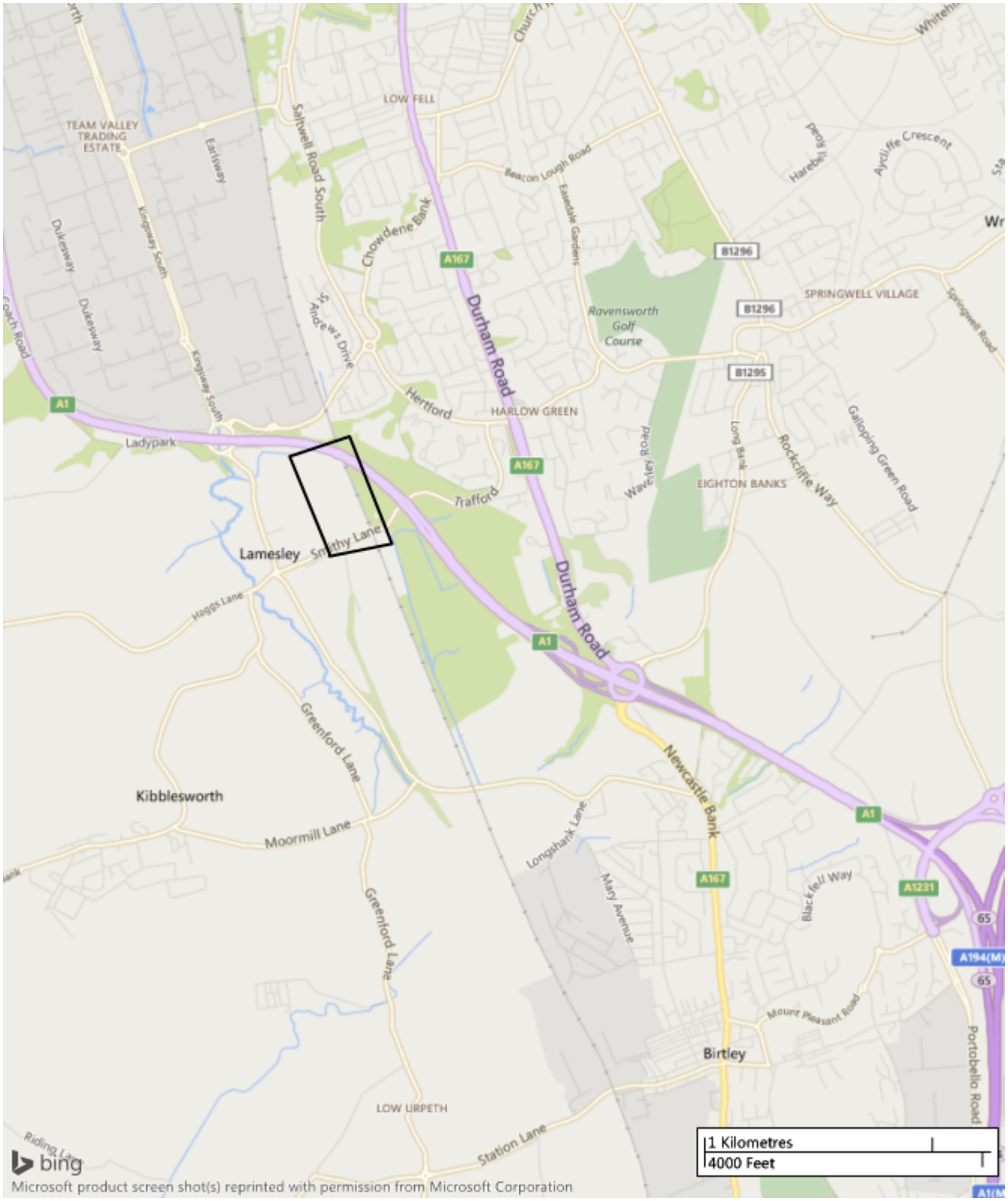
APPENDIX A

Site Location Plan	A1

Site Location Plan

SOCOTEC

Site location



Notes	Project	A1 BIRTLEY TO COAL HOUSE CPT	Figure
	Project No.	M8012-18	A1
	Carried out for	Central Alliance Limited	

APPENDIX B

Cone Calibration Certificate — Cone S10-CFIP.361

Cone Penetration Test Logs — Sheet 1 to 22

(See Table 1)

Environmental Scientifics Group.

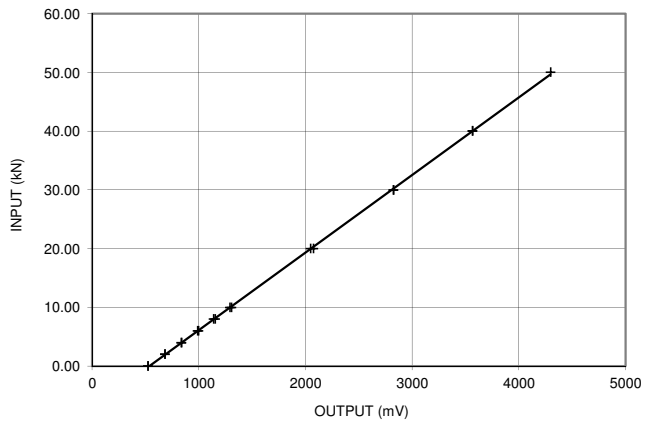
CPT CONE

Cone No.	S10-CFIP.361	Date of Calibration	30 January 2018
Manufacturer	GeoPoint.	Reference Standards	BS 1377 : 1990 Part 9
Compression/ Subtraction	Subtraction	Reference Equipment	Pressure meter 1972A
			Vernier callipers GCV1
Pore Pressure Channel (Y/N)	Y		Load cell 22541
			Voltmeter 06402486
Cone end area ratio (by dimension measurement), a	0.8	Sleeve end area ratio (by dimension measurement), b	1.0

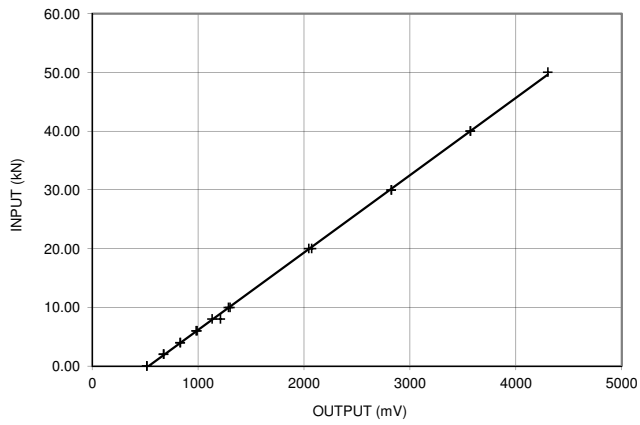
Note: Calibration Zero taken as no load in free air, Output taken as slope of linear regression line x maximum load.

Cone Type (S/ C/ M/ D/ T)	S		Ch 3 (P/ C/ T/ N/ F)	P				
	Output		Input		Zero		Area		Alarm	
Channel 1	3786	mV	50	kN	479	mV	10	cm^2	45	kN
Channel 2	3796	mV	50.0	kN	474	mV	150	cm^2	10	kN
Channel 3	7674	mV	20	Bar	197	mV			16	Bar
Inclination	0°		5°		10°				Alarm	
	16		109		484				12	°
	15°		20°		25°					
	1077		1846		2517		Extra Channels		N	

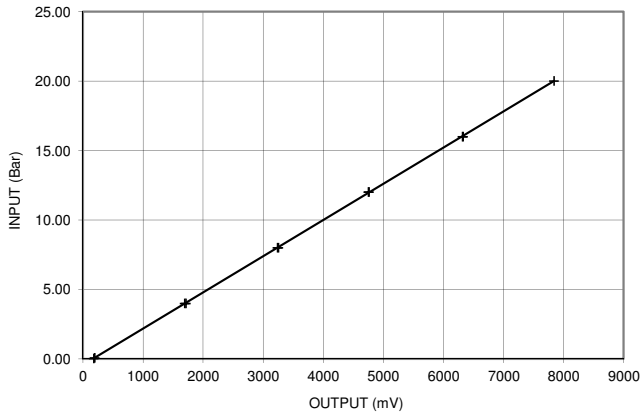
CHANNEL 1 - TIP



CHANNEL 2 - FRICTION SLEEVE



CHANNEL 3 - PORE PRESSURE



SOCOTEC	Cone calibrated by: SDPearce	Authorised for use by:

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

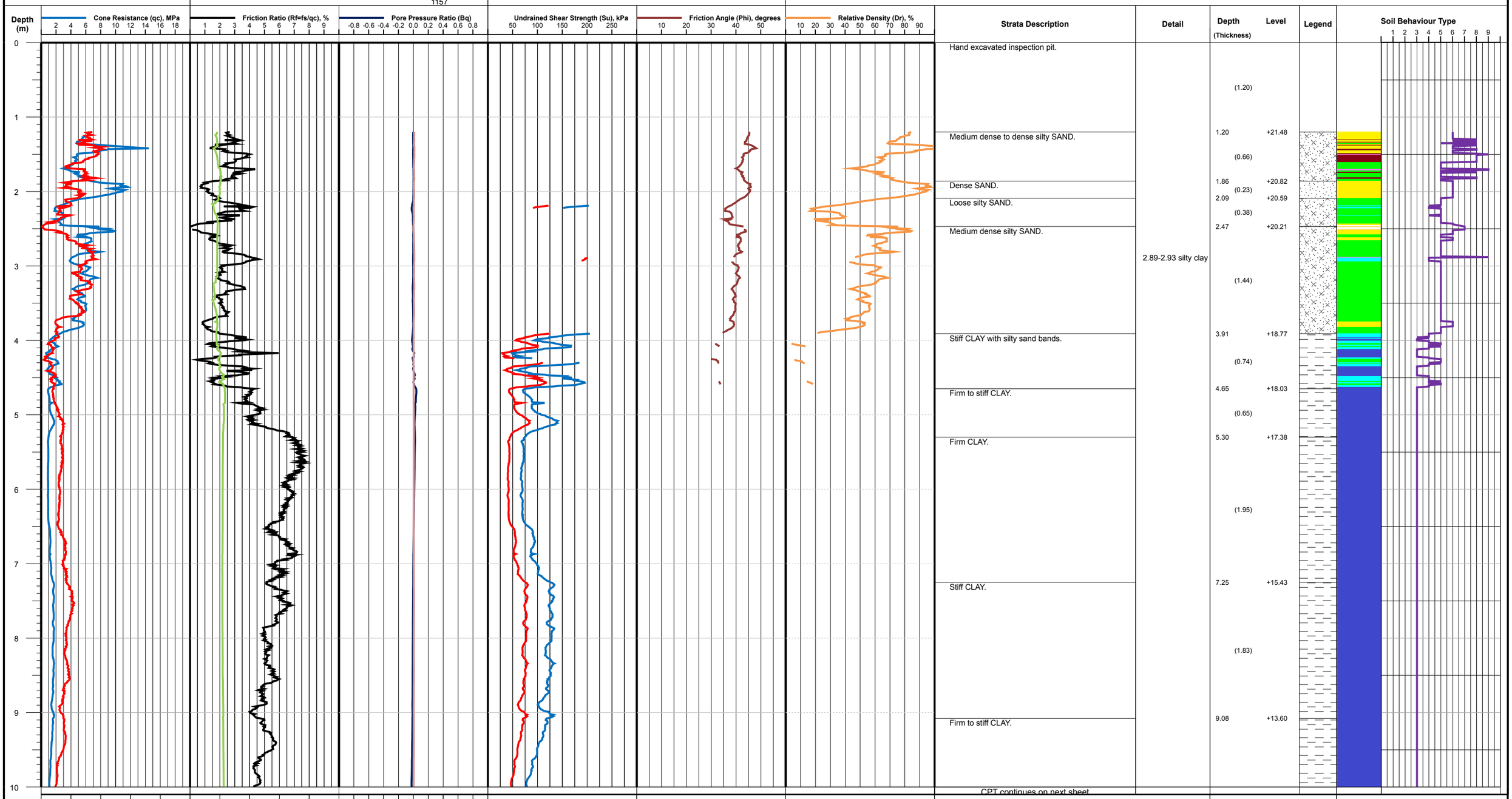
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	22.68 mOD
Co-ordinates (m)	E 425545.14
National Grid	N 558410.88

Remarks Terminated due to total thrust
Dissipation test carried out at 15.01m

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
Medium dense to dense silty SAND.		1.20	+21.48
		(0.66)	
Dense SAND.		1.86	+20.82
		(0.23)	
Loose silty SAND.		2.09	+20.59
		(0.38)	
Medium dense silty SAND.	2.89-2.93 silty clay	2.47	+20.21
		(1.44)	
Stiff CLAY with silty sand bands.		3.91	+18.77
		(0.74)	
Firm to stiff CLAY.		4.65	+18.03
		(0.65)	
Firm CLAY.		5.30	+17.38
		(1.95)	
Stiff CLAY.		7.25	+15.43
		(1.83)	
Firm to stiff CLAY.		9.08	+13.60
CPT continues on next sheet			

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.
CPT17-16

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

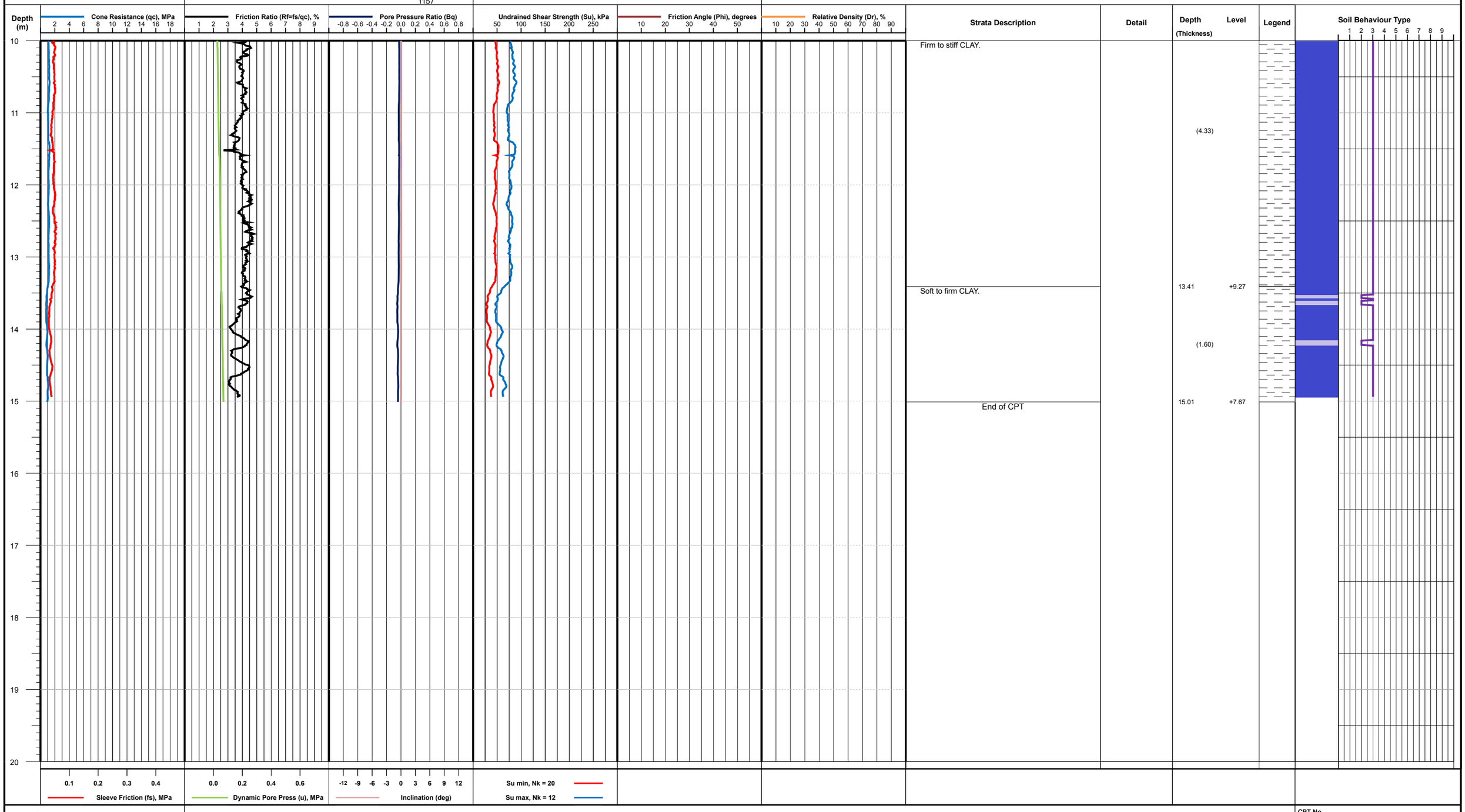
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	22.68 mOD
Co-ordinates (m)	E 425545.14
National Grid	N 558410.88

Remarks Terminated due to total thrust
Dissipation test carried out at 15.01m

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Firm to stiff CLAY.		(4.33)	
Soft to firm CLAY.		13.41	+9.27
		(1.60)	
End of CPT		15.01	+7.67

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-16

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

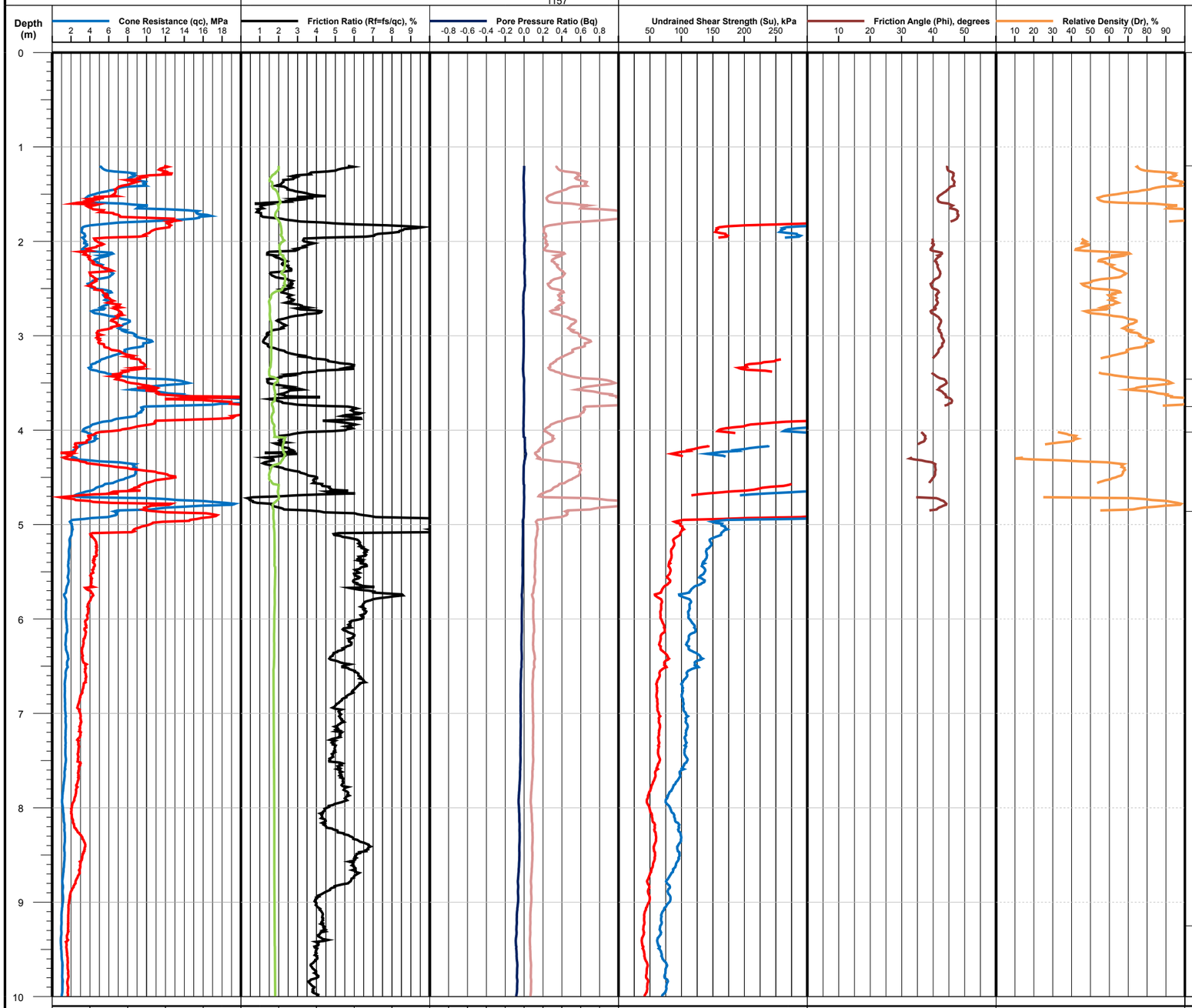
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	28.16 mOD
Co-ordinates (m)	E 425565.39
National Grid	N 558378.99

Remarks Terminated due to total thrust

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
		1.20	+26.96
Medium dense silty SAND.	1.66-1.77 becomes dense 1.80-1.96 clay	(2.26)	
	3.25-3.38 silty clay	3.46	+24.70
Dense to very dense SAND.		(0.29)	
		3.75	+24.41
Very stiff silty CLAY.		(0.27)	
		4.02	+24.14
Medium dense to dense silty SAND with silty clay bands.		(0.84)	
		4.86	+23.30
Firm to stiff CLAY.		(4.39)	
		9.25	+18.91
Soft to firm CLAY.			
CPT continues on next sheet			

Legend

Soil Behaviour Type

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-17

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

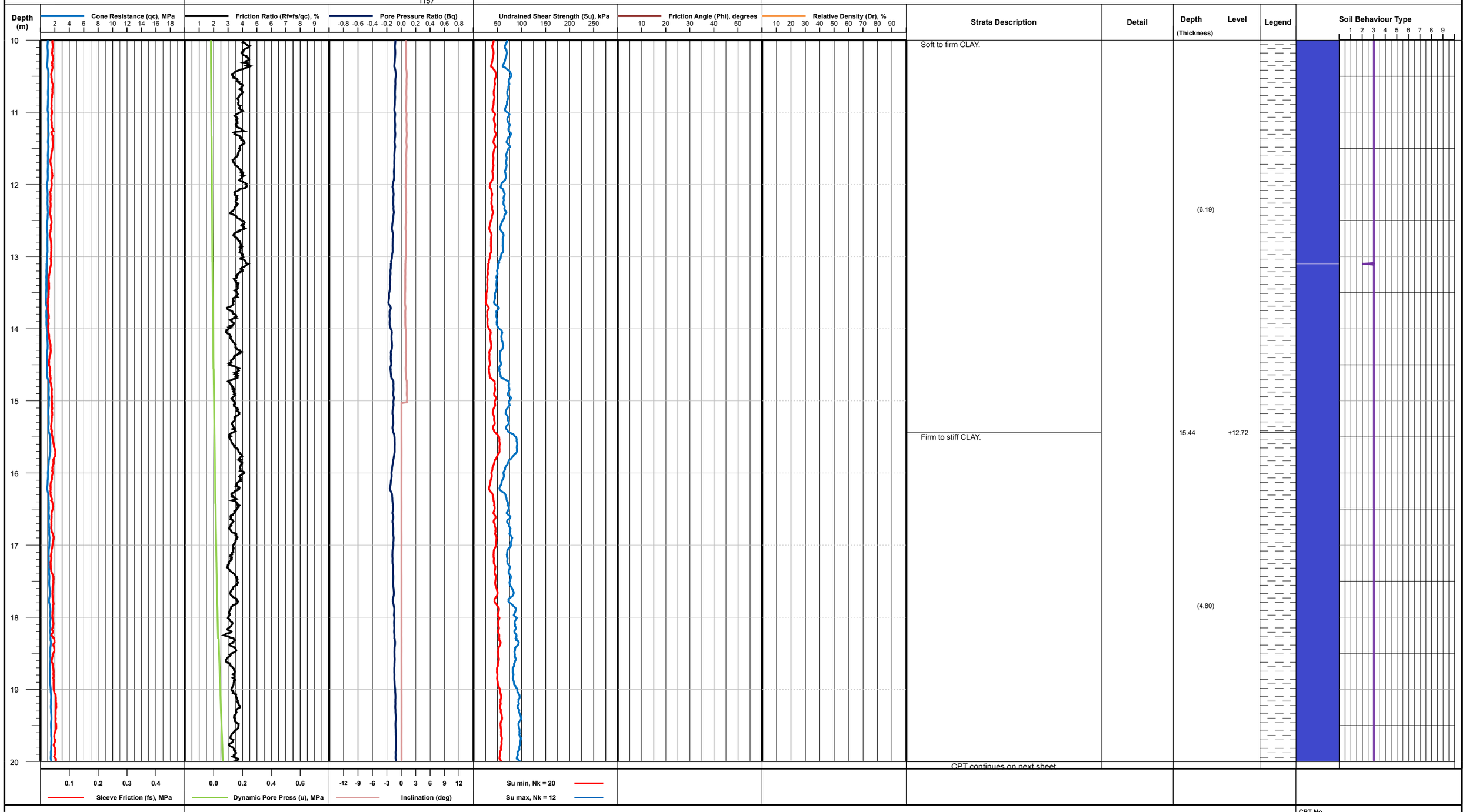
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	28.16 mOD
Co-ordinates (m)	E 425565.39
National Grid	N 558378.99

Remarks Terminated due to total thrust

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level	Legend
Soft to firm CLAY.		(6.19)		
Firm to stiff CLAY.		15.44 (4.80)	+12.72	
CPT continues on next sheet				

Soil Behaviour Type

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.
CPT17-17

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018	**Equipment and Methods**	Test according to BS 1377 : Part 9 : Method 3.1	**Ground level**	28.16 mOD
Cone ID	S10-CFIP.361			**Co-ordinates (m)**	E 425565.39
Operator	DT/JG			**National Grid**	N 558378.99
Checked	JMH			**Remarks**	Terminated due to total thrust
Approved	PH			**Assumed Groundwater Level (m)**	5.00

UKAS TESTING 1157

Strata Description	Depth (Thickness)	Level
Firm to stiff CLAY.	20.24	+7.92
Dense silty SAND.	(0.71)	
	20.95	+7.21
Very stiff CLAY.	(0.20)	
End of CPT	21.15	+7.01

Detail

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-17

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

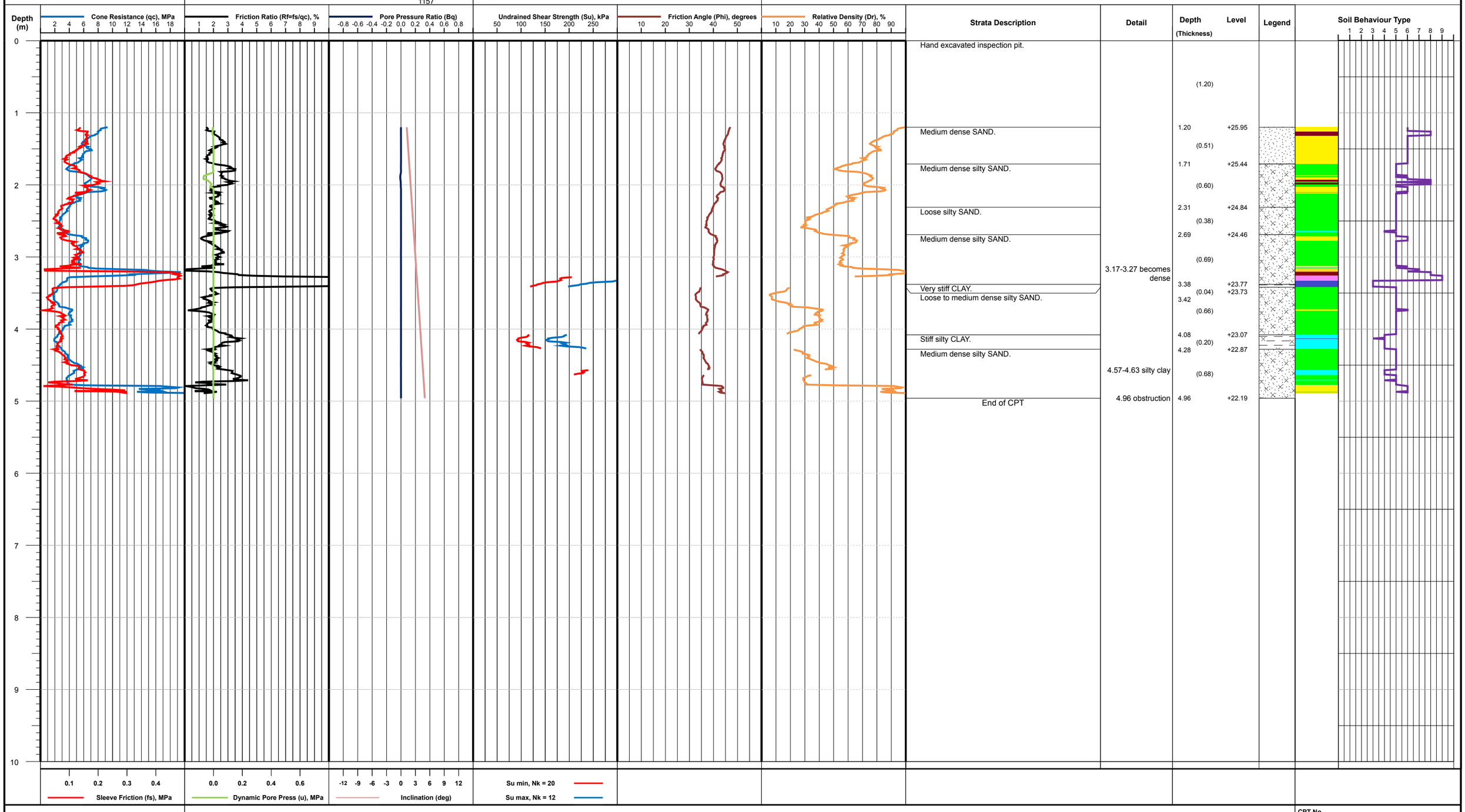
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	27.15 mOD
Co-ordinates (m)	E 425591.80
National Grid	N 558385.55

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

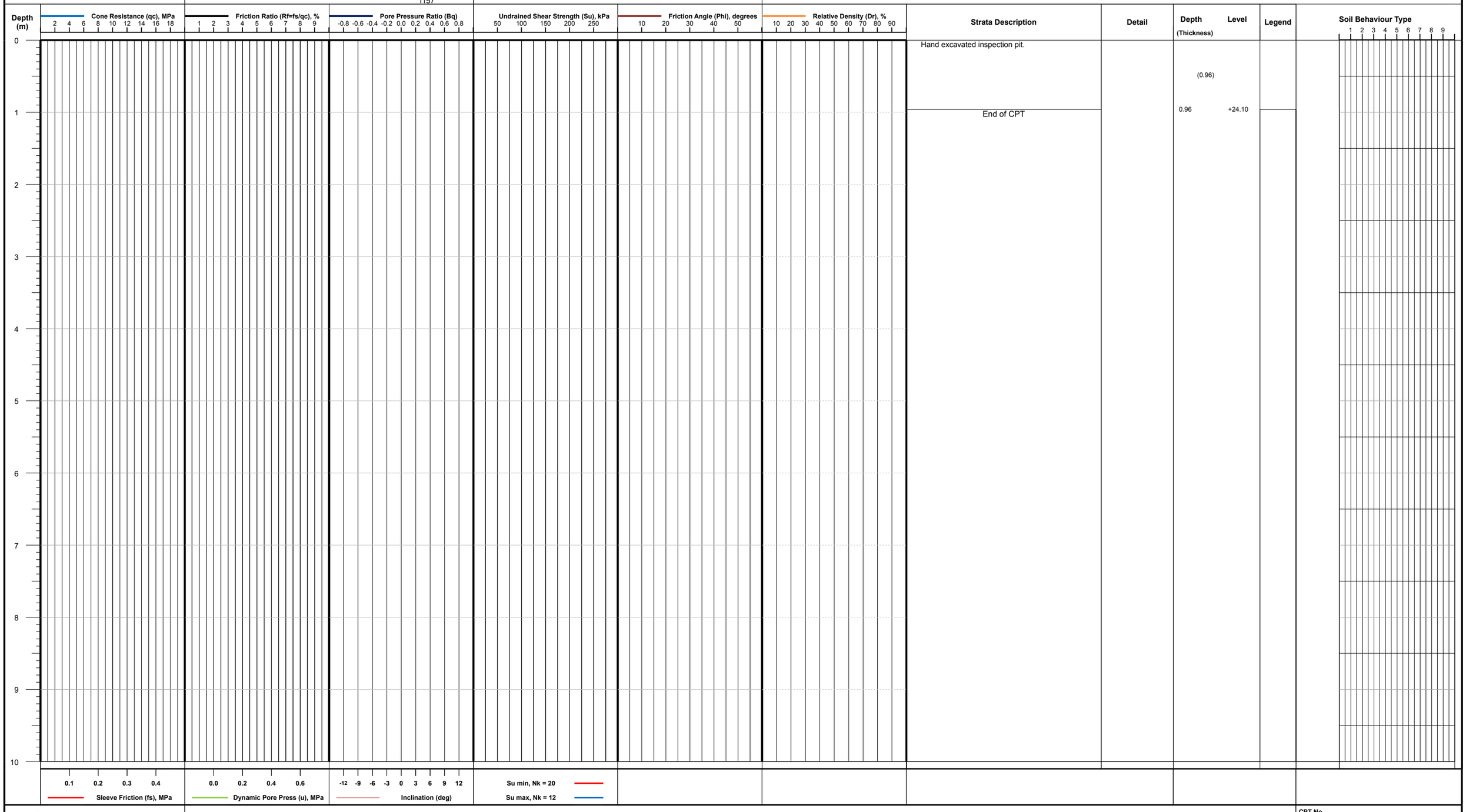
CPT17-18

Sheet 1 of 1

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018	**Equipment and Methods**		**Ground level**	25.06 mOD
Cone ID	S10-CFIP.361	Test according to BS 1377 : Part 9 : Method 3.1		**Co-ordinates (m)**	E 425551.01
Operator	DT/JG			**National Grid**	N 558419.71
Checked	JMH	UKAS TESTING 1157		**Remarks**	Terminated due to obstruction
Approved	PH			**Assumed Groundwater Level (m)**	5.00



Strata Description	Detail	Depth (Thickness)	Level	Legend	Soil Behaviour Type
Hand excavated inspection pit.		(0.96)			1 2 3 4 5 6 7 8 9
End of CPT		0.96	+24.10		

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-19

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

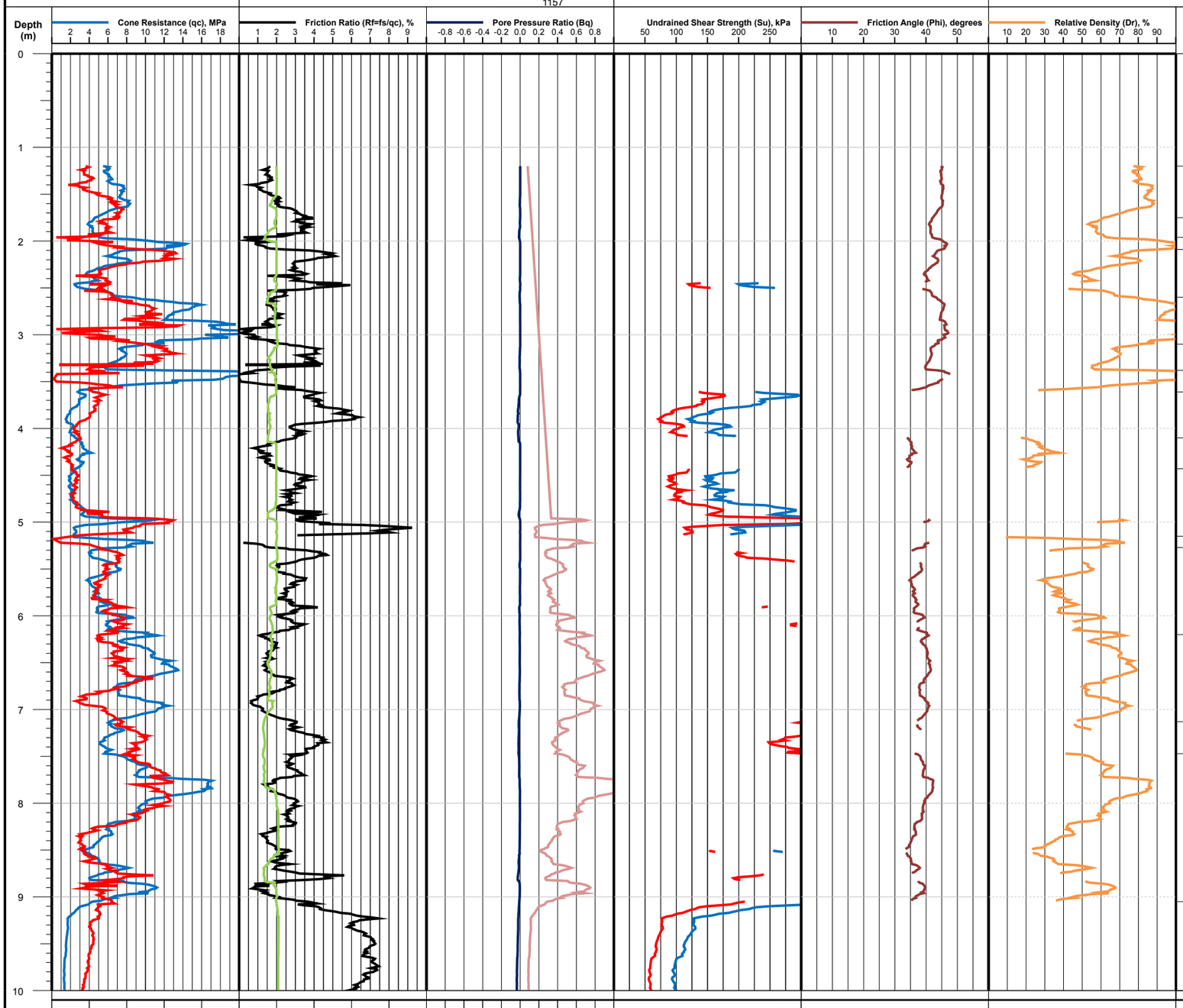
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	25.30 mOD
Co-ordinates (m)	E 425550.16
National Grid	N 558420.25

Remarks Terminated due to excessive inclination

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
		1.20	+24.10
Medium dense SAND.		(0.55)	
		1.75	+23.55
Medium dense silty SAND.		(0.21)	
		1.96	+23.34
Dense SAND.		(0.13)	
		2.09	+23.21
Medium dense silty SAND.		(0.51)	
	2.45-2.50 silty clay	2.60	+22.70
Dense to very dense, locally gravelly, SAND.		(0.50)	
		3.10	+22.20
Medium dense silty SAND.		(0.28)	
		3.38	+21.92
Dense gravelly SAND.		(0.23)	
		3.61	+21.69
Stiff CLAY.		(0.49)	
		4.10	+21.20
Loose silty SAND.		(0.33)	
		4.43	+20.87
Stiff to very stiff silty CLAY.		(0.72)	
	4.97-5.00 silty sand	5.15	+20.15
Medium dense SAND.		(0.12)	
		5.27	+20.03
Medium dense silty SAND.	5.32-5.42 silty clay	(0.93)	
		6.20	+19.10
Medium dense to dense SAND.	6.08-6.11 silty clay	(0.93)	
		7.13	+18.17
Very stiff silty CLAY.		(0.34)	
		7.47	+17.83
Medium dense to dense silty SAND.		(1.58)	
		9.05	+16.25
Firm to stiff CLAY.			
CPT continues on next sheet			

Soil Behaviour Type

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

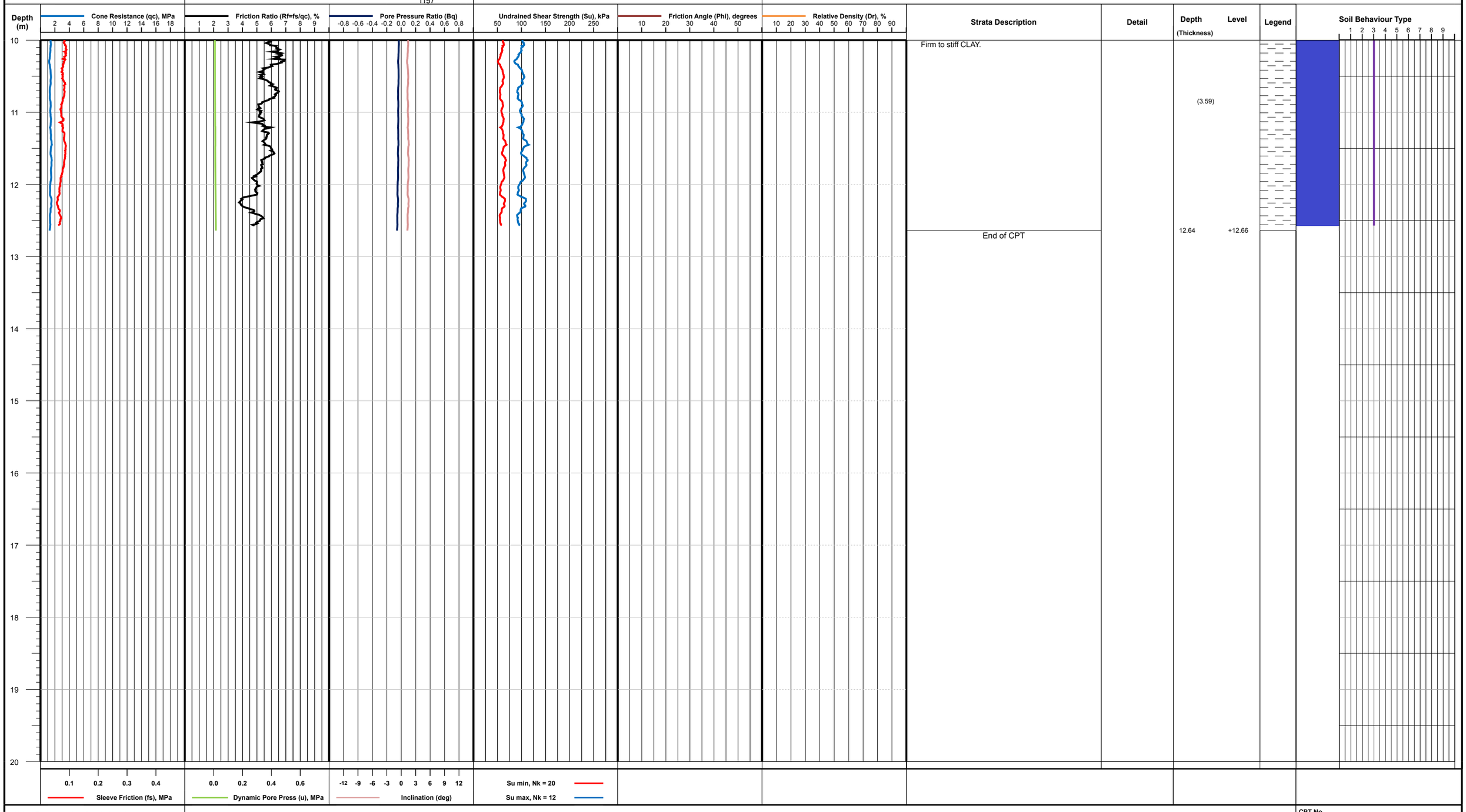
CPT17-19A

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018	**Equipment and Methods**	Test according to BS 1377 : Part 9 : Method 3.1	**Ground level**	25.30 mOD
Cone ID	S10-CFIP.361			**Co-ordinates (m)**	E 425550.16
Operator	DT/JG			**National Grid**	N 558420.25
Checked	JMH			**Remarks**	Terminated due to excessive inclination
Approved	PH			**Assumed Groundwater Level (m)**	5.00

UKAS TESTING 1157



Strata Description	Detail	Depth (Thickness)	Level
Firm to stiff CLAY.		(3.59)	
End of CPT		12.64	+12.66

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

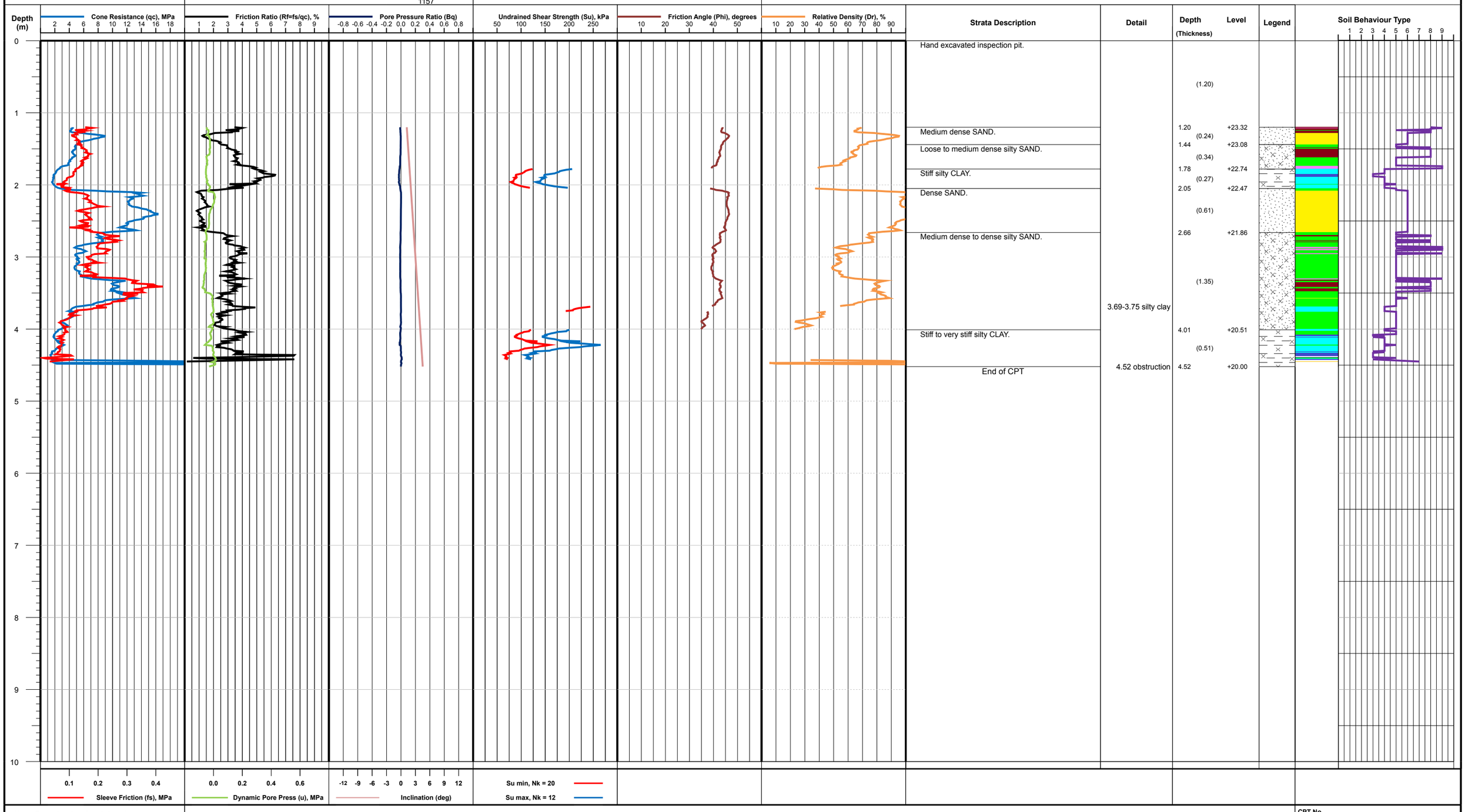
CPT No.

CPT17-19A

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018	**Equipment and Methods**		**Ground level**	24.52 mOD
Cone ID	S10-CFIP.361	Test according to BS 1377 : Part 9 : Method 3.1		**Co-ordinates (m)**	E 425583.53
Operator	DT/JG			**National Grid**	N 558374.22
Checked	JMH	UKAS TESTING 1157		**Remarks**	Terminated due to obstruction
Approved	PH			**Assumed Groundwater Level (m)**	5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
		1.20	+23.32
Medium dense SAND.		(0.24)	
		1.44	+23.08
Loose to medium dense silty SAND.		(0.34)	
		1.78	+22.74
Stiff silty CLAY.		(0.27)	
		2.05	+22.47
Dense SAND.		(0.61)	
		2.66	+21.86
Medium dense to dense silty SAND.		(1.35)	
	3.69-3.75 silty clay		
		4.01	+20.51
Stiff to very stiff silty CLAY.		(0.51)	
End of CPT	4.52 obstruction	4.52	+20.00

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-20

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

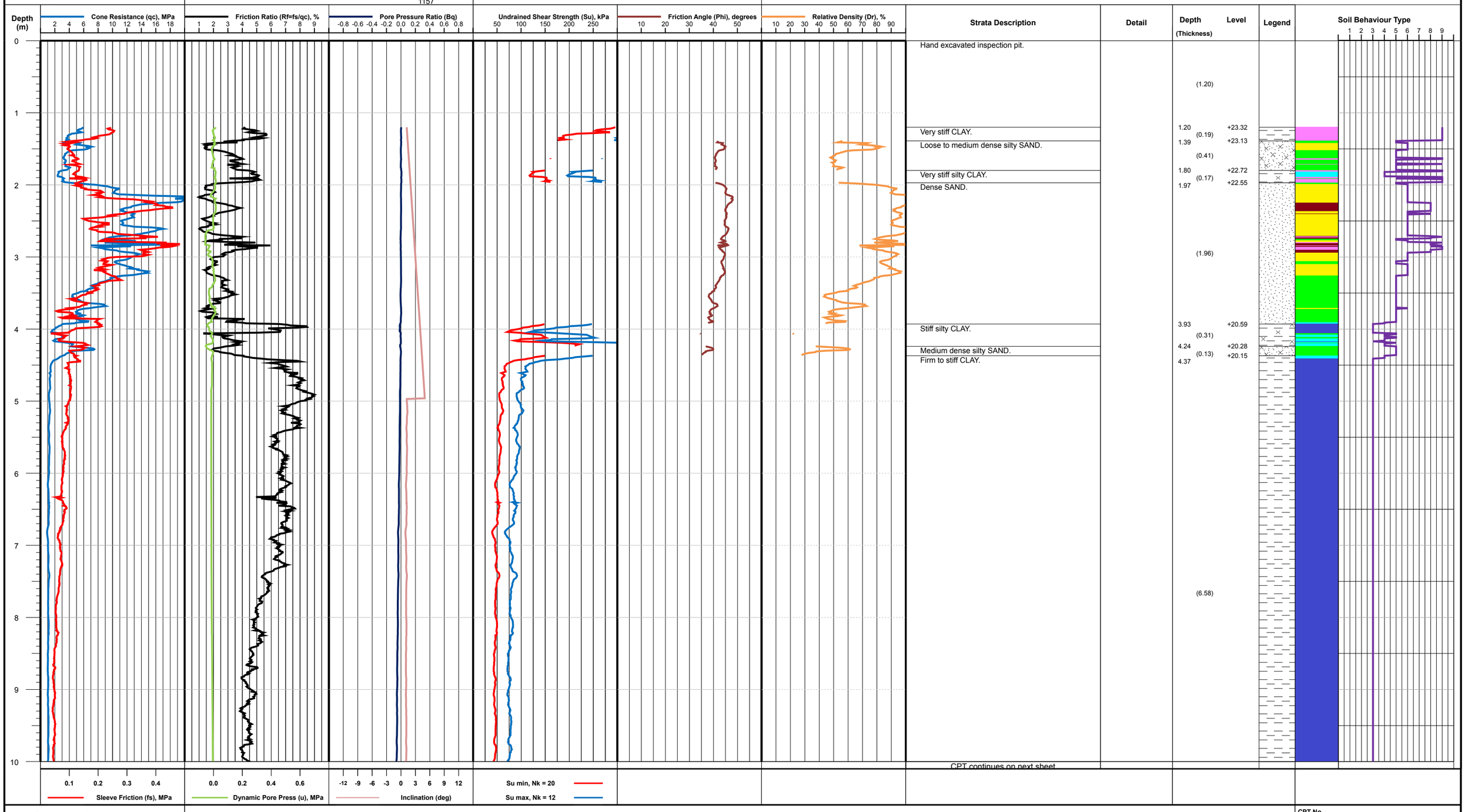
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	24.52 mOD
Co-ordinates (m)	E 425584.27
National Grid	N 558374.90

Remarks Terminated due to total thrust
Dissipation test carried out at 20.55m

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
		1.20	+23.32
Very stiff CLAY.		(0.19)	
		1.39	+23.13
Loose to medium dense silty SAND.		(0.41)	
		1.80	+22.72
Very stiff silty CLAY.		(0.17)	
		1.97	+22.55
Dense SAND.		(1.96)	
		3.93	+20.59
Stiff silty CLAY.		(0.31)	
		4.24	+20.28
Medium dense silty SAND.		(0.13)	
		4.37	+20.15
Firm to stiff CLAY.		(6.58)	
CPT continues on next sheet			

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.
CPT17-20A

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

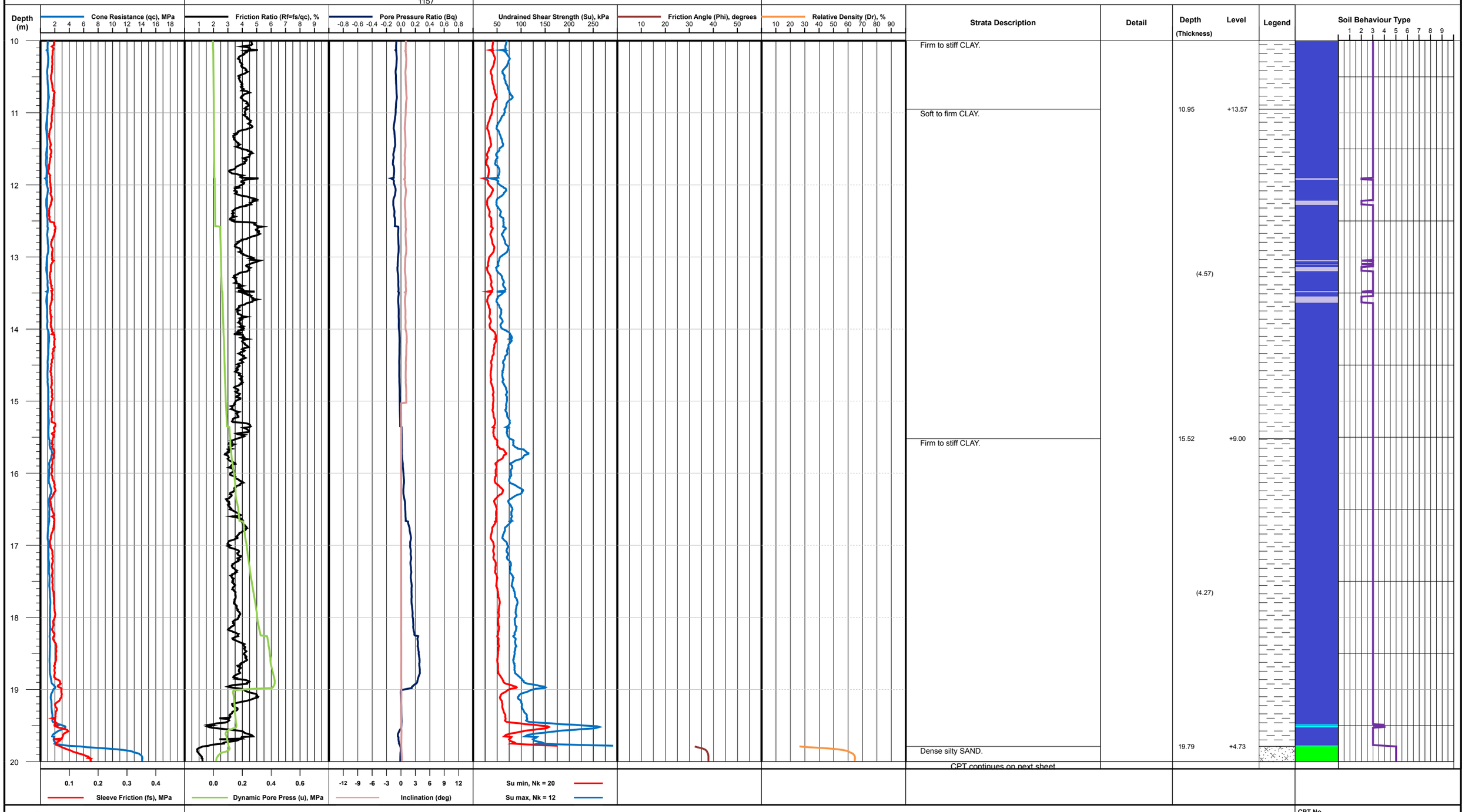
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	24.52 mOD
Co-ordinates (m)	E 425584.27
National Grid	N 558374.90

Remarks Terminated due to total thrust
Dissipation test carried out at 20.55m

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Firm to stiff CLAY.		
Soft to firm CLAY.	10.95	+13.57
	(4.57)	
Firm to stiff CLAY.	15.52	+9.00
	(4.27)	
Dense silty SAND.	19.79	+4.73
CPT continues on next sheet		

Legend

Soil Behaviour Type

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

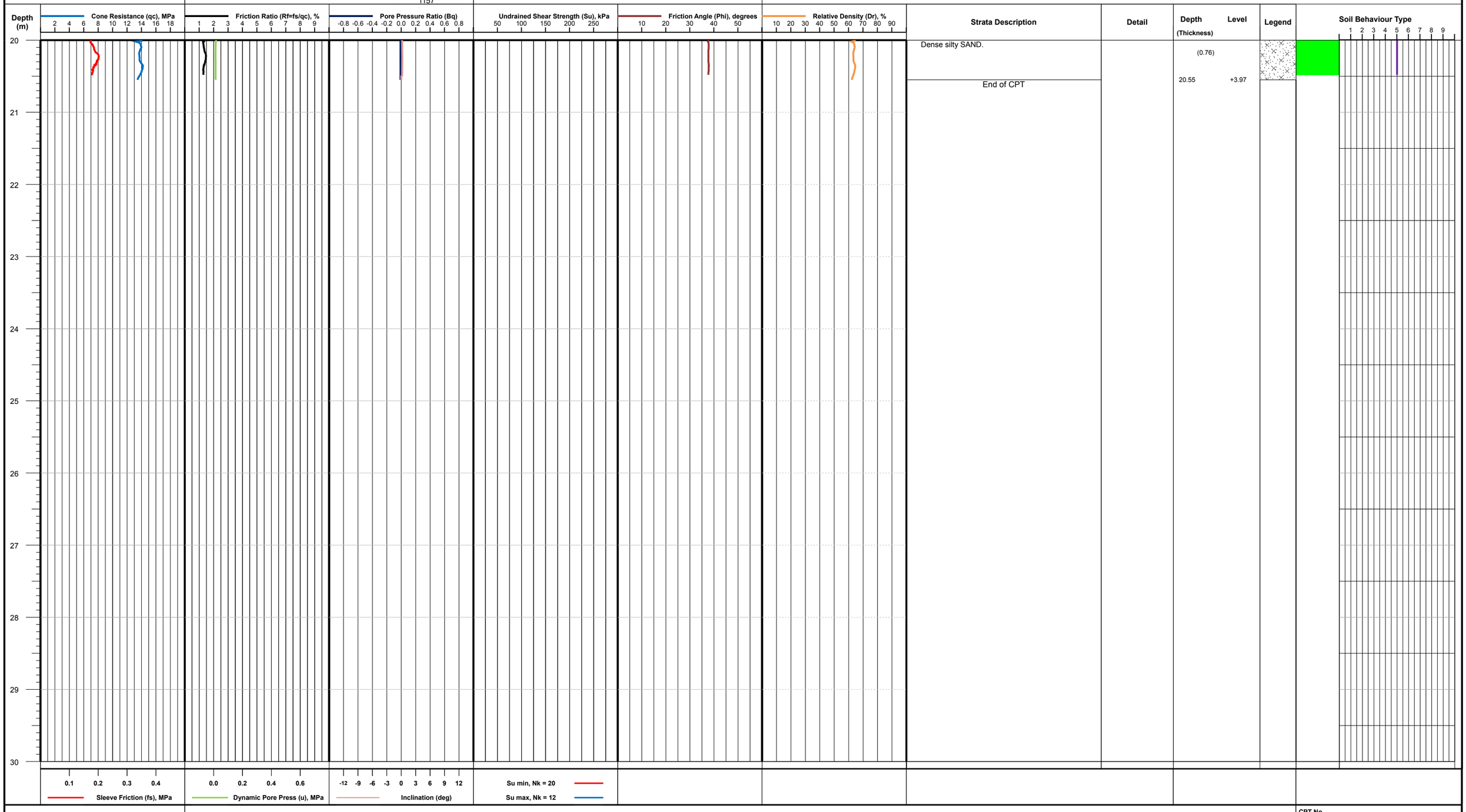
CPT No.
CPT17-20A

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018	**Equipment and Methods**	Test according to BS 1377 : Part 9 : Method 3.1	**Ground level**	24.52 mOD
Cone ID	S10-CFIP.361			**Co-ordinates (m)**	E 425584.27
Operator	DT/JG			**National Grid**	N 558374.90
Checked	JMH			**Remarks**	Terminated due to total thrust Dissipation test carried out at 20.55m
Approved	PH			**Assumed Groundwater Level (m)**	5.00

UKAS TESTING 1157



Strata Description	Detail	Depth (Thickness)	Level
Dense silty SAND.		(0.76)	
End of CPT		20.55	+3.97

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-20A

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

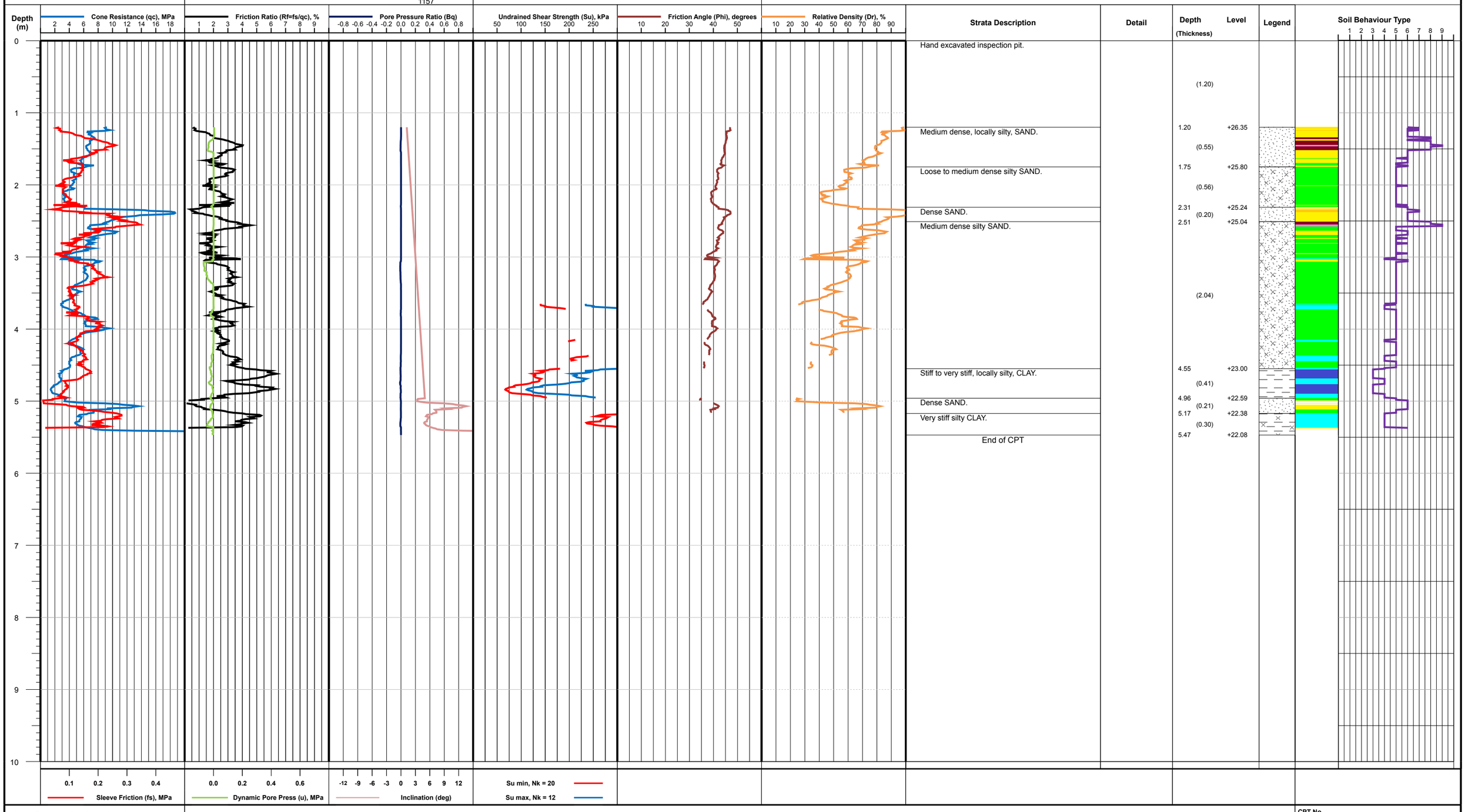
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	27.55 mOD
Co-ordinates (m)	E 425613.36
National Grid	N 558367.83

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense, locally silty, SAND.	1.20	+26.35
	(0.55)	
Loose to medium dense silty SAND.	1.75	+25.80
	(0.56)	
Dense SAND.	2.31	+25.24
	(0.20)	
Medium dense silty SAND.	2.51	+25.04
	(2.04)	
Stiff to very stiff, locally silty, CLAY.	4.55	+23.00
	(0.41)	
Dense SAND.	4.96	+22.59
	(0.21)	
Very stiff silty CLAY.	5.17	+22.38
	(0.30)	
End of CPT	5.47	+22.08

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-21

Cone Penetration Test Log

SOCOTEC

Date	10/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

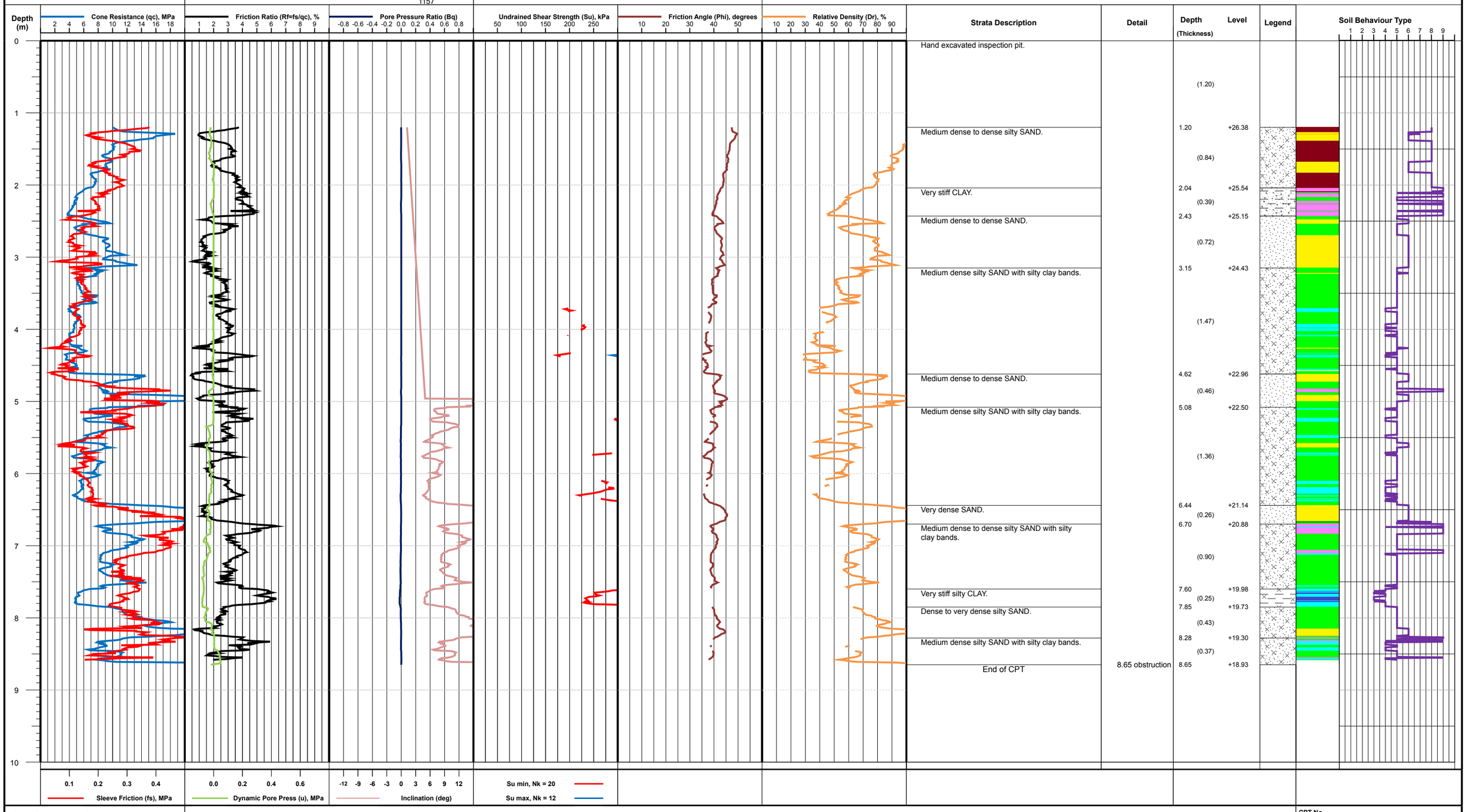
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	27.58 mOD
Co-ordinates (m)	E 425612.65
National Grid	N 558368.54

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level
Hand excavated inspection pit.		(1.20)	
		1.20	+26.38
Medium dense to dense silty SAND.		(0.84)	
		2.04	+25.54
Very stiff CLAY.		(0.39)	
		2.43	+25.15
Medium dense to dense SAND.		(0.72)	
		3.15	+24.43
Medium dense silty SAND with silty clay bands.		(1.47)	
		4.62	+22.96
Medium dense to dense SAND.		(0.46)	
		5.08	+22.50
Medium dense silty SAND with silty clay bands.		(1.36)	
		6.44	+21.14
Very dense SAND.		(0.26)	
		6.70	+20.88
Medium dense to dense silty SAND with silty clay bands.		(0.90)	
		7.60	+19.98
Very stiff silty CLAY.		(0.25)	
		7.85	+19.73
Dense to very dense silty SAND.		(0.43)	
		8.28	+19.30
Medium dense silty SAND with silty clay bands.		(0.37)	
End of CPT	8.65 obstruction	8.65	+18.93

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.
CPT17-21A
Sheet 1 of 1

Cone Penetration Test Log

SOCOTEC

Date	12/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

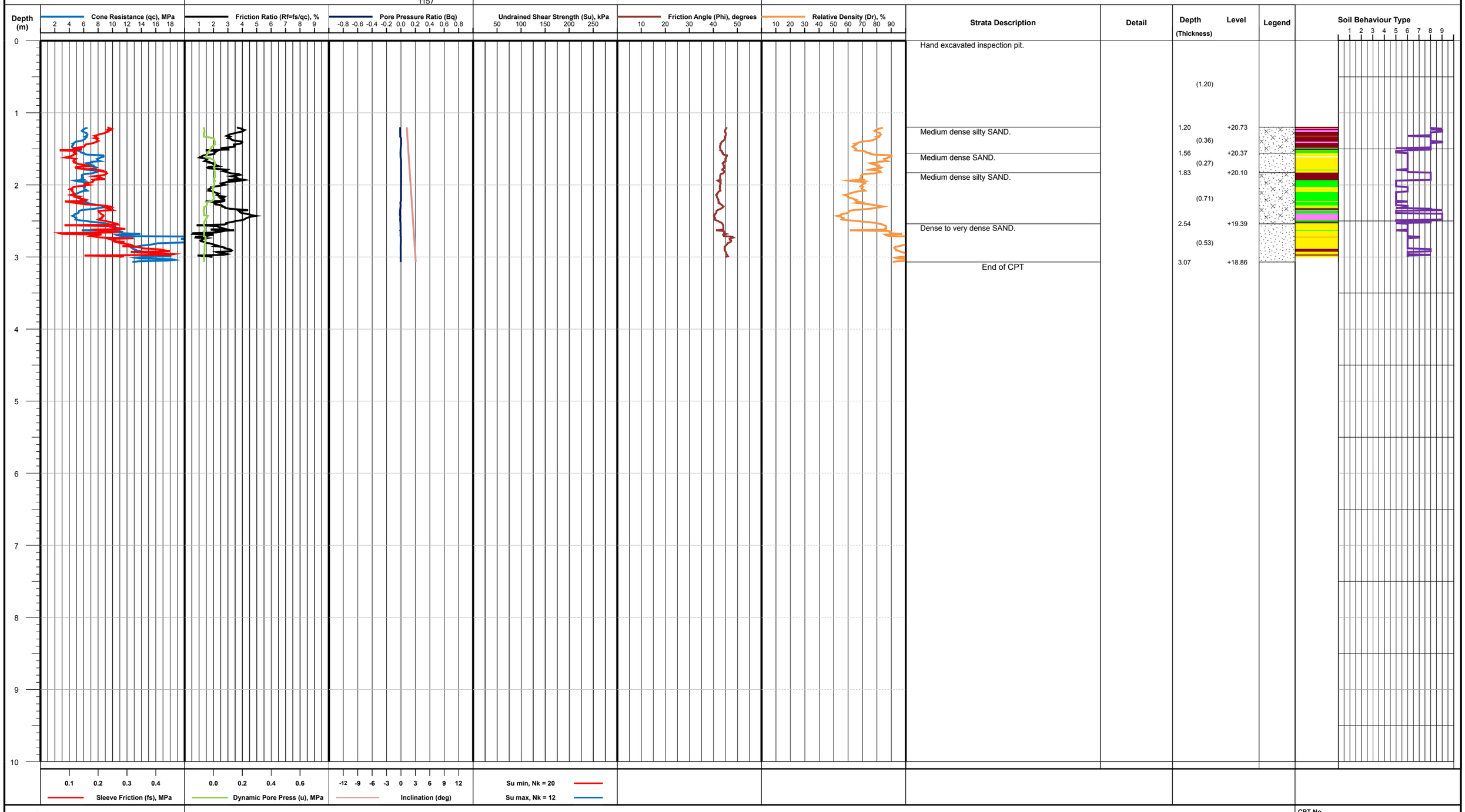
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	21.93 mOD
Co-ordinates (m)	E 425555.19
National Grid	N 558386.84

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense silty SAND.	1.20	+20.73
	(0.36)	
Medium dense SAND.	1.56	+20.37
	(0.27)	
Medium dense silty SAND.	1.83	+20.10
	(0.71)	
Dense to very dense SAND.	2.54	+19.39
	(0.53)	
End of CPT	3.07	+18.86

Detail

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

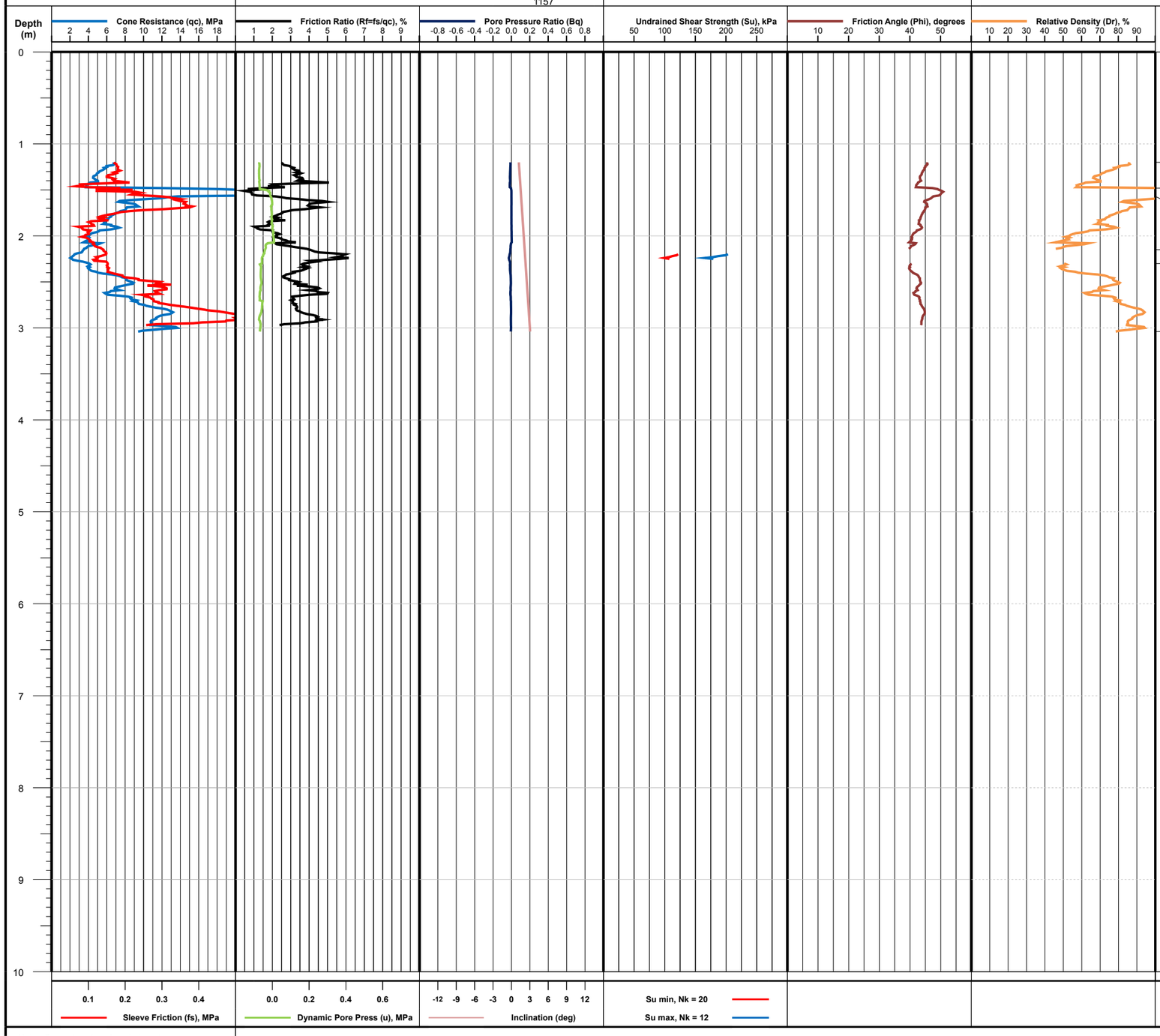
CPT17-22

Cone Penetration Test Log

SOCOTEC

Date	12/04/2018	**Equipment and Methods**	Test according to BS 1377 : Part 9 : Method 3.1	**Ground level**	24.30 mOD
Cone ID	S10-CFIP.361			**Co-ordinates (m)**	E 425555.78
Operator	DT/JG			**National Grid**	N 558386.03
Checked	JMH			**Remarks**	Terminated due to excessive inclination
Approved	PH			**Assumed Groundwater Level (m)**	5.00

UKAS TESTING 1157



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense silty SAND.	1.20 (0.28)	+23.10
Very dense gravelly SAND.	1.48 (0.09)	+22.82
Medium dense silty SAND.	1.57 (0.58)	+22.73
Stiff to very stiff silty CLAY.	2.15 (0.15)	+22.15
Medium dense to dense silty SAND.	2.30 (0.74)	+22.00
End of CPT	3.04	+21.26

Detail

Legend

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-22A

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

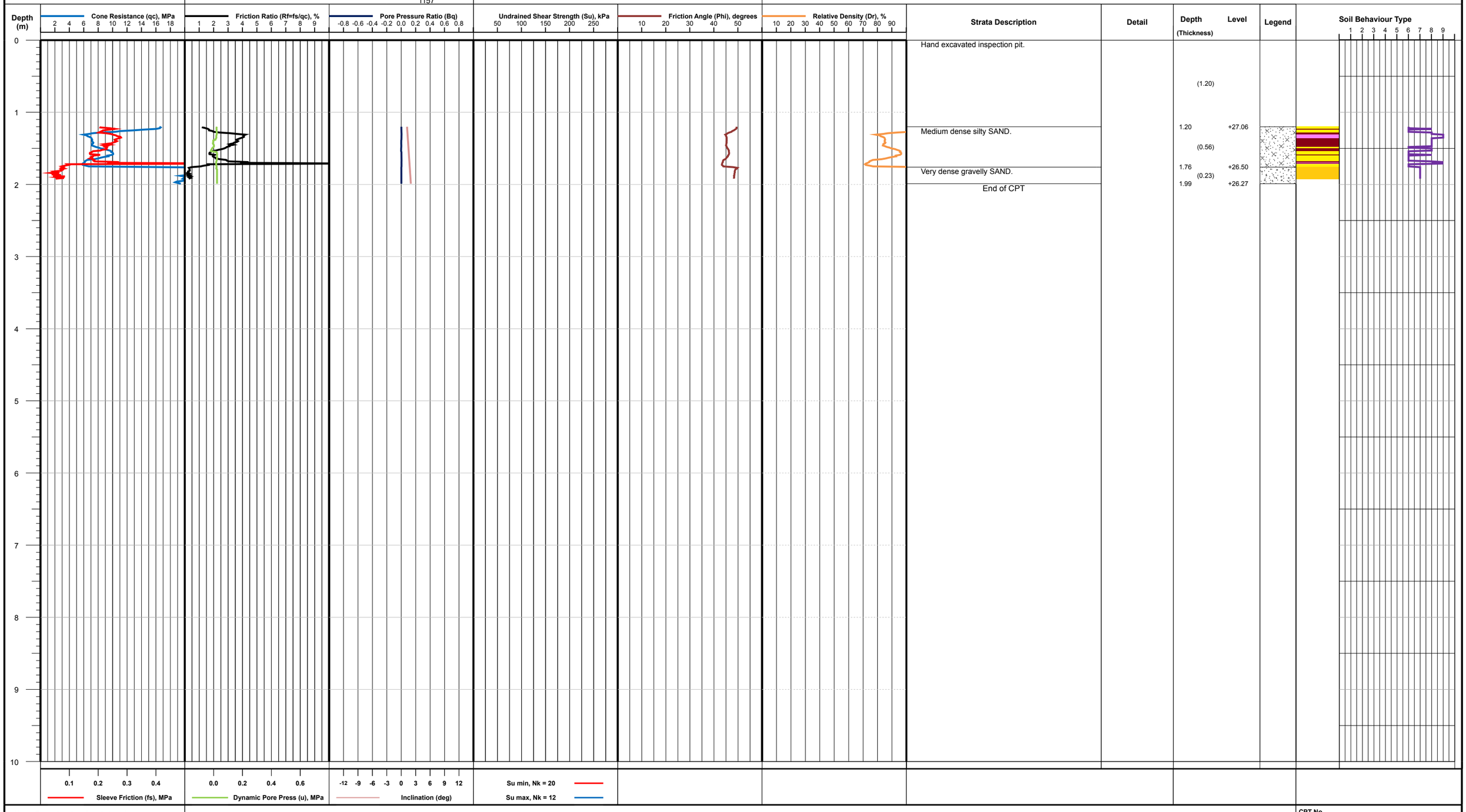
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	28.26 mOD
Co-ordinates (m)	E 425644.84
National Grid	N 558345.50

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense silty SAND.	1.20	+27.06
	(0.56)	
Very dense gravelly SAND.	1.76	+26.50
	(0.23)	
End of CPT	1.99	+26.27

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-23

Cone Penetration Test Log

SOCOTEC

Date	12/04/2018
Cone ID	S10-CFIP.361
Operator	DT/JG
Checked	JMH
Approved	PH

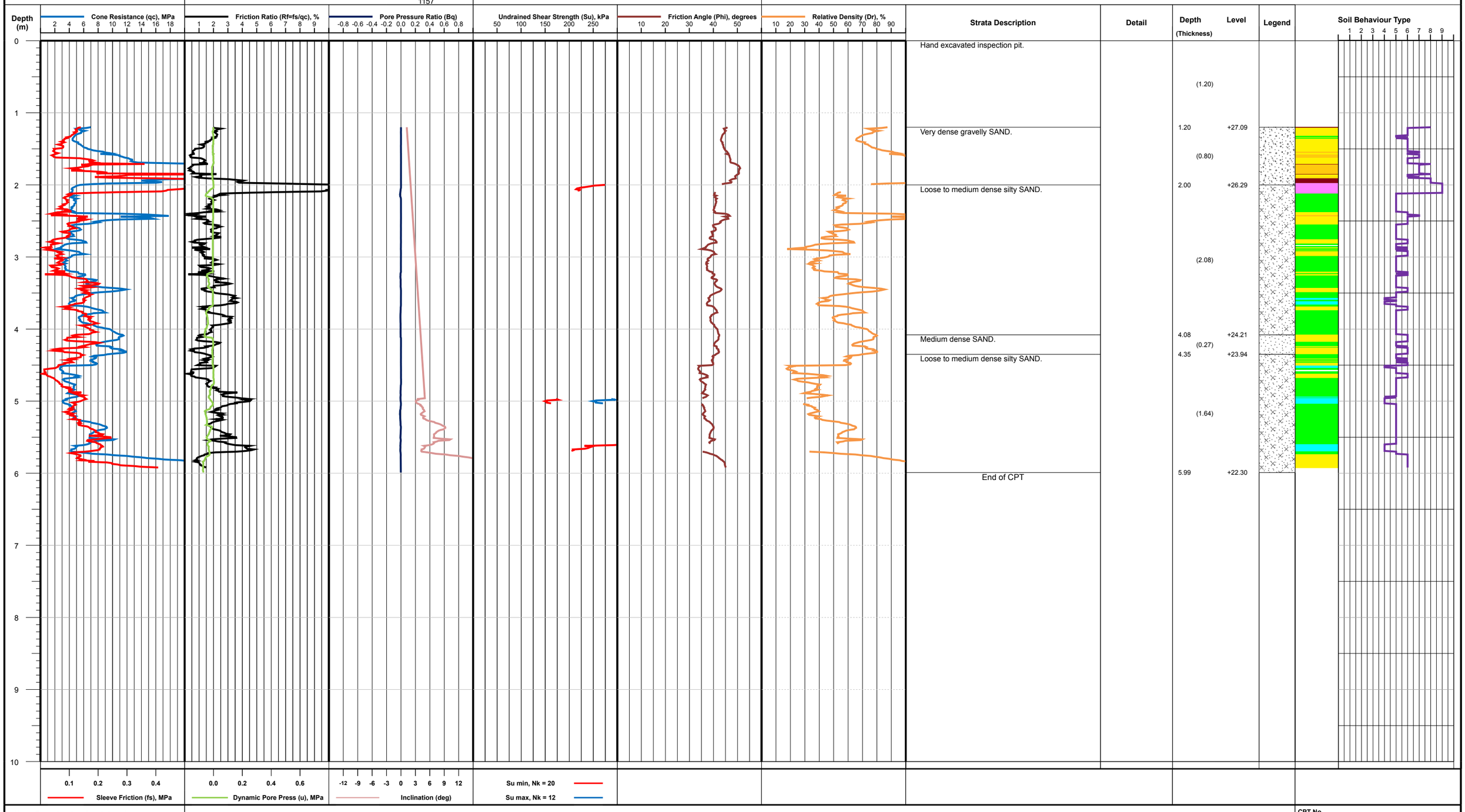
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	28.29 mOD
Co-ordinates (m)	E 425643.89
National Grid	N 558345.19

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Very dense gravelly SAND.	1.20	+27.09
	(0.80)	
Loose to medium dense silty SAND.	2.00	+26.29
	(2.08)	
Medium dense SAND.	4.08	+24.21
	(0.27)	
Loose to medium dense silty SAND.	4.35	+23.94
	(1.64)	
End of CPT	5.99	+22.30

Soil Behaviour Type

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-23A

Cone Penetration Test Log

SOCOTEC

Date	11/04/2018
Cone ID	S10CFIP.361
Operator	DT
Checked	JMH
Approved	PH

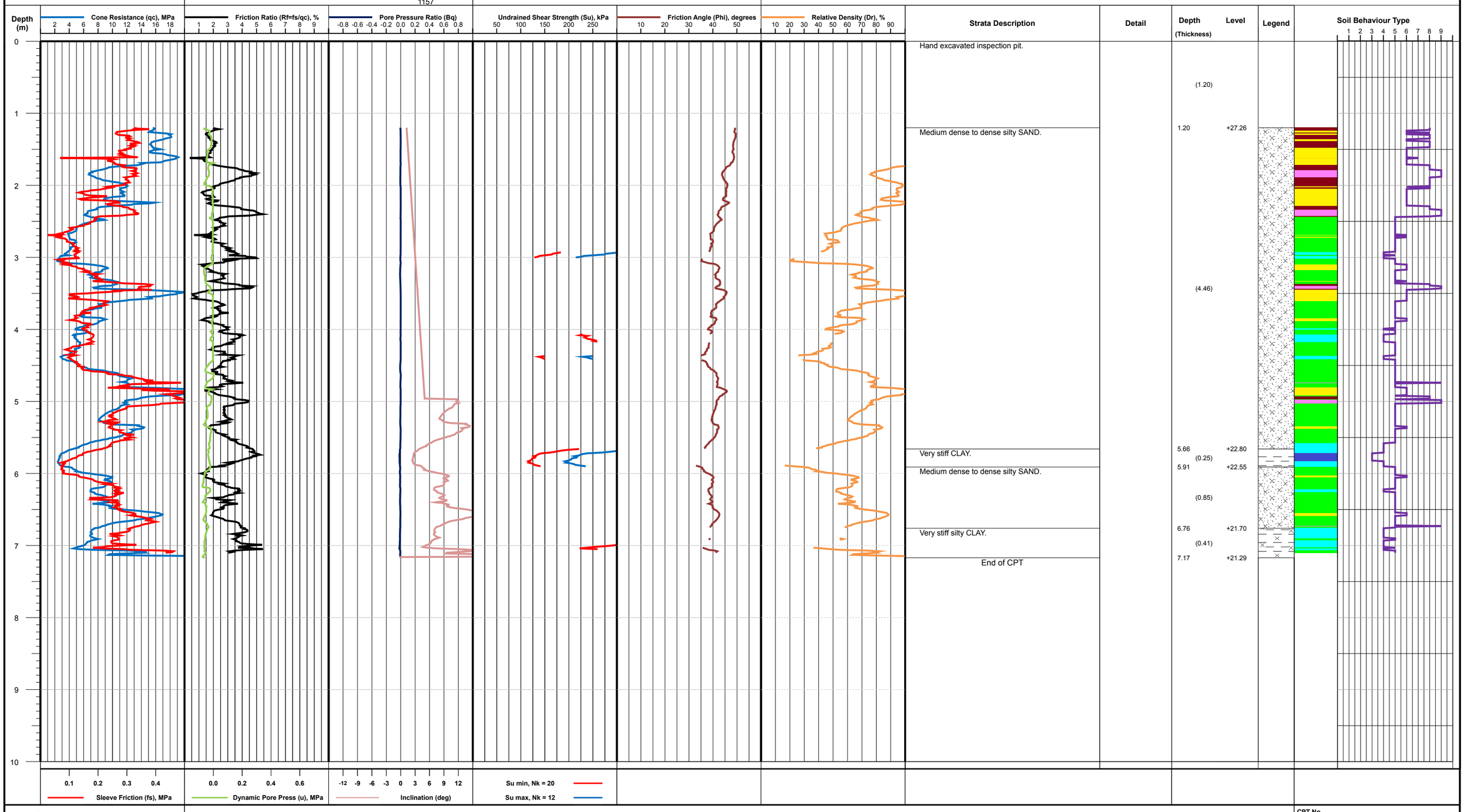
Equipment and Methods
Test according to BS 1377 : Part 9 : Method 3.1

UKAS TESTING 1157

Ground level	28.46 mOD
Co-ordinates (m)	E 425667.73
National Grid	N 558326.98

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense to dense silty SAND.	1.20	+27.26
	(4.46)	
Very stiff CLAY.	5.66	+22.80
	(0.25)	
Medium dense to dense silty SAND.	5.91	+22.55
	(0.85)	
Very stiff silty CLAY.	6.76	+21.70
	(0.41)	
End of CPT	7.17	+21.29

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-24

Cone Penetration Test Log

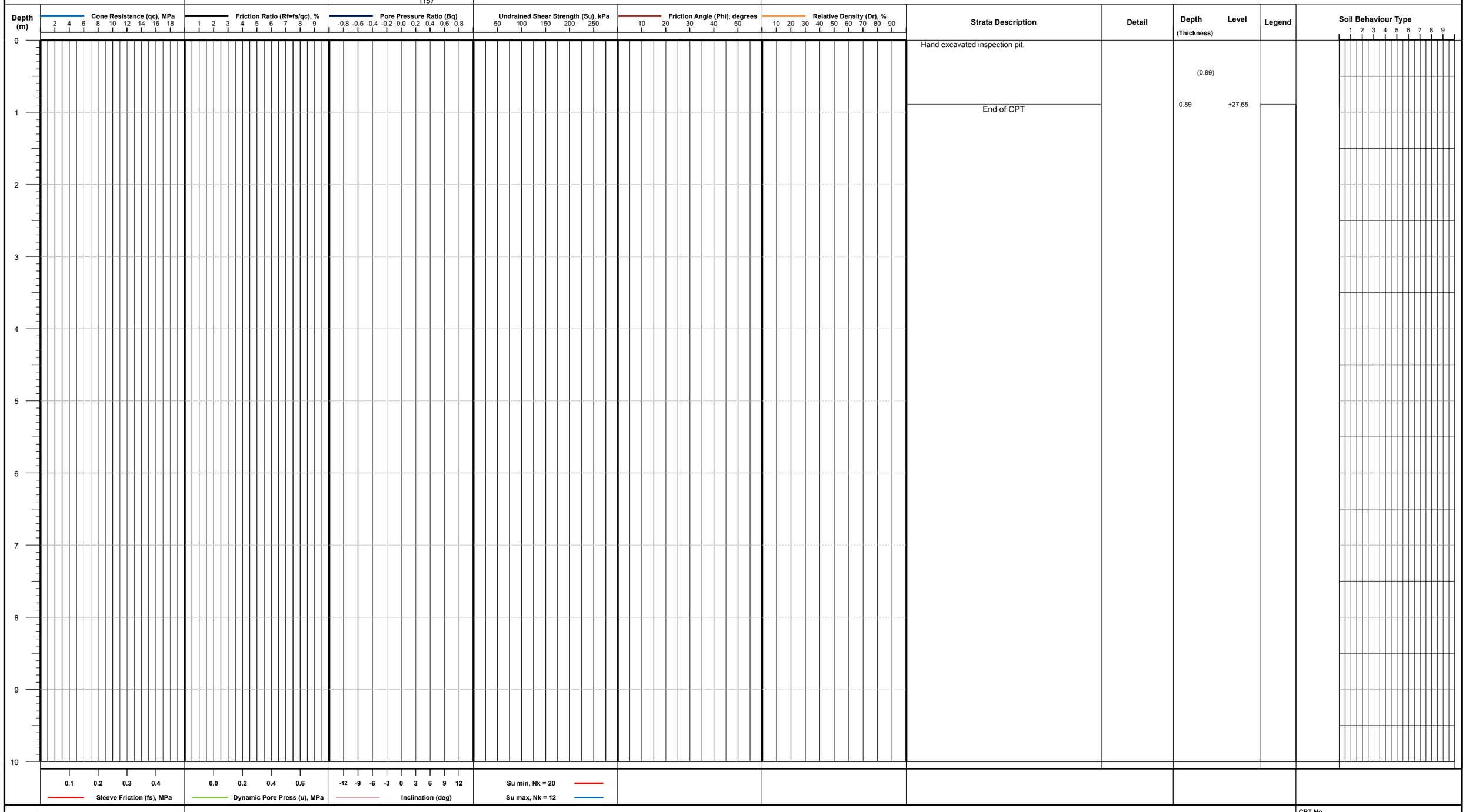
SOCOTEC

Date	11/04/2018	**Equipment and Methods**		**Ground level**	28.54 mOD
Cone ID	S10CFIP.361	Test according to BS 1377 : Part 9 : Method 3.1		**Co-ordinates (m)**	E 425667.03
Operator	DT			**National Grid**	N 558327.70
Checked	JMH				
Approved	PH				

UKAS TESTING 1157

Remarks Terminated due to obstruction

Assumed Groundwater Level (m) 5.00



Strata Description	Detail	Depth (Thickness)	Level	Legend
Hand excavated inspection pit.		(0.89)		
End of CPT		0.89	+27.65	

Soil Behaviour Type

1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

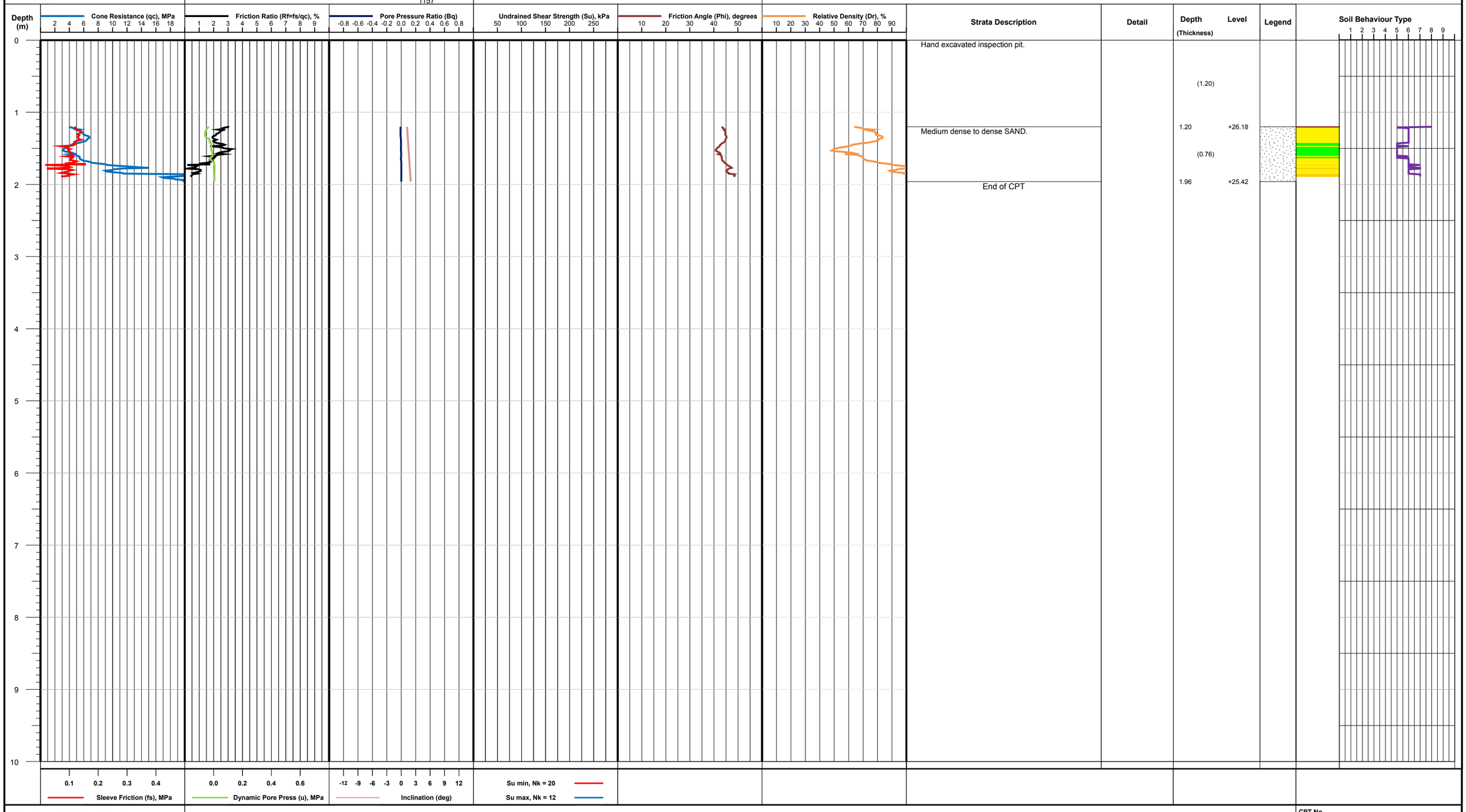
CPT No.

CPT17-24A

Cone Penetration Test Log

SOCOTEC

Date	12/04/2018	**Equipment and Methods**		**Ground level**	27.38 mOD
Cone ID	S10-CFIP.361	Test according to BS 1377 : Part 9 : Method 3.1		**Co-ordinates (m)**	E 425698.64
Operator	DT/JG	UKAS TESTING 1157		**National Grid**	N 558296.56
Checked	JMH			**Remarks**	Terminated due to obstruction
Approved	PH			**Assumed Groundwater Level (m)**	5.00



Strata Description	Depth (Thickness)	Level
Hand excavated inspection pit.	(1.20)	
Medium dense to dense SAND.	1.20	+26.18
	(0.76)	
End of CPT	1.96	+25.42

Soil Behaviour Type
1 2 3 4 5 6 7 8 9

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

AGS

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

CPT No.

CPT17-25

APPENDIX C

Dissipation Test Results

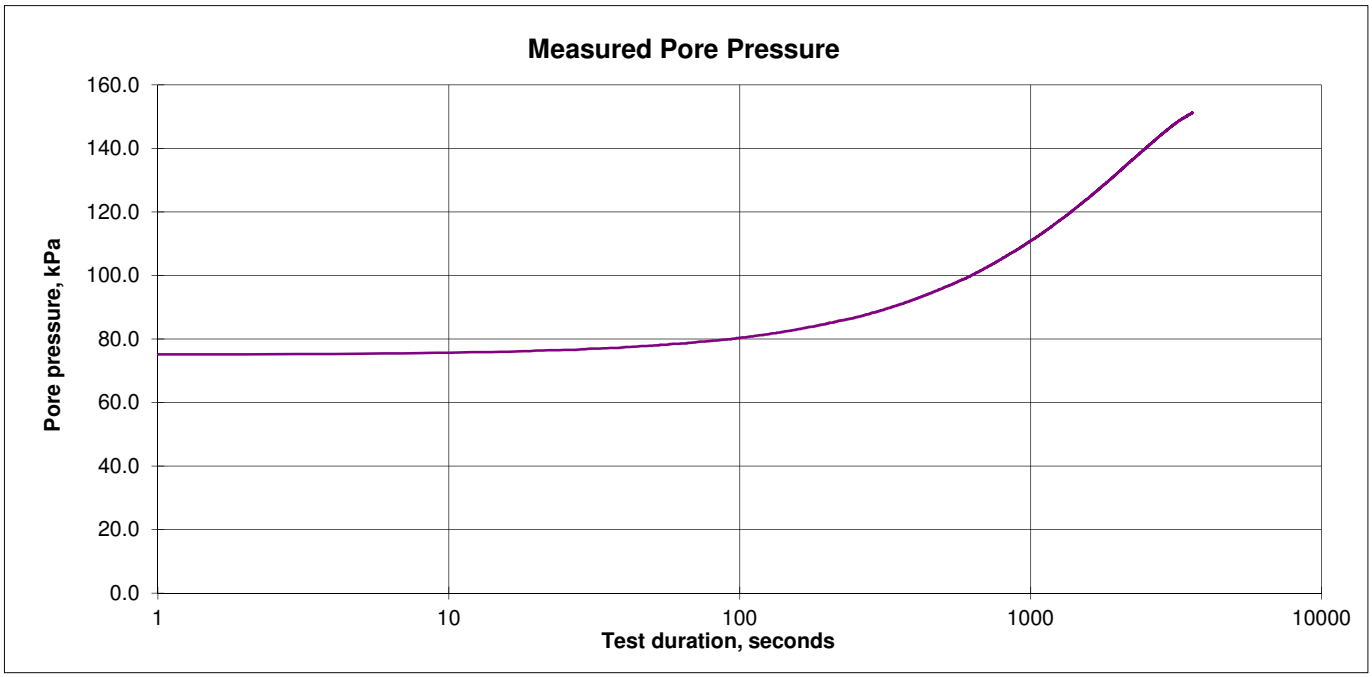
Sheet 1 to 2

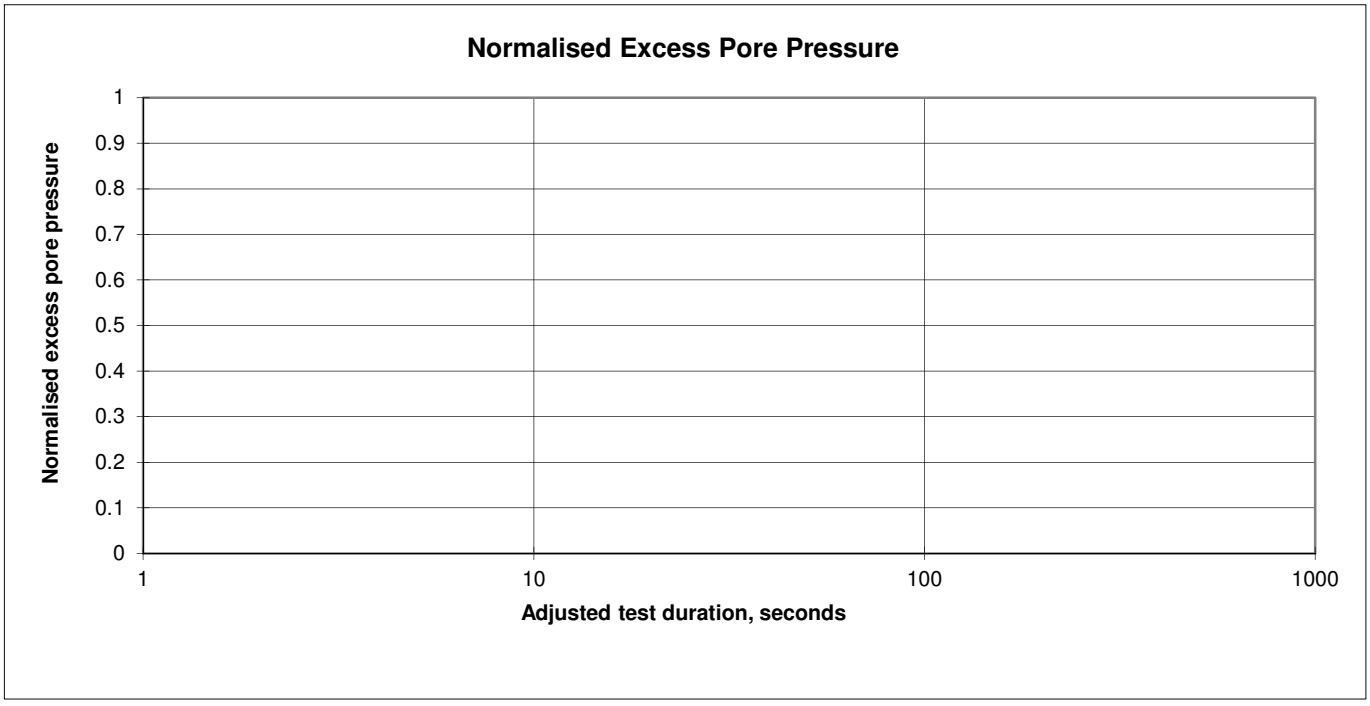
(See Table 2)

Dissipation Test Results

Cone Ref	S10-CFIP.361
PWP filter location	u2

CPT No	CPT16
Depth, m	15.01





Conditions used for analysis:

Initial pore water pressure, u_i	n/a kPa	(Peak pore pressure during test)
Equilibrium pore water pressure, u_0	n/a kPa	(Nominal value)
Equivalent groundwater level	n/a m bgl	

Porewater pressure rising during test period.
Data unsuitable for interpretation.

Notes: Interpretation of dissipation tests is not covered by the SOCOTEC UK UKAS accreditation

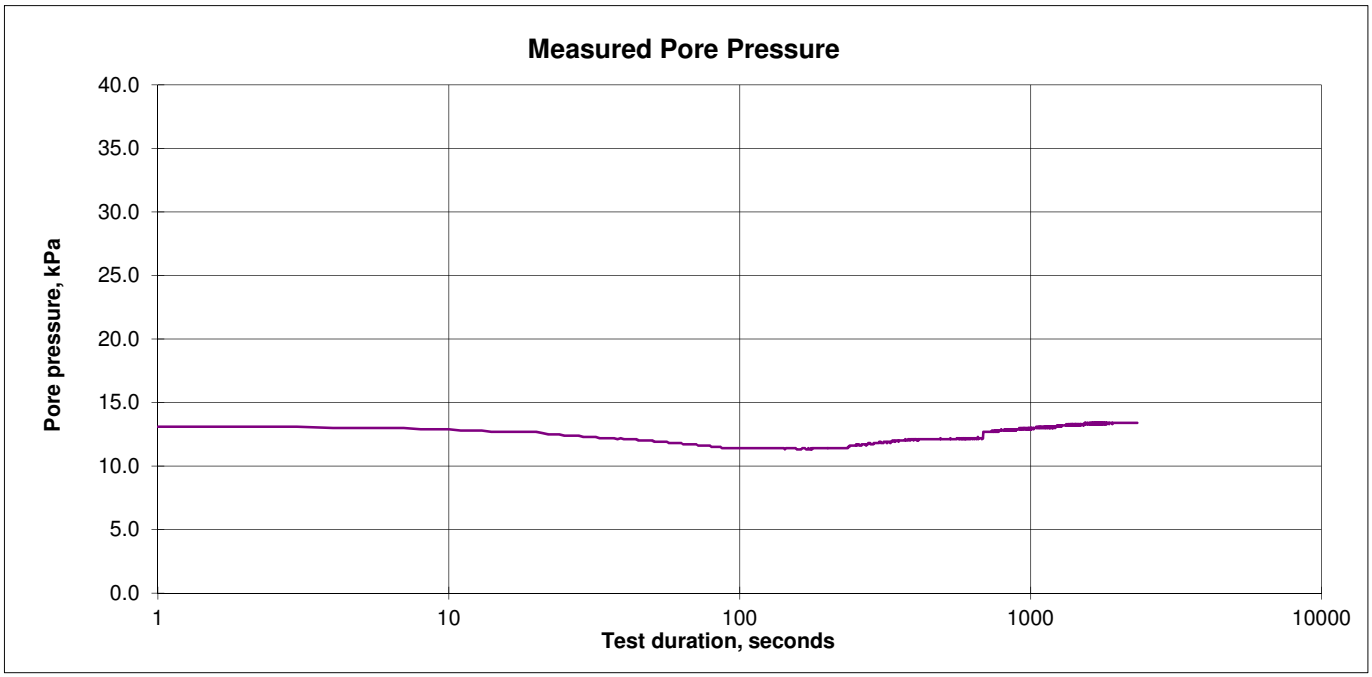
Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

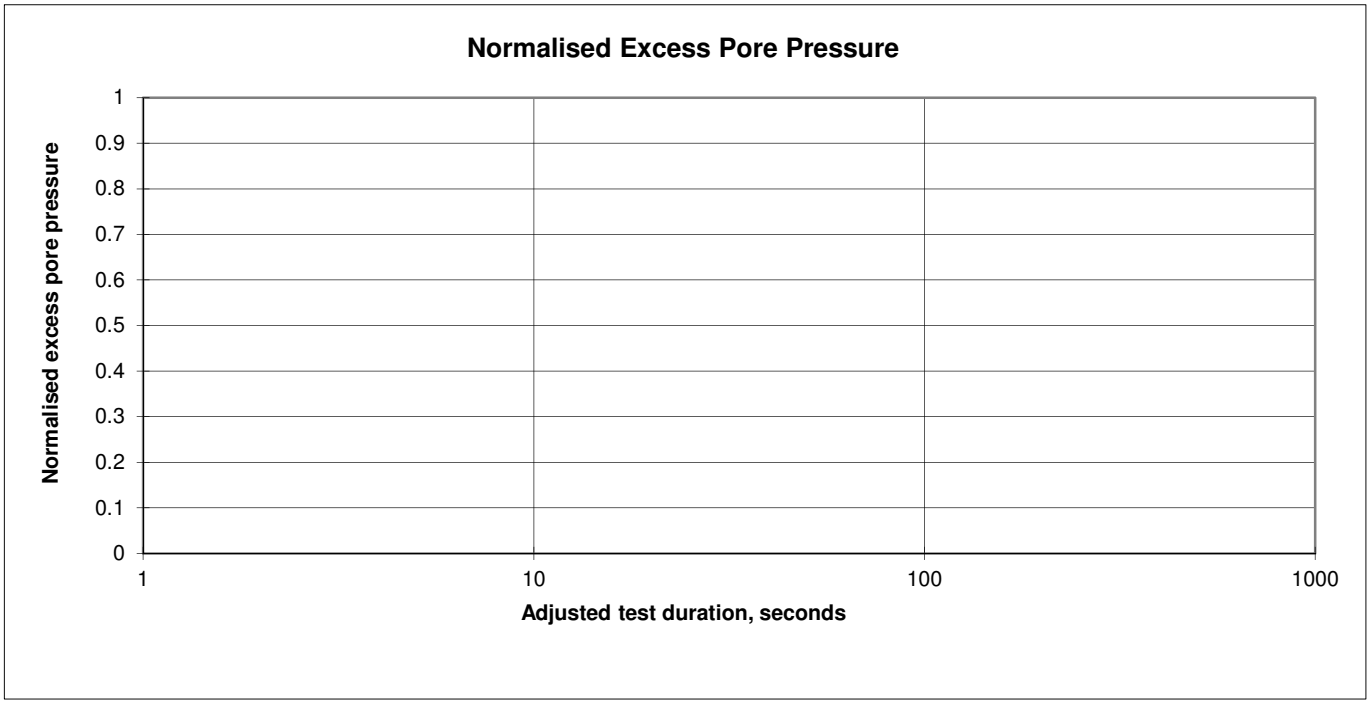
Figure
CPT16 D01

Dissipation Test Results

Cone Ref	S10-CFIP.361
PWP filter location	u2

CPT No	CPT20A
Depth, m	20.55





Conditions used for analysis:

Initial pore water pressure, u_i	n/a kPa	(Peak pore pressure during test)
Equilibrium pore water pressure, u_0	n/a kPa	(Nominal value)
Equivalent groundwater level	n/a m bgl	

Insufficient porewater pressure response during test period.
Data unsuitable for interpretation.

Notes: Interpretation of dissipation tests is not covered by the SOCOTEC UK UKAS accreditation

Project	A1 BIRTLEY TO COAL HOUSE CPT
Project No.	M8012-18
Carried out for	Central Alliance Limited

Figure
CPT20A D01

APPENDIX D
DOWNHOLE GEOPHYSICAL TESTING

REPORT ON THE

GEOPHYSICAL LOGGING

OF

TWO BOREHOLES

FOR THE

A1 B2CH PROJECT

JCTN 65 -67

Prepared For:

CENTRAL ALLIANCE
EXPLORE > IDENTIFY > DELIVER

Central Alliance, Alliance House,
South Park Way,
Wakefield 41 Business Park
Wakefield
WF2 0XJ

DEC 2017/CENT1702_ rpt/NZ25

European Geophysical Services Ltd
eurogeophys@europeangeophysical.com
www.europeangeophysical.com

CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

[illegible]

[illegible]

[illegible]

BH17-19

Log / Tool	From (m)	To (m)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

BH17-20

Log / Tool	From (m)	To (m)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

[illegible]

[illegible]

Full Wave Sonic (FWS)

[illegible]

[illegible]

Formation Density (Db)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Acoustic Borehole Imager (Amplitude and Travel Time)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

3.0 SITE DETAILS

Site: B2CH – A1 Jn 65-67 **OS Grid Ref: NZ 25453 58396**

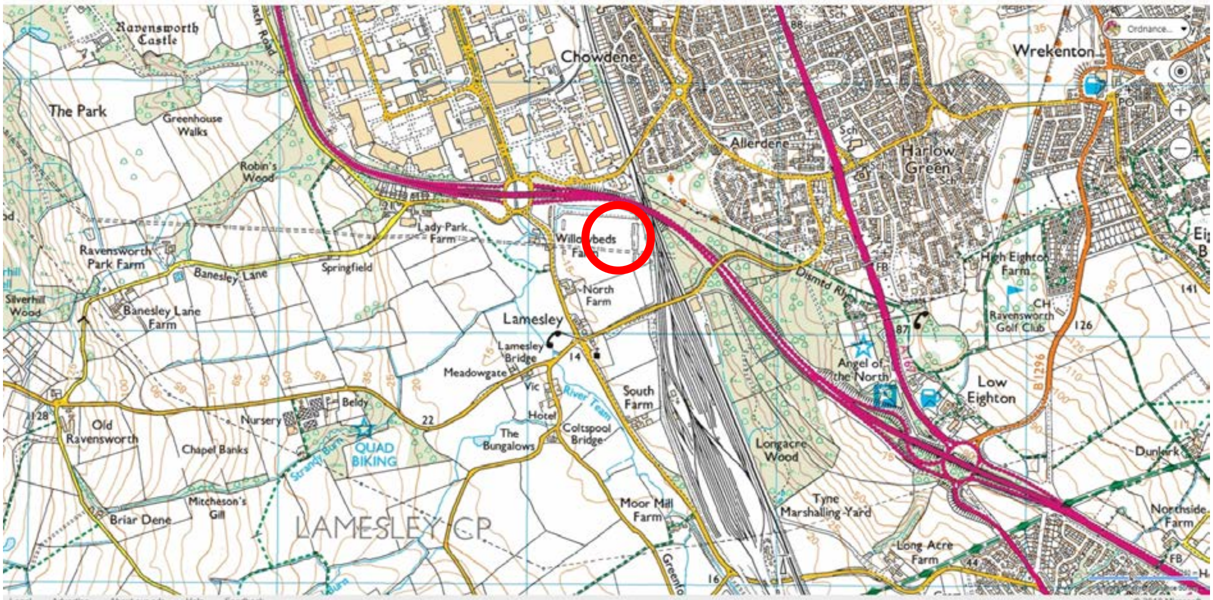


Figure 3.1 [illegible]

Figure 3.2 [illegible]

4.0 PROCESSING AND PRESENTATION OF IMAGER RESULTS

4.0 PROCESSING AND PRESENTATION OF IMAGER RESULTS cont.

Taking into account the accuracies of the manufacturer's transducers and dependent upon tool centralisation, borehole rugosity, borehole eccentricity and picking techniques etc the overall accuracy of the technique is estimated at +/- 5 degrees for azimuth and +/- 2 degrees for dip.

5.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access restrictions**

  [illegible]

- **Tool access restrictions**

  [illegible]

- **Borehole conditions / risk to equipment**

  [illegible]

- **Lack of fluid filled column / cloudy fluid**

  [illegible]

- **Time constraint**

  [illegible]

- **Borehole construction / casing**

Appendix 1

Discontinuity Classification.

Discontinuity	Colour	Classification Parameters
M[illegible]	[illegible]	[illegible] **continuous** [illegible]
M[illegible]	[illegible]	[illegible] **continuous or discontinuous** [illegible]
[illegible]	[illegible]	[illegible] **continuous or discontinuous** [illegible]
[illegible]	R[illegible]d[illegible]	D[illegible] **continuous or discontinuous** [illegible]
[illegible]	[illegible]	[illegible] **continuous** [illegible]
[illegible]	[illegible]	[illegible] **can not** [illegible]

Appendix 2

Geophysical Logs

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-19**

Log Type: ***Composite***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425457.61E 558442.56N** Elevation: **19.75m**

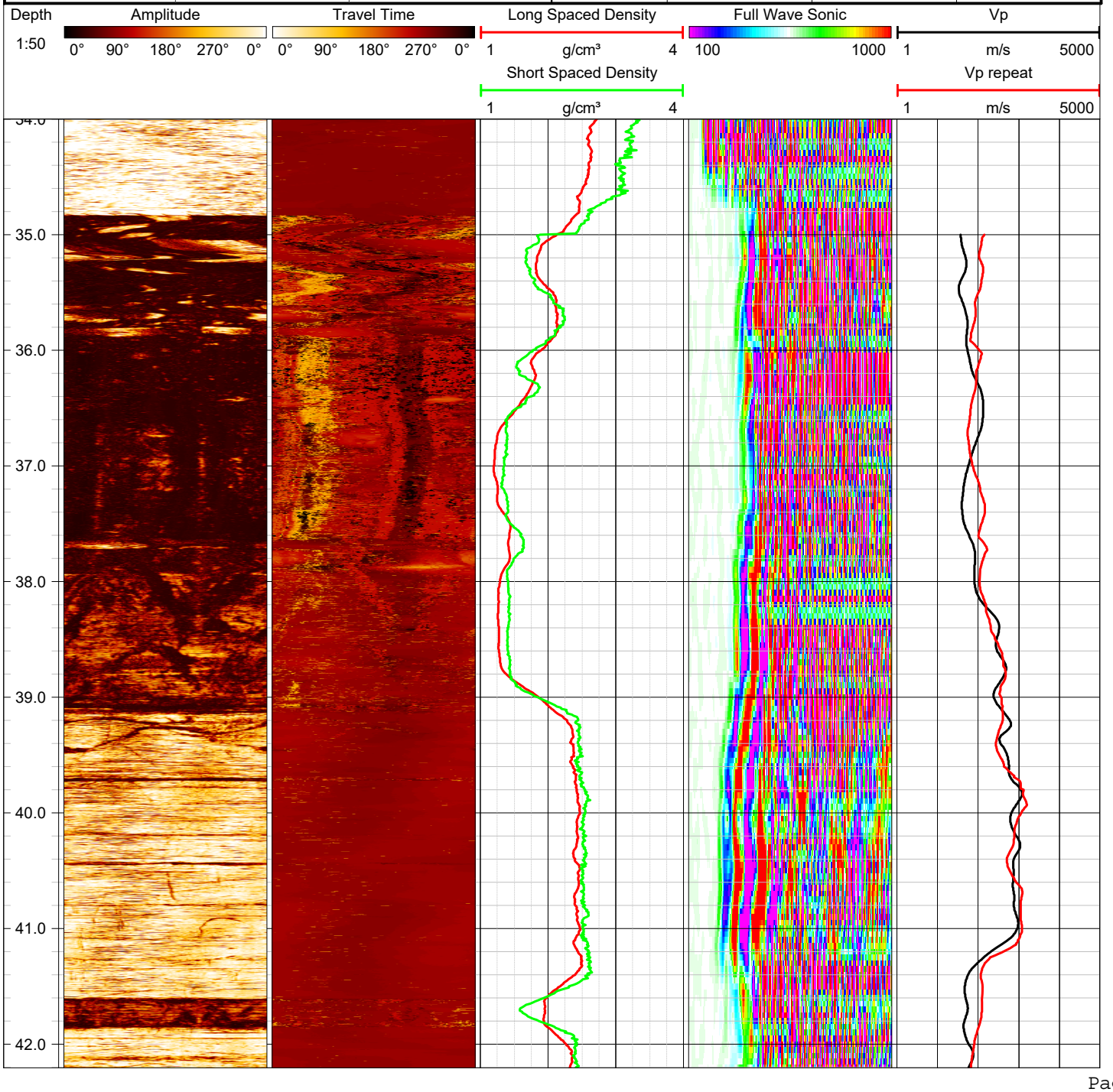
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**62.4**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**34.8 - 62.4**		
Fluid Level: (m)	**26.1**	**Ref:**	

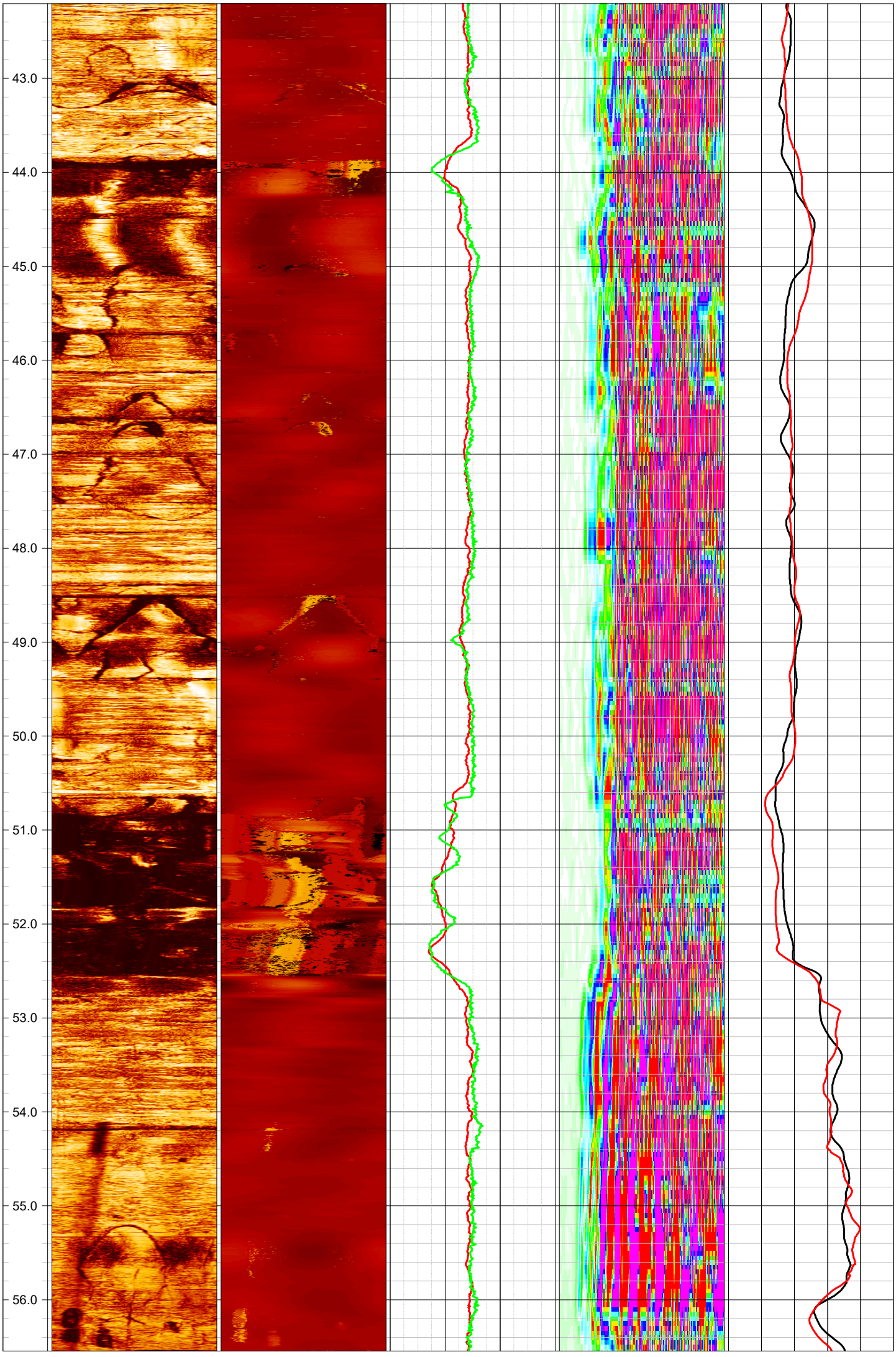
BOREHOLE RECORD

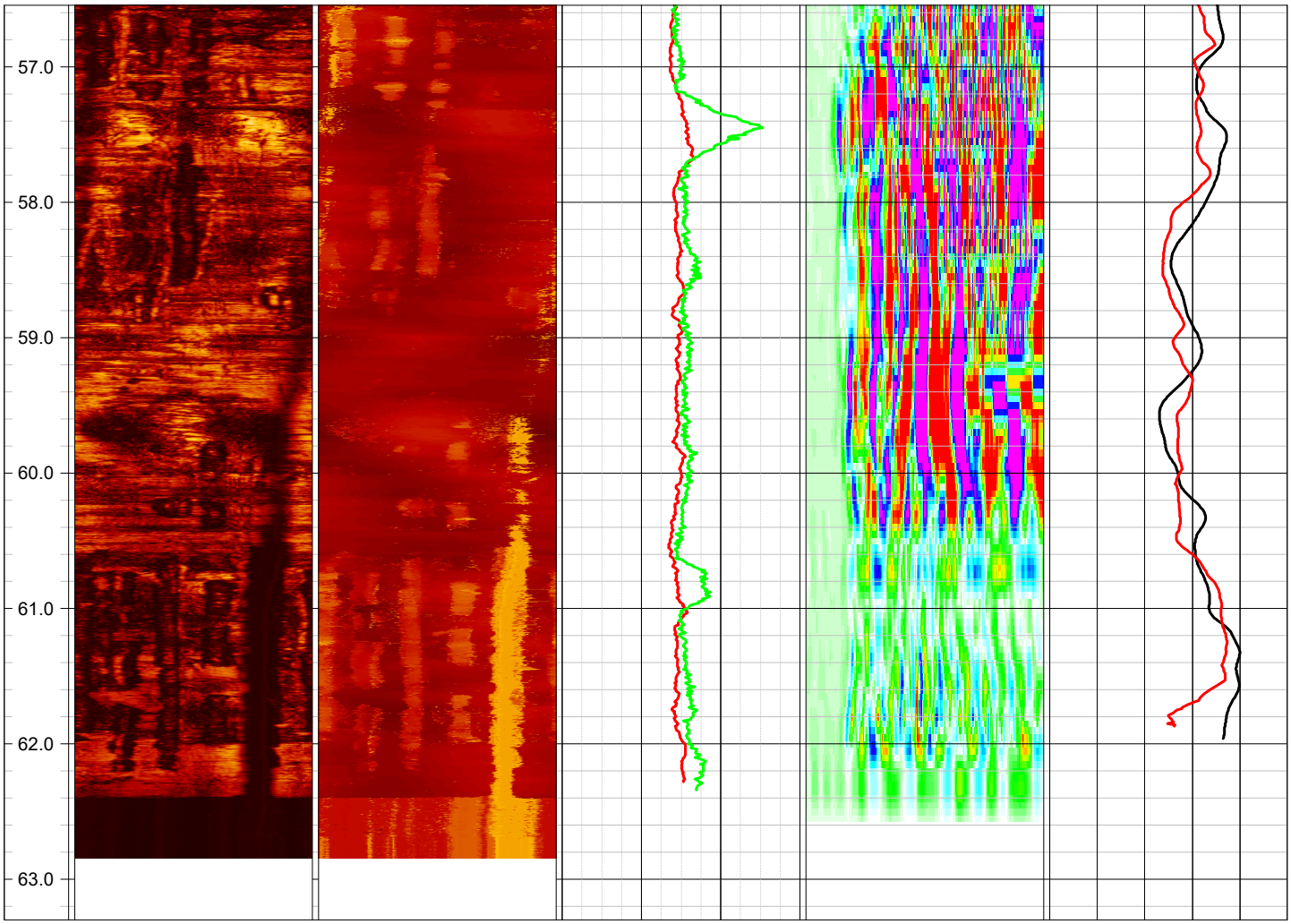
Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**-0.2**	**34.8**




43.0
44.0
45.0
46.0
47.0
48.0
49.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0


57.0
58.0
59.0
60.0
61.0
62.0
63.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-19**

Log Type: ***Image***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425457.61E 558442.56N** Elevation: **19.75m**

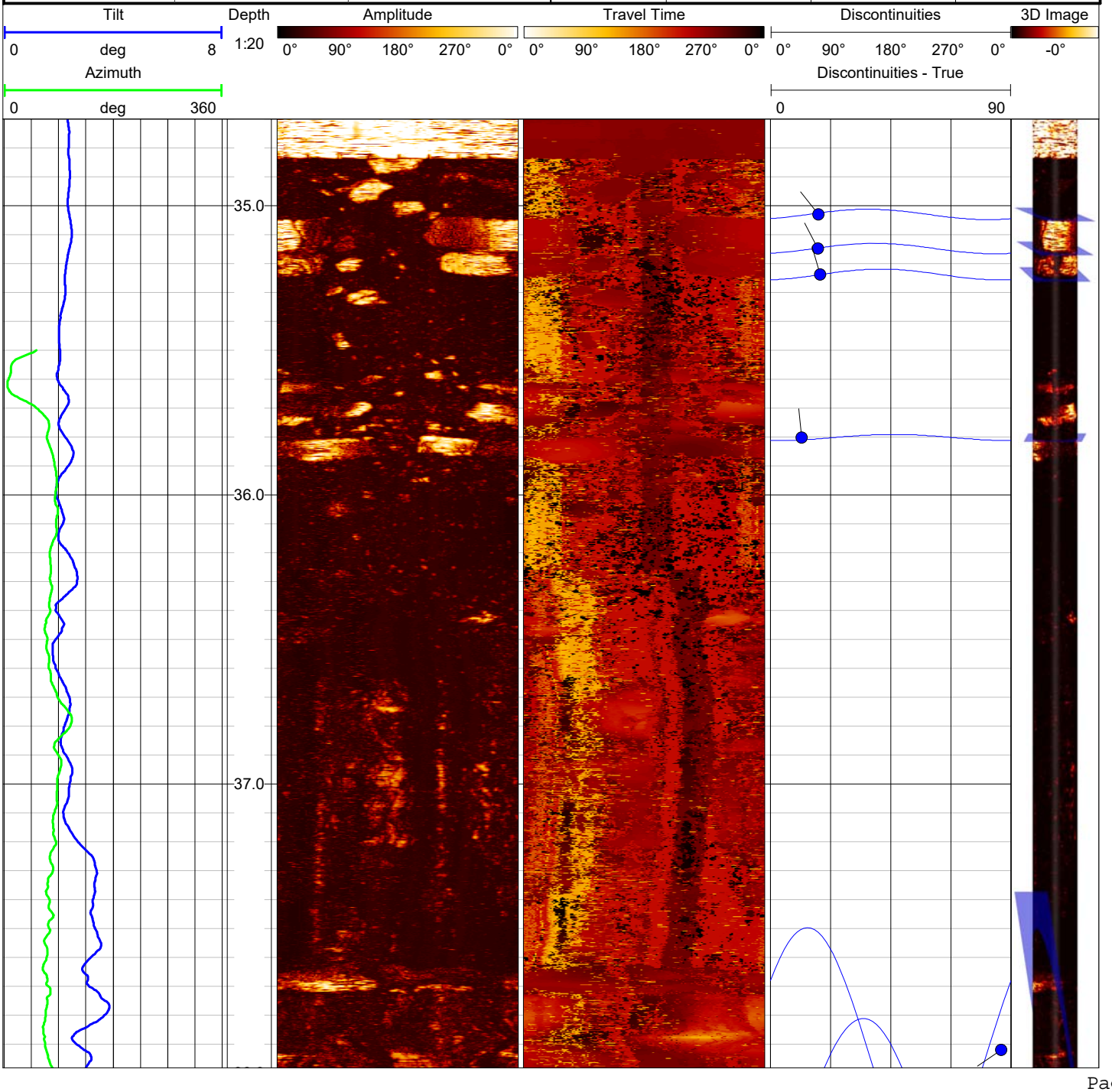
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**62.4**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**34.8 - 62.4**		
Fluid Level: (m)	**26.1**	**Ref:**	

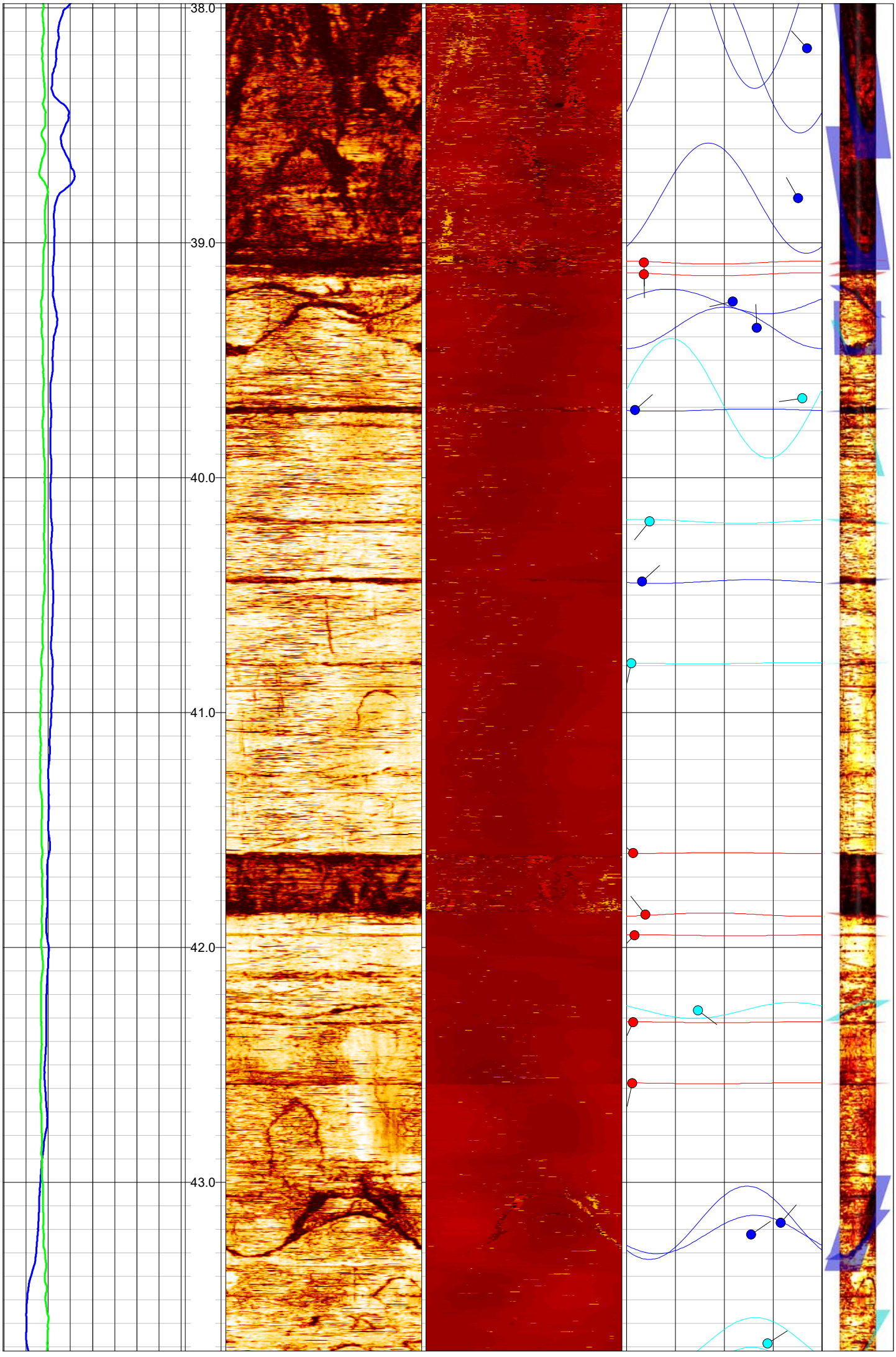
BOREHOLE RECORD

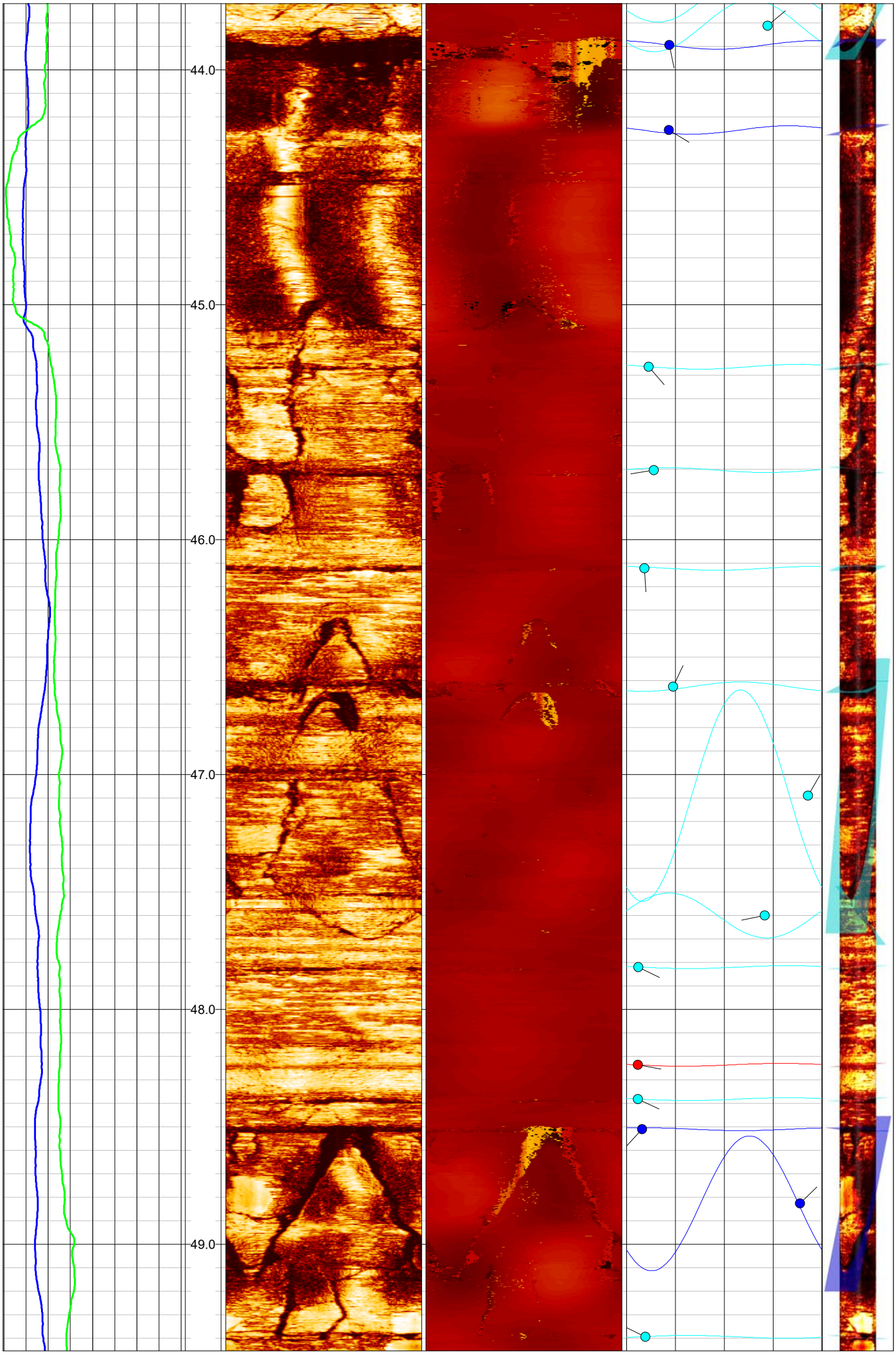
Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

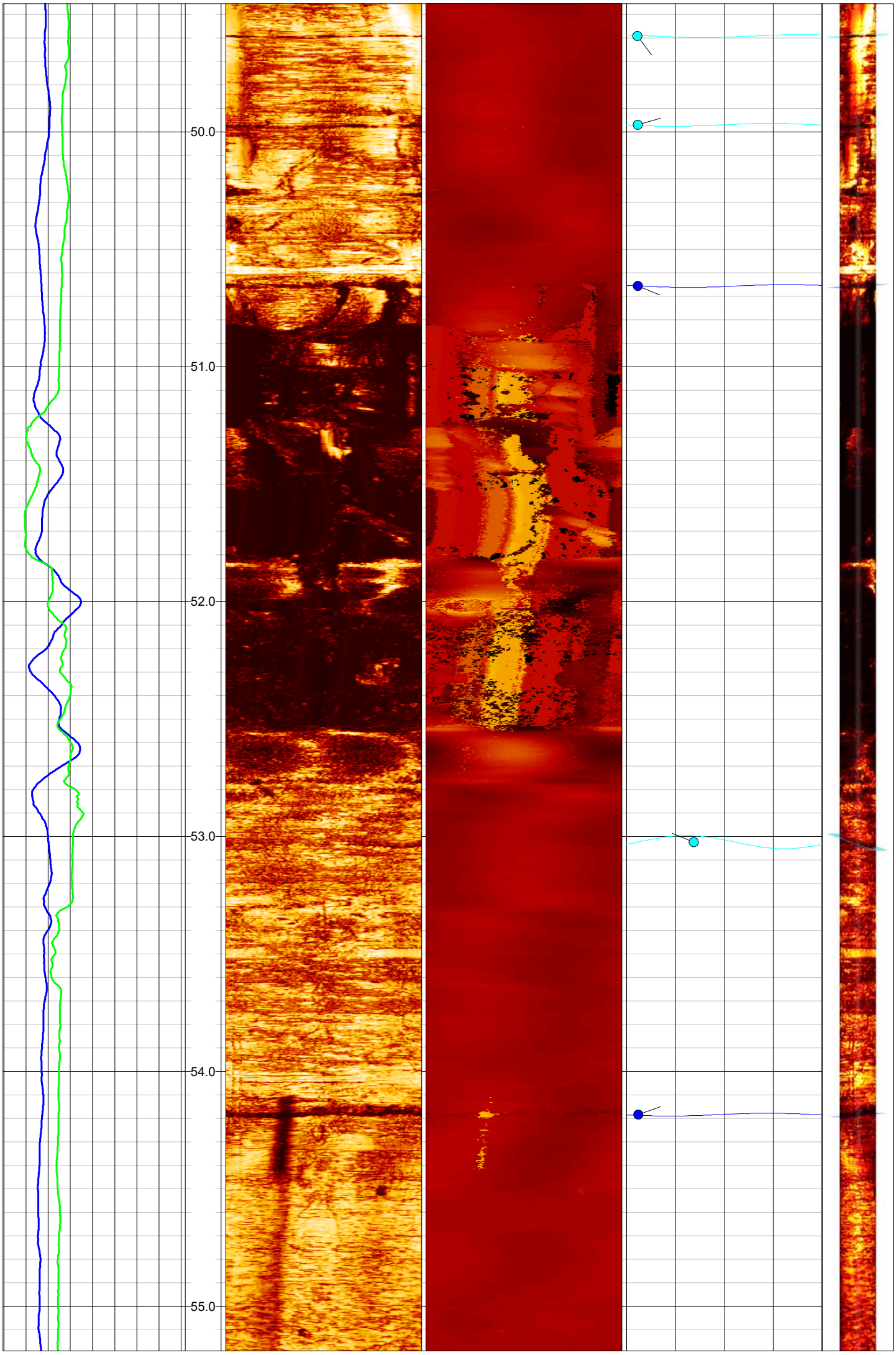
CASING RECORD

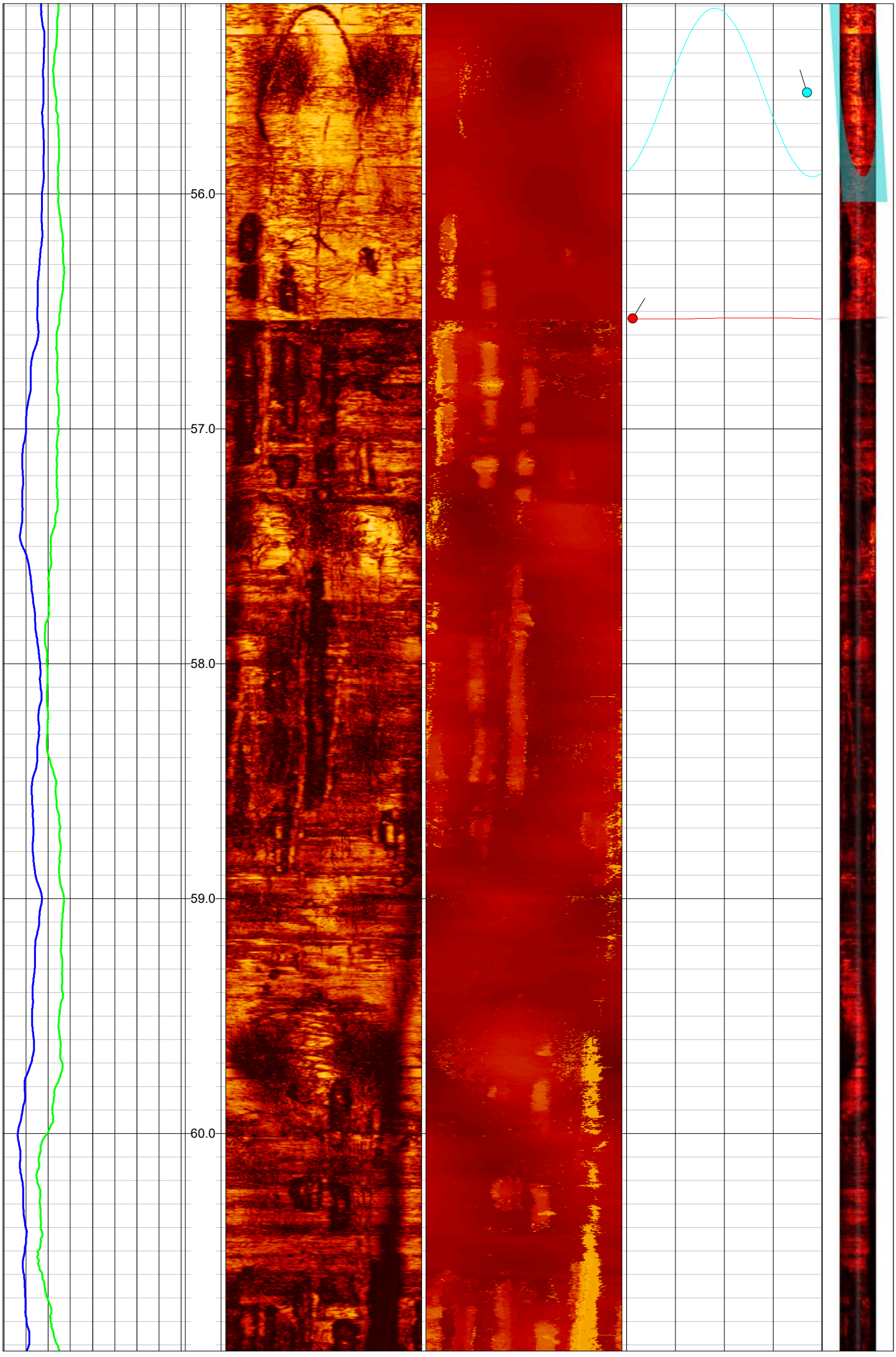
Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**-0.2**	**34.8**

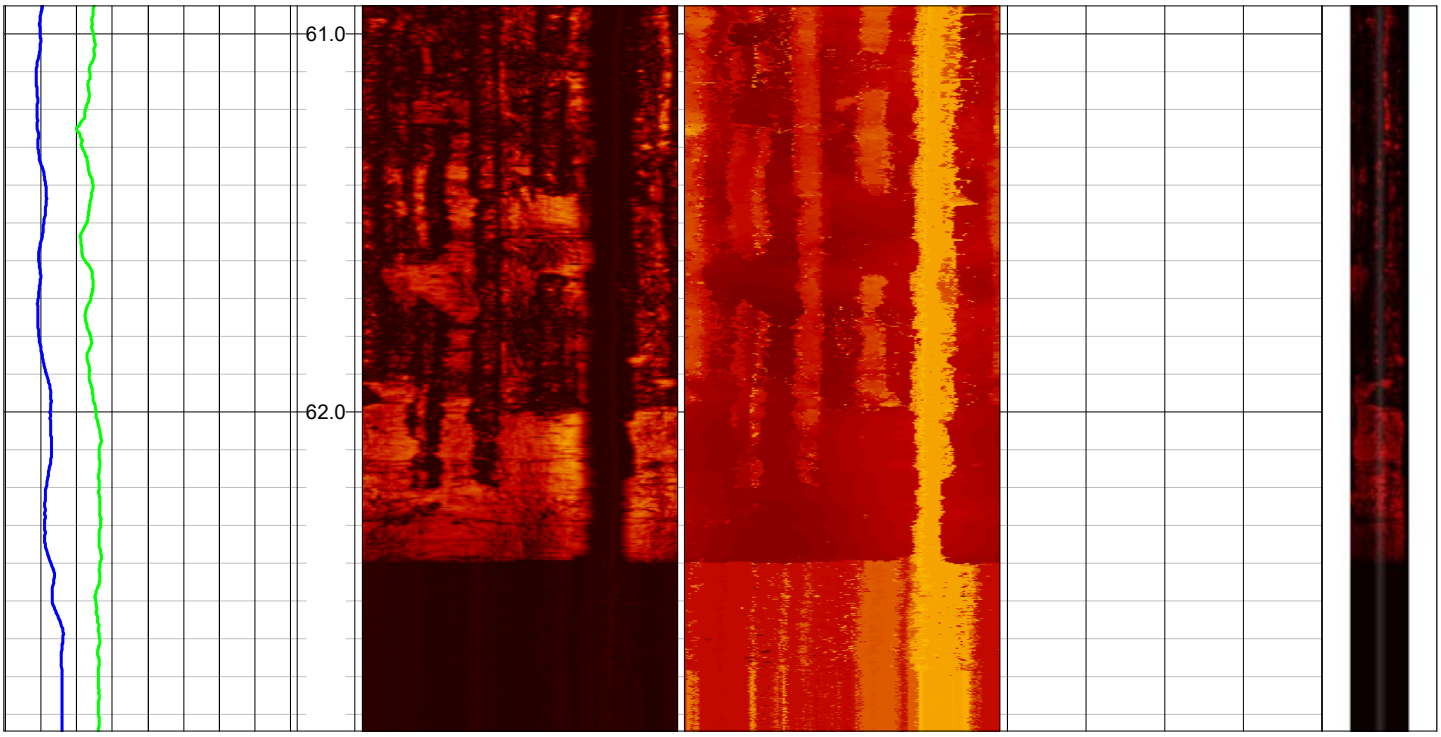



38.0
39.0
40.0
41.0
42.0
43.0


44.0
45.0
46.0
47.0
48.0
49.0


50.0
51.0
52.0
53.0
54.0
55.0


56.0
57.0
58.0
59.0
60.0


61.0
62.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-19**

Log Type: ***Stereonet***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425457.61E 558442.56N** Elevation: **19.75m**

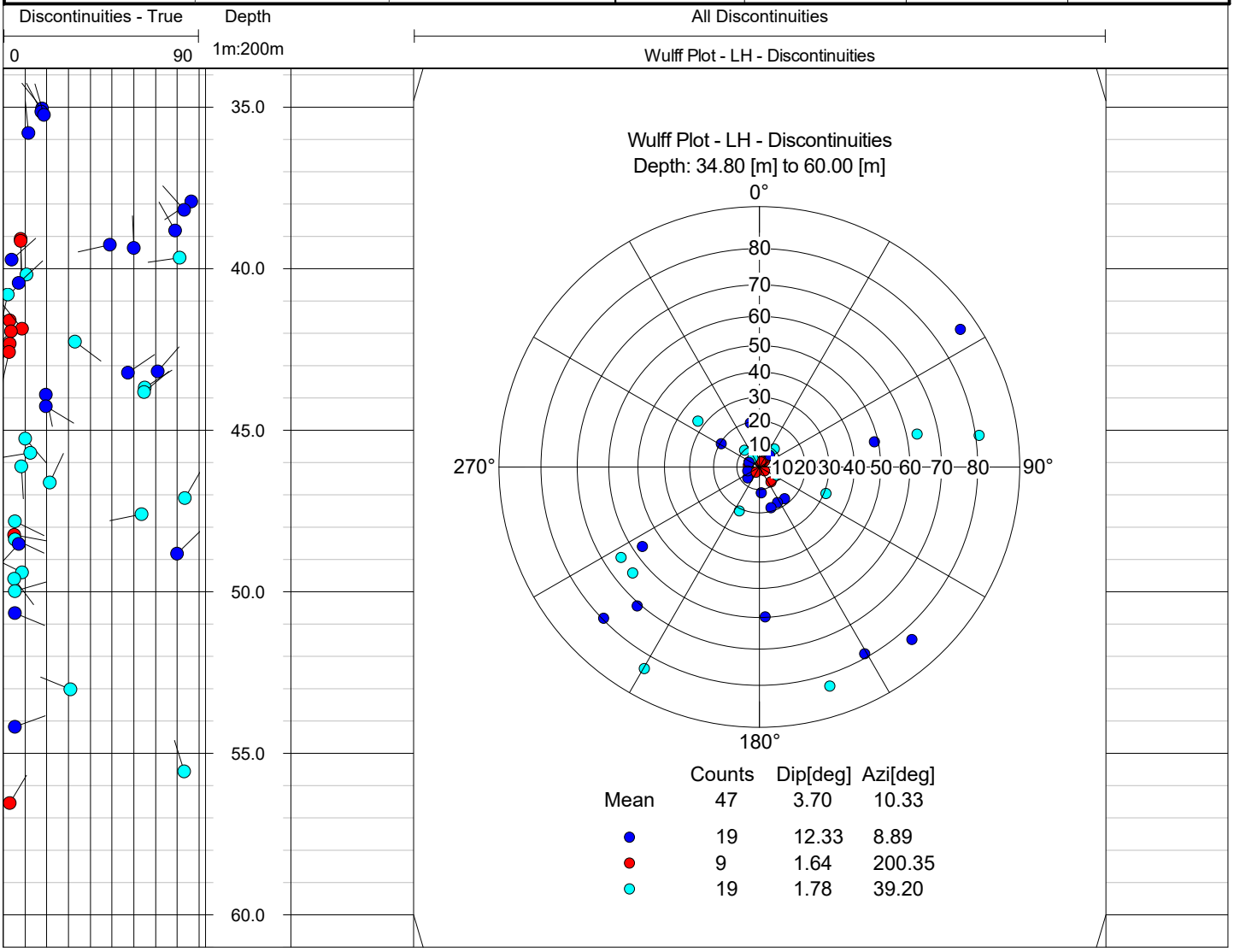
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**62.4**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**34.8 - 62.4**		
Fluid Level: (m)	**26.1**	**Ref:**	

BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**-0.2**	**34.8**



EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-20**

Log Type: ***Composite***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425462.87E 558418.32N** Elevation: **19.04m**

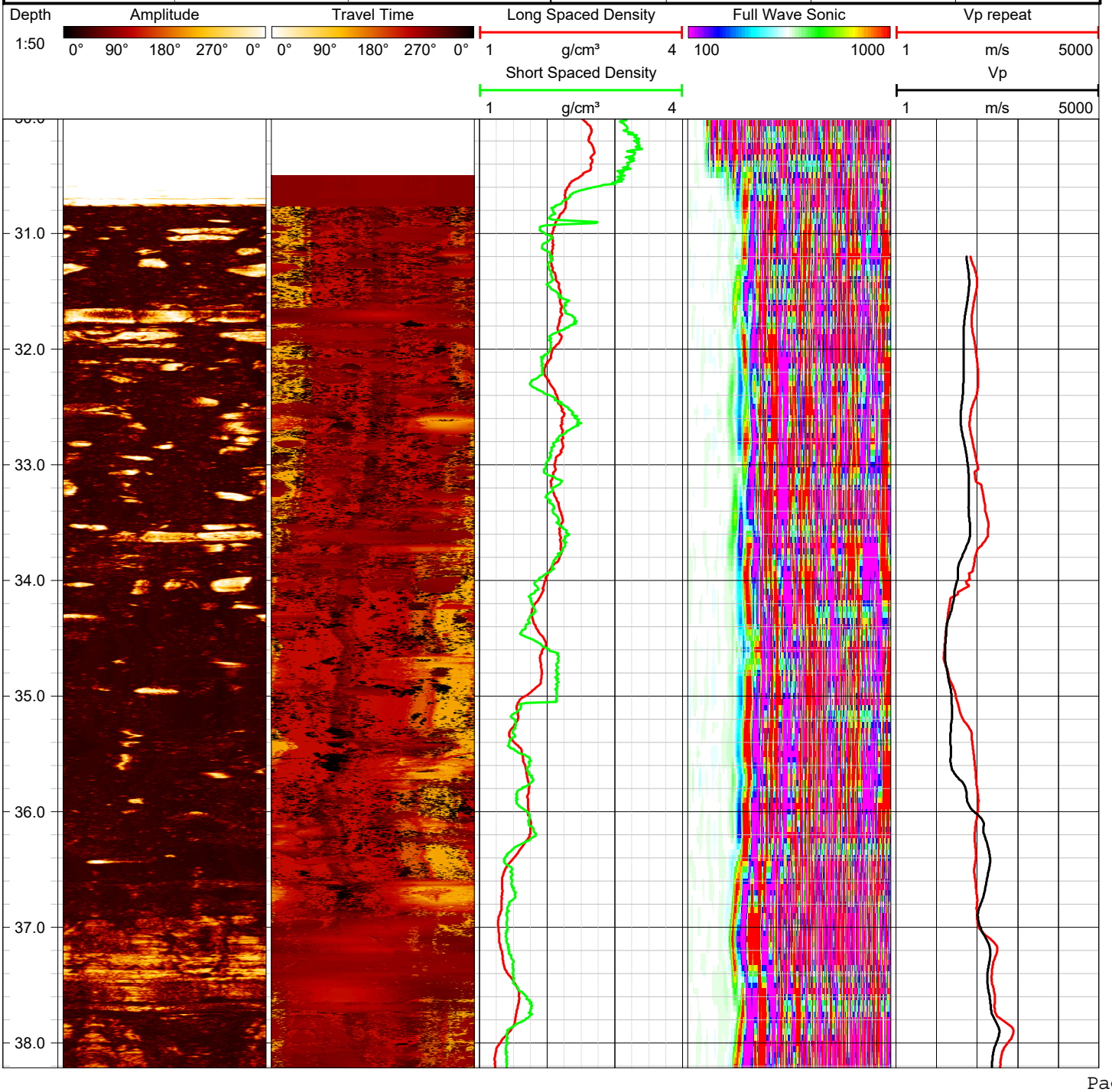
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**52.6**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**30.8 - 52.6**		
Fluid Level: (m)	**26.1**	**Ref:**	

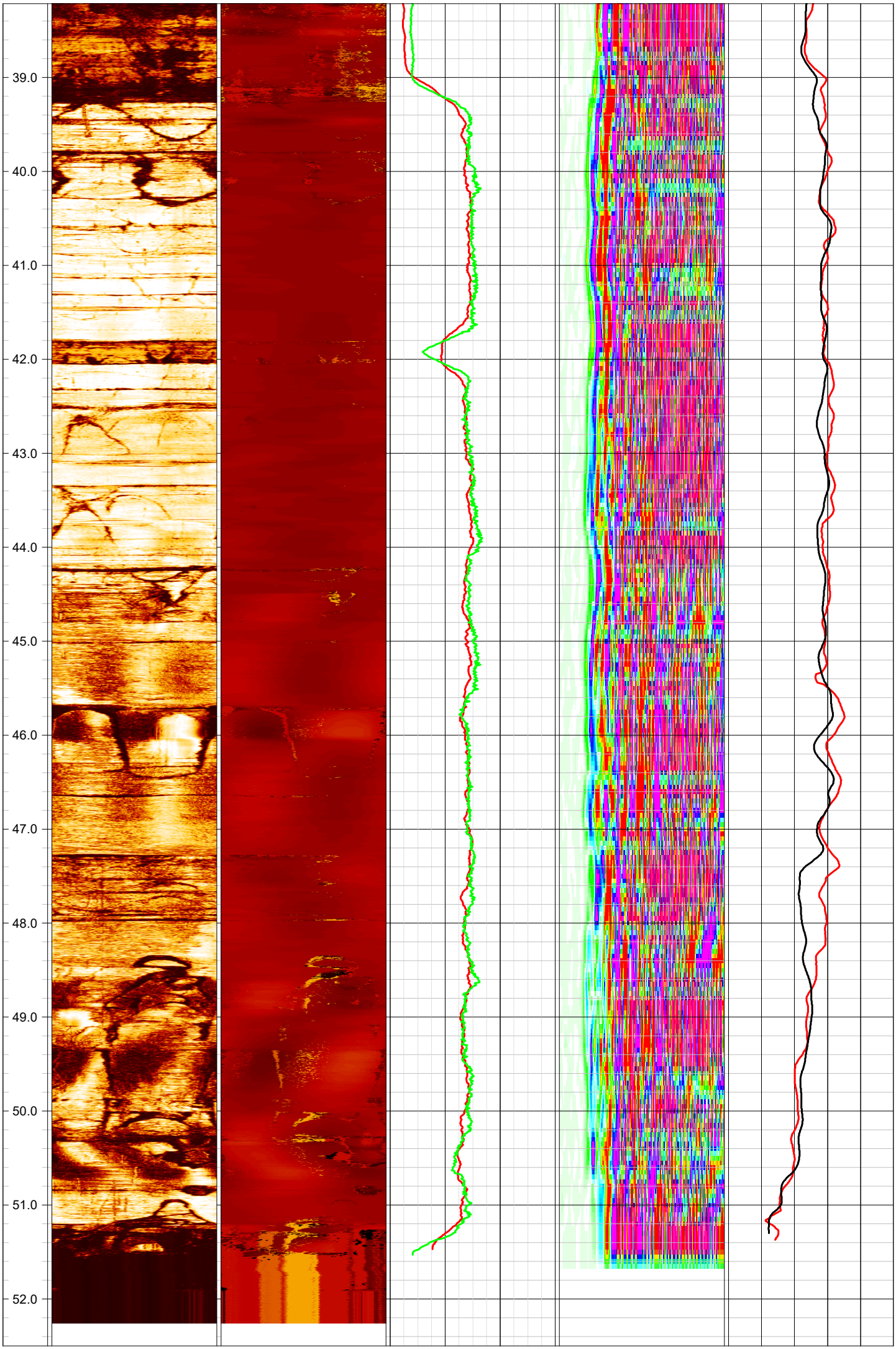
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**-0.2**	**30.8**




39.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0
48.0
49.0
50.0
51.0
52.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-20**

Log Type: ***Image***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425462.87E 558418.32N** Elevation: **19.04m**

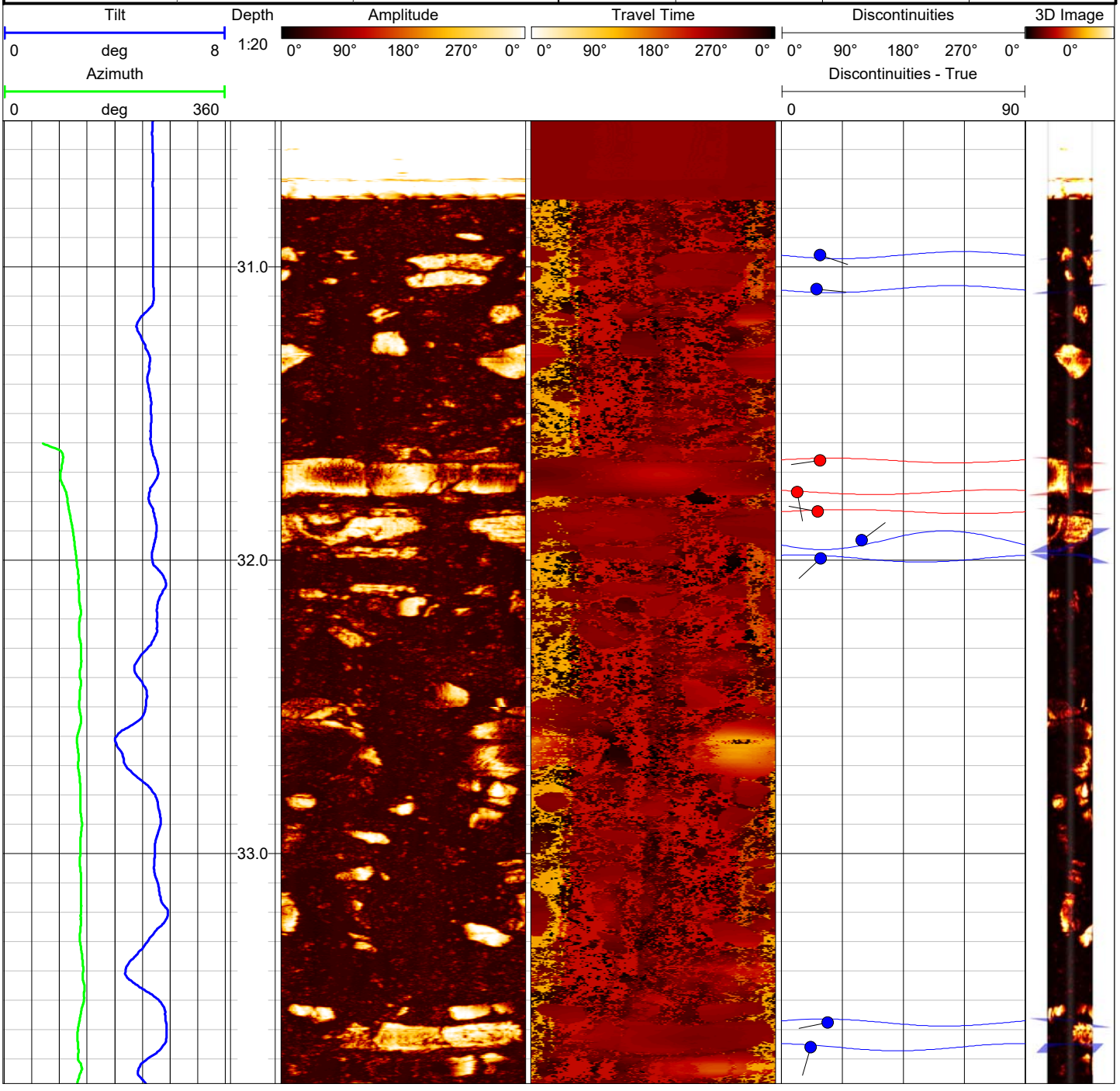
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**52.6**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**30.8 - 52.6**		
Fluid Level: (m)	**26.1**	**Ref:**	

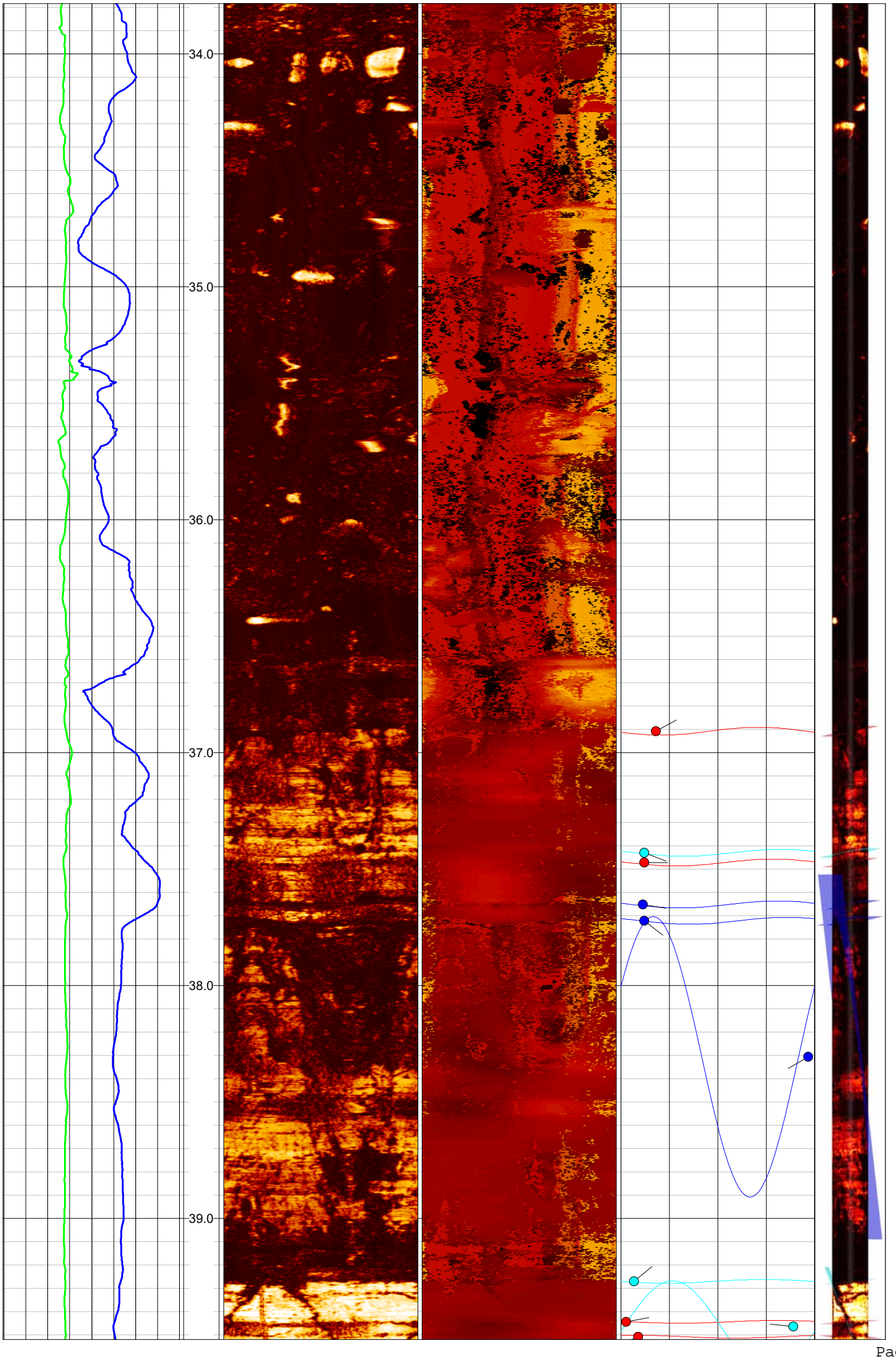
BOREHOLE RECORD

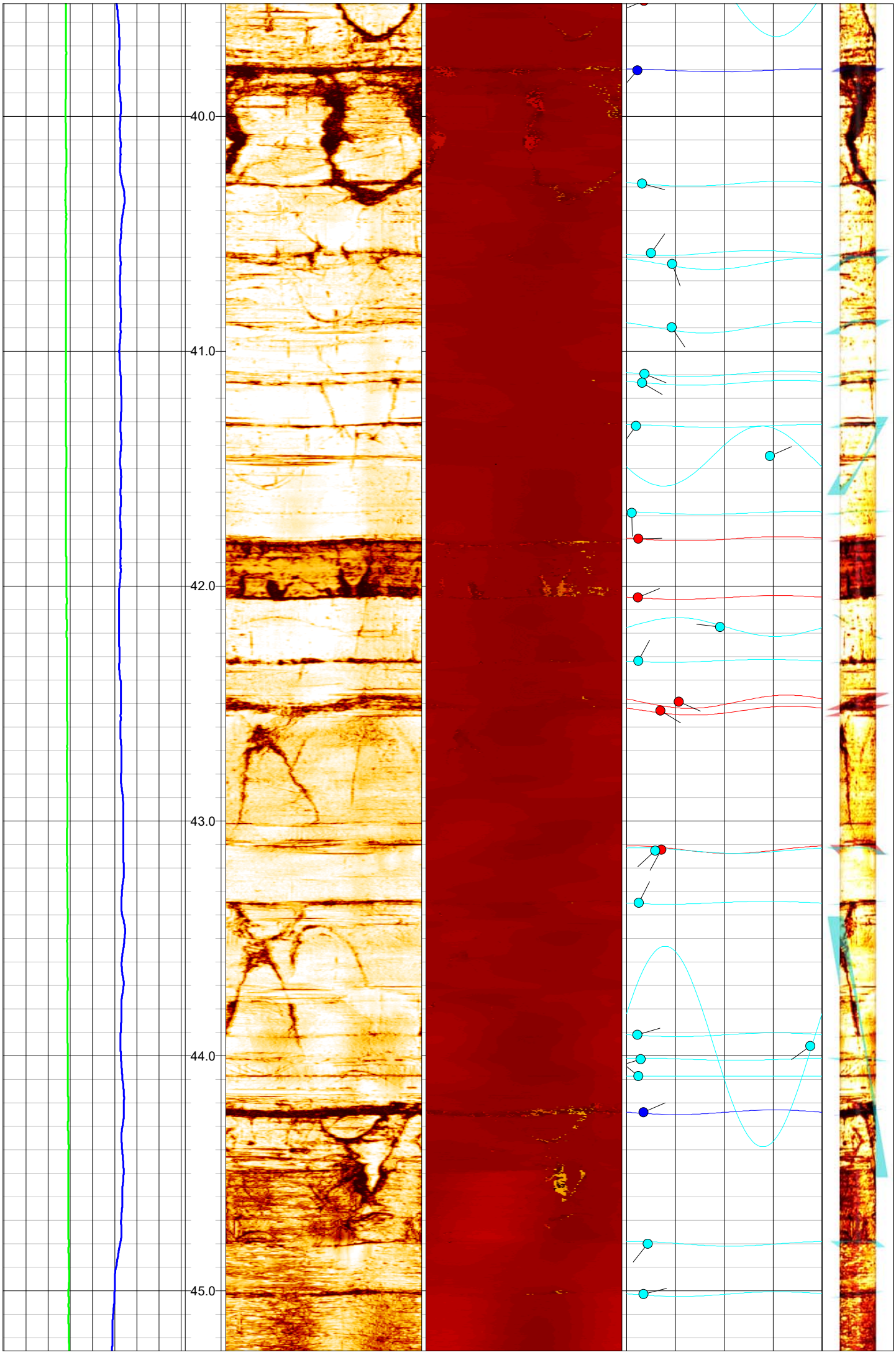
Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

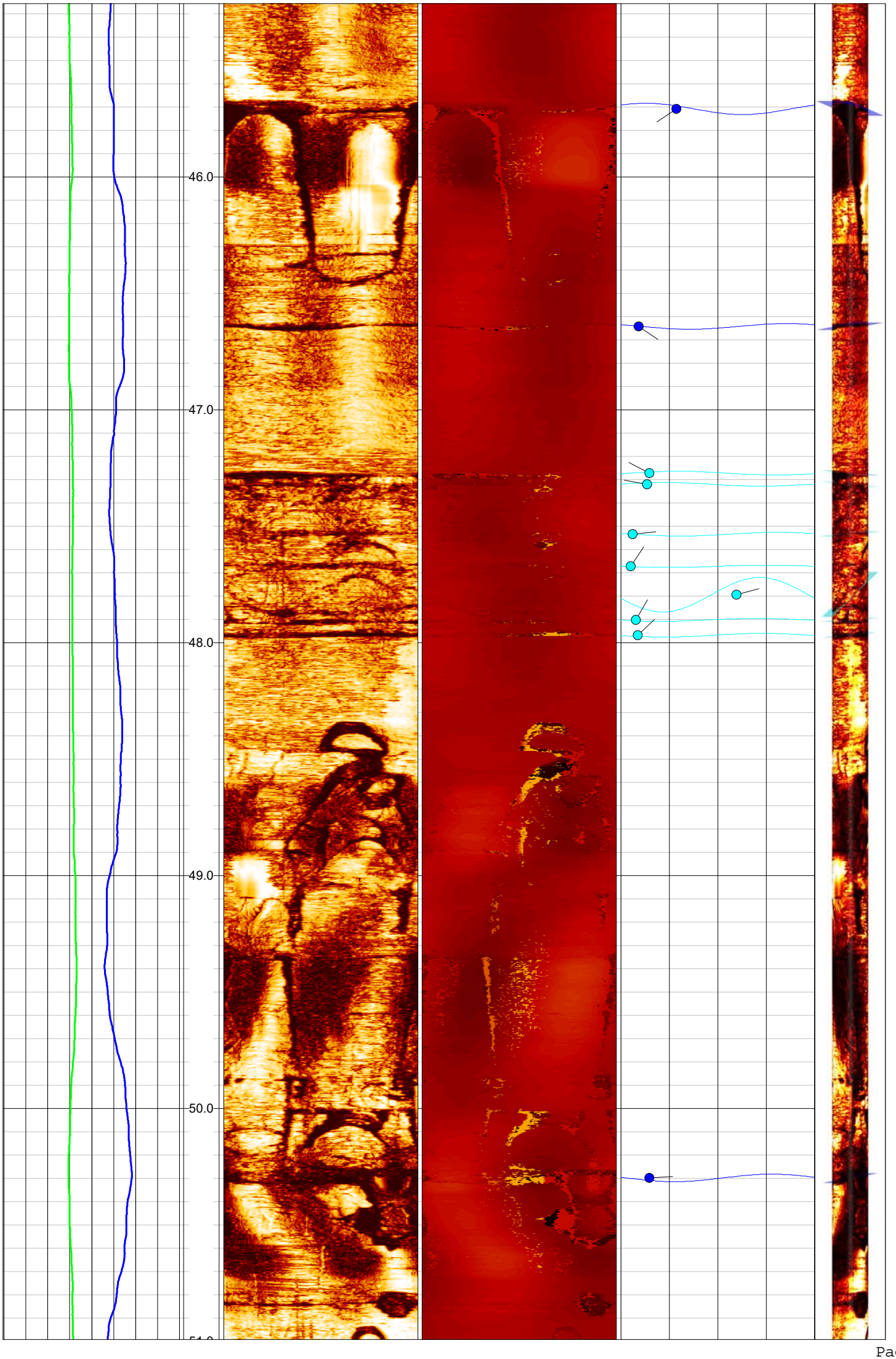
CASING RECORD

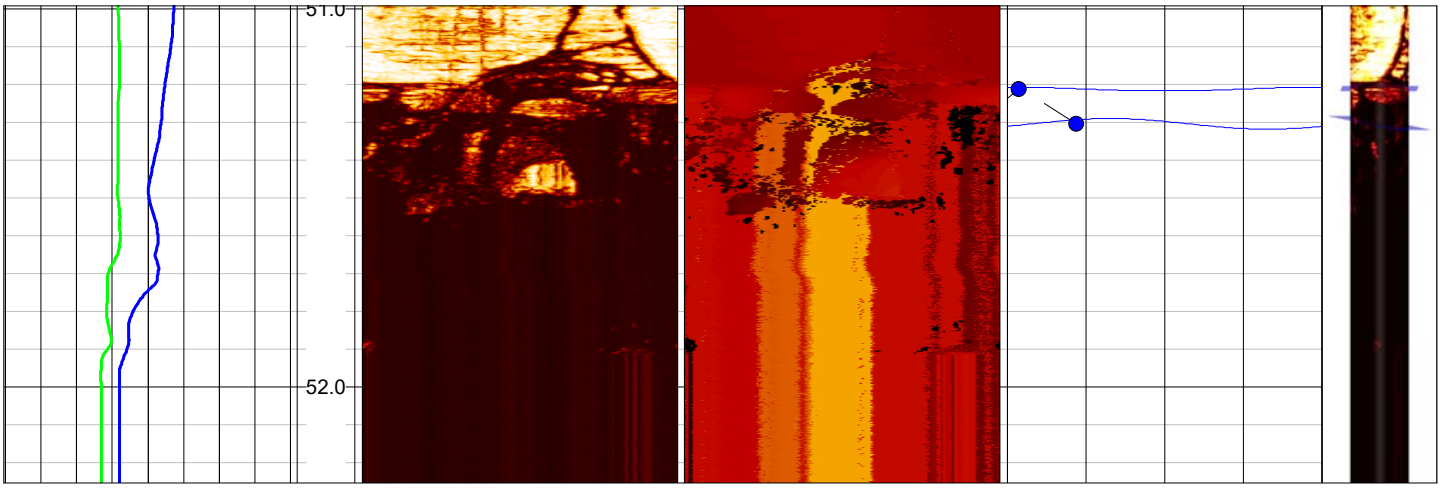
Type	Size: (mm)	From: (m)	To: (m)
Steel	**136**	**-0.2**	**30.8**




34.0
35.0
36.0
37.0
38.0
39.0


40.0
41.0
42.0
43.0
44.0
45.0


46.0
47.0
48.0
49.0
50.0


51.0
52.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-20**

Log Type: ***Stereonet***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425462.87E 558418.32N** Elevation: **19.04m**

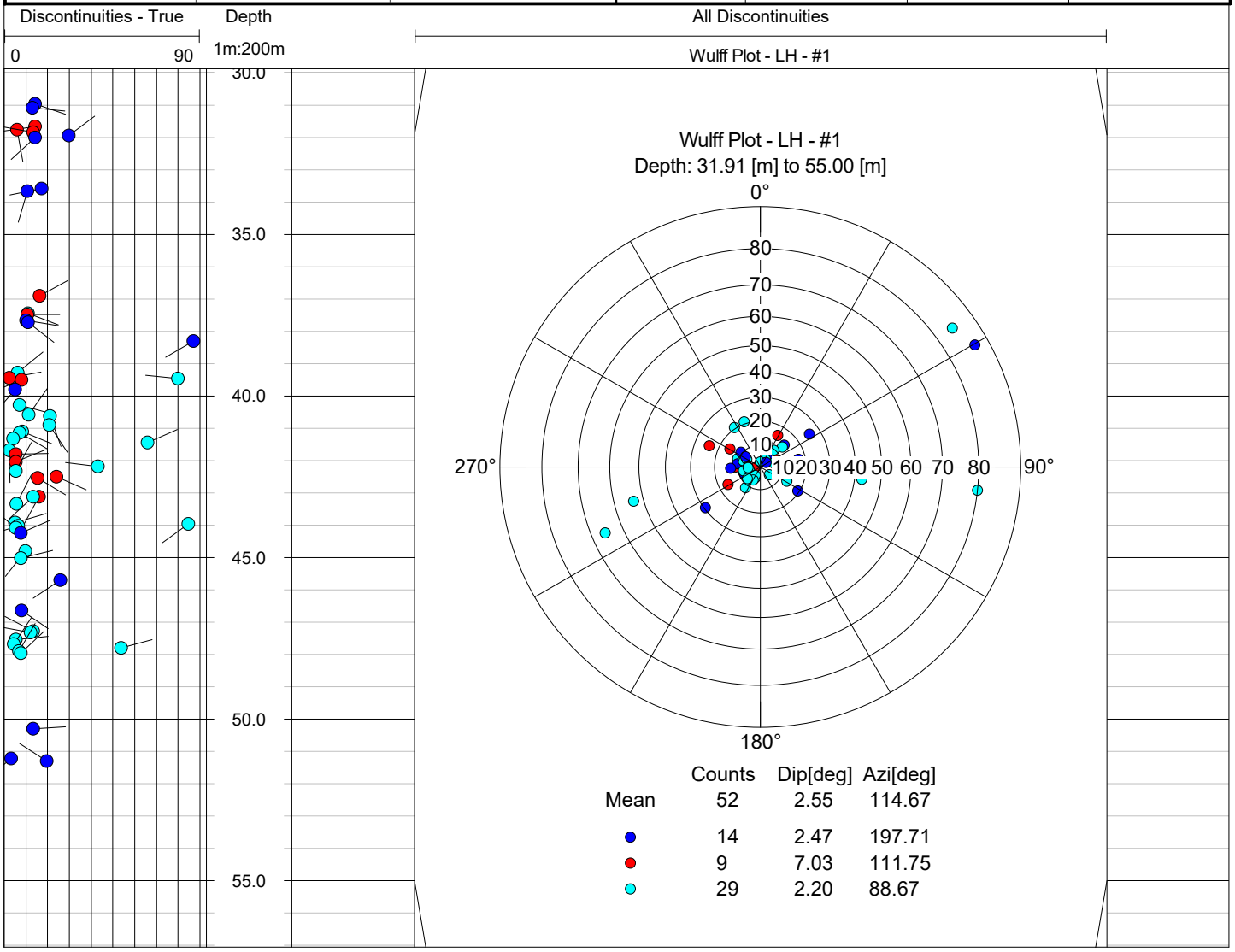
Drilled Depth: (m)	**65.0***	Date:	**14.12.17**
Logged Depth: (m)	**52.6**	Recorded By:	**Dave Hingley**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**30.8 - 52.6**		
Fluid Level: (m)	**26.1**	**Ref:**	

BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**65.0***

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**136**	**-0.2**	**30.8**



REPORT ON THE

GEOPHYSICAL LOGGING

OF

BOREHOLES 17-21 & 17-22

FOR THE

A1 B2CH PROJECT

JCTN 65 -67

Prepared For:

CENTRAL ALLIANCE
EXPLORE > IDENTIFY > DELIVER

Central Alliance, Alliance House,
South Park Way,
Wakefield 41 Business Park
Wakefield
WF2 0XJ

MAY 2018/CENTAL1801_ rpt/NZ25

European Geophysical Services Ltd
eurogeophys@europeangeophysical.com
www.europeangeophysical.com

CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

[illegible]

[illegible]

[illegible]

BH17-22

Log / Tool	From (m)	To (m)
[illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

1.0 INTRODUCTION

The following logs were run on the 10 May 2018:-

BH17-22 (cased to 20m)

Log / Tool	From (m)	To (m)
Natural Gamma (Hole stability check)	27	0
Acoustic Image	27	20
Full Wave Sonic (FWS)	26.7	20
Caliper (Hole quality check – poor FWS response)	26.5	20

BH17-21

Log / Tool	From (m)	To (m)
Optical Image	656	27.2
Full Wave Sonic (FWS)	68.5	27.2
Formation Density (Gamma-gamma)	64.8	1.8

2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

Full Wave Sonic (FWS)

Formation Density (Db)

2.0 THE GEOPHYSICAL LOGGING METHODS

Optical Borehole Imager (Optical)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Acoustic Borehole Imager (Amplitude and Travel Time)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

3.0 SITE DETAILS

Site: A1 B2CH – Jn 65-67 **OS Grid Ref: NZ 25453 58396**

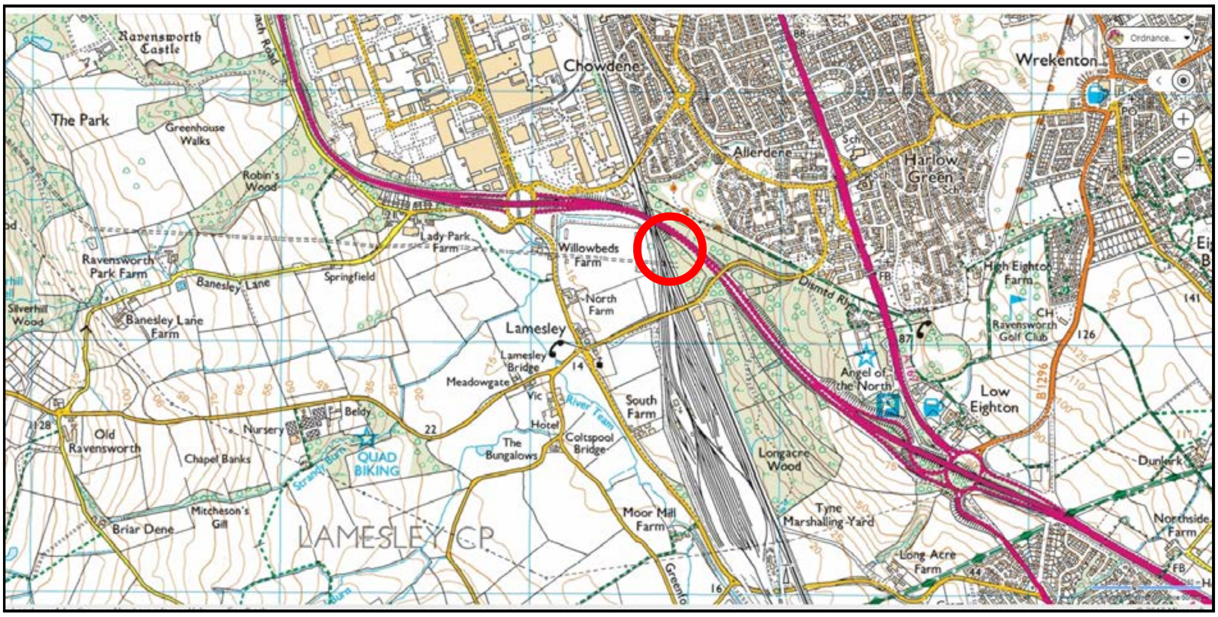


Figure 3.1 r d d r d r r r

Figure 3.2 r r r

4.0 PROCESSING AND PRESENTATION OF IMAGER RESULTS

D

M

4.0 PROCESSING AND PRESENTATION OF IMAGER RESULTS cont.

[illegible]

[illegible]

Taking into account the accuracies of the manufacturer's transducers and dependent upon tool centralisation, borehole rugosity, borehole eccentricity and picking techniques etc the overall accuracy of the technique is estimated at +/- 5 degrees for azimuth and +/- 2 degrees for dip.

5.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access restrictions**

  [illegible]

- **Tool access restrictions**

  [illegible]

- **Borehole conditions / risk to equipment**

  [illegible]

  [illegible]

  [illegible]

- **Lack of fluid filled column / cloudy fluid**

  [illegible]

  [illegible]

- **Time constraint**

  [illegible]

- **Borehole construction / casing**

  [illegible]

Appendix 1

Discontinuity Classification.

Discontinuity	Colour	Classification Parameters
[illegible]	[illegible]	[illegible] **continuous** [illegible]
[illegible]	[illegible]	[illegible] **continuous or discontinuous** [illegible]
[illegible]	[illegible]	[illegible] **continuous or discontinuous** [illegible]
[illegible]	Red	[illegible] **continuous or discontinuous** [illegible]
[illegible]	[illegible]	[illegible] **continuous** [illegible]
[illegible]	[illegible]	[illegible] **cannot** [illegible]

Appendix 2

Geophysical Logs

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-21**

Log Type: ***Composite***

Location: **A1 B2CH** Area: **Lamesley** Grid Ref: **425535E 558419N** Elevation: **22.44m**

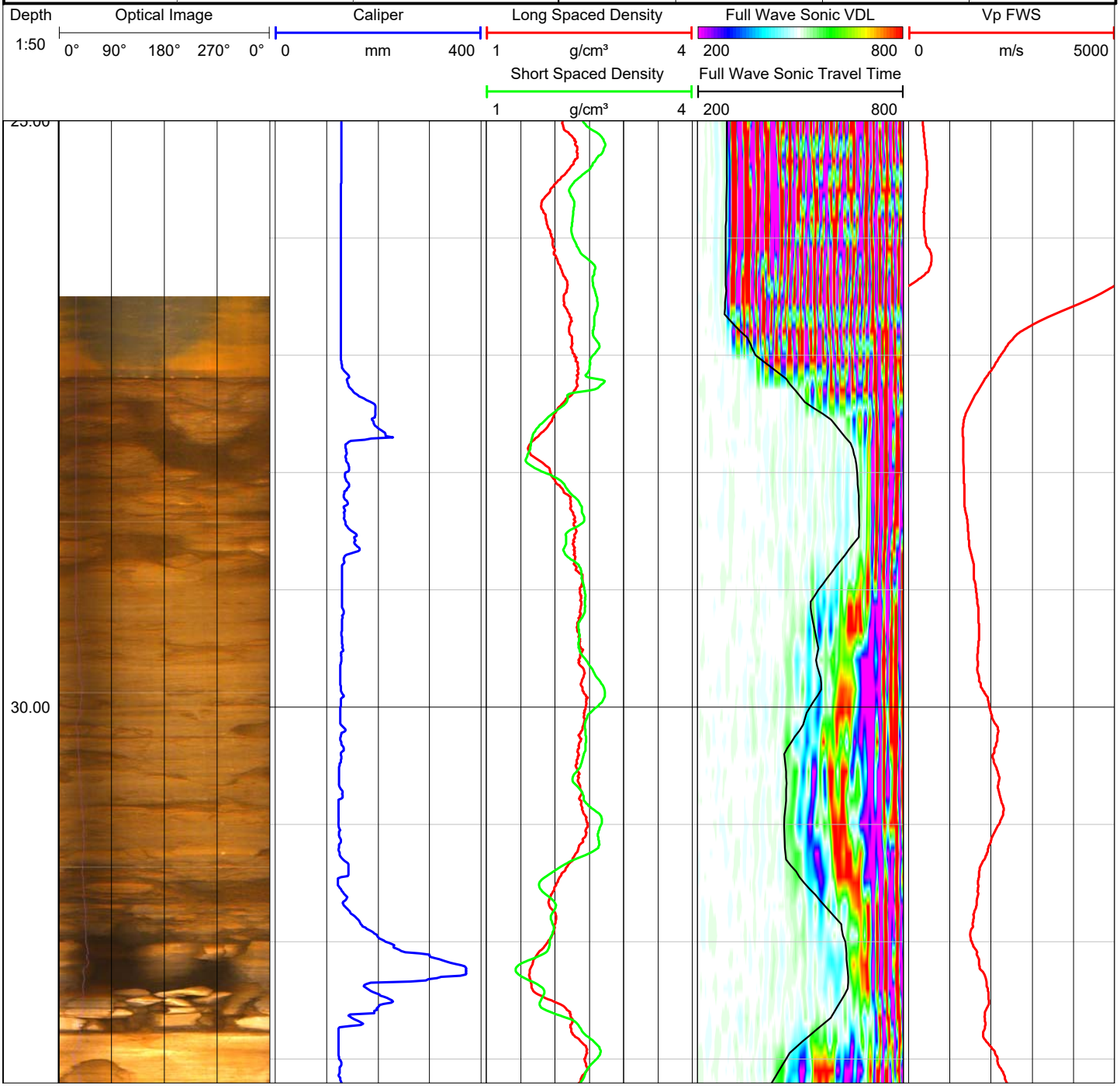
Drilled Depth: (m)	**70**	Date:	**10.05.2018**
Logged Depth: (m)	**65**	Recorded By:	**M. Hand/R. Jennins**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**27.2 - 65**		
Fluid Level: (m)	**Unknown**	**Ref:**	**CA B2C BH17-21 Composite Final.wcl**

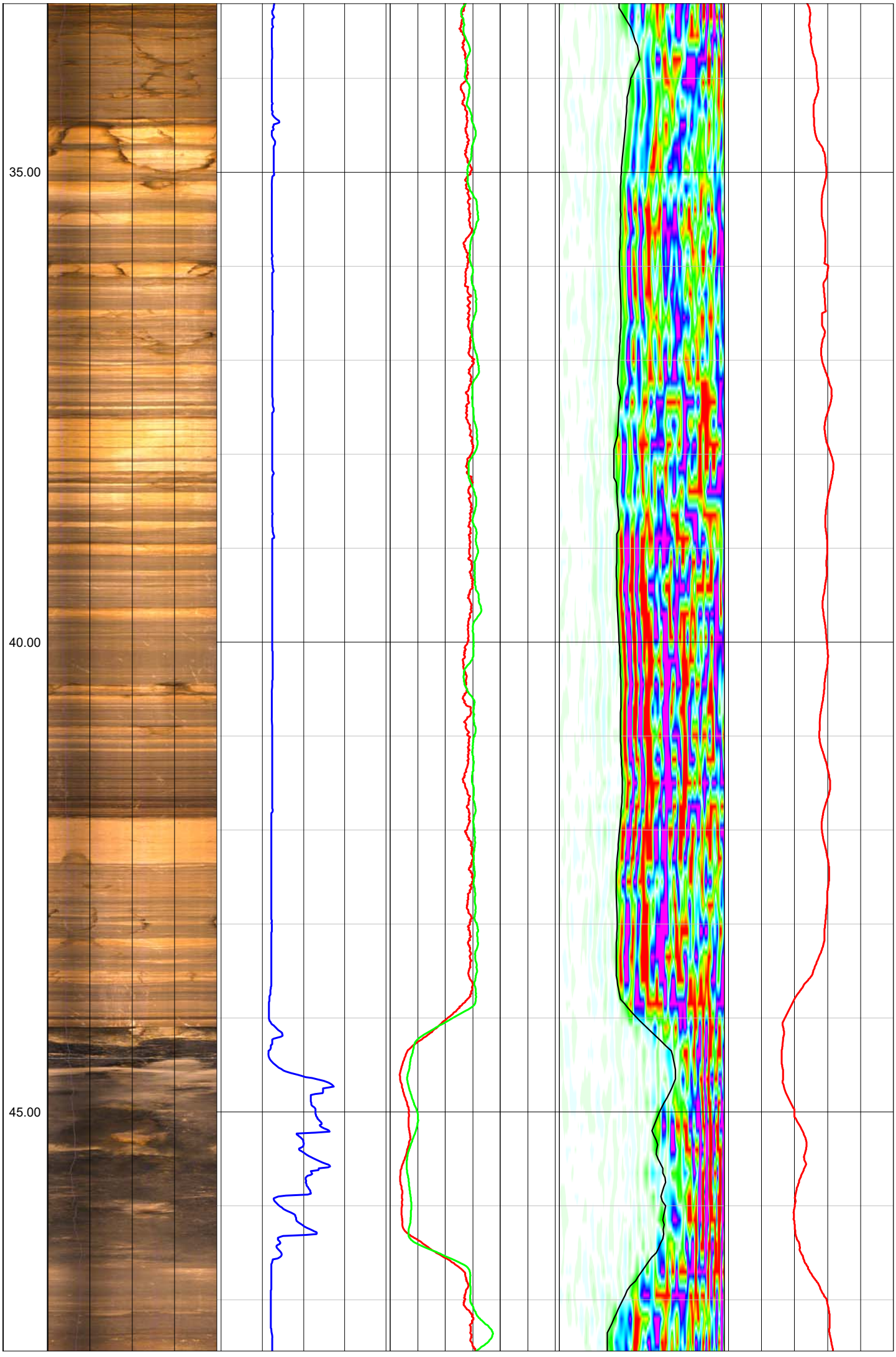
BOREHOLE RECORD

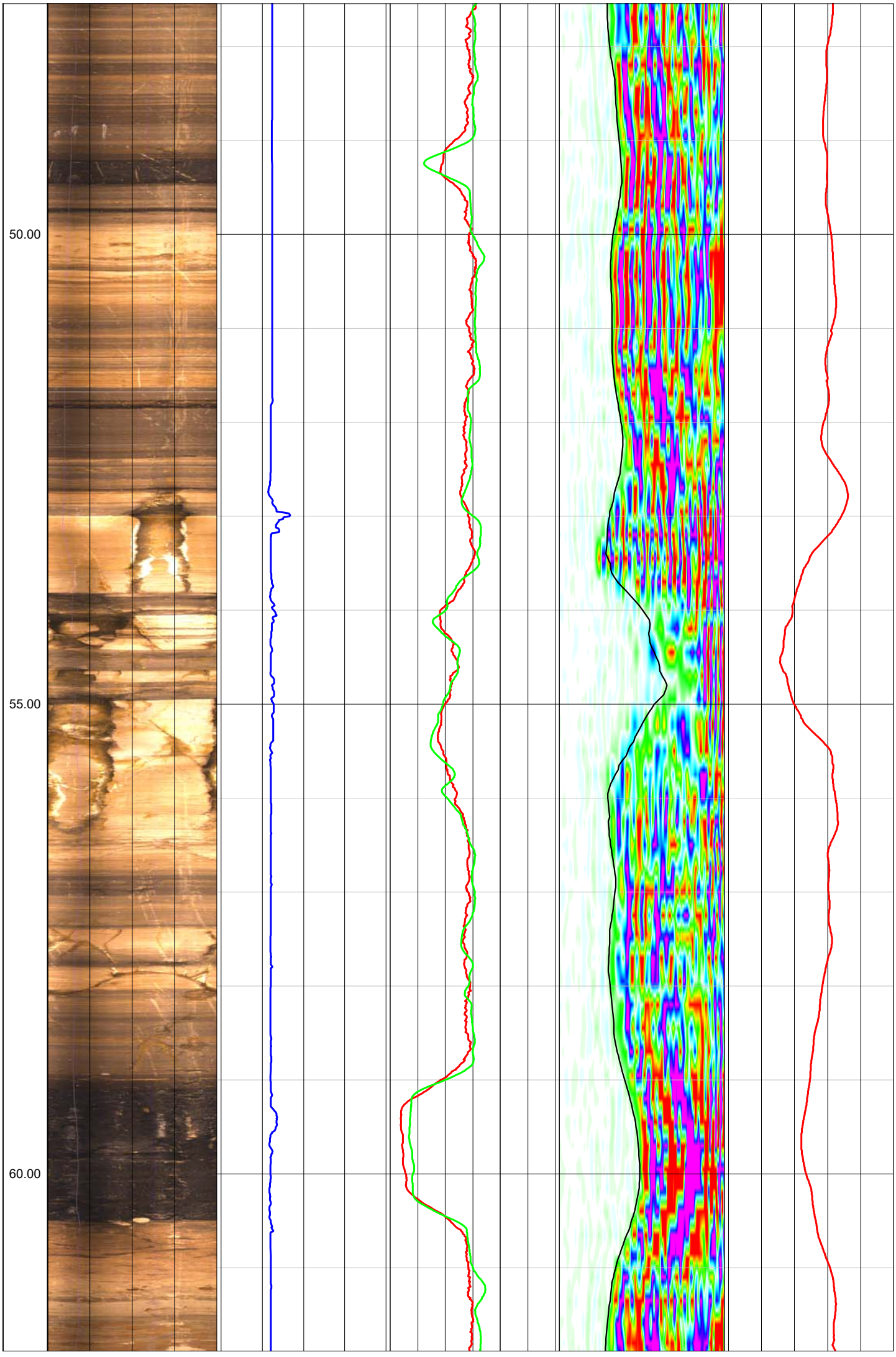
Bit: (mm)	From: (m)	To: (m)
Geobore S	**0**	**27.2**
PQ	**27.2**	**70**

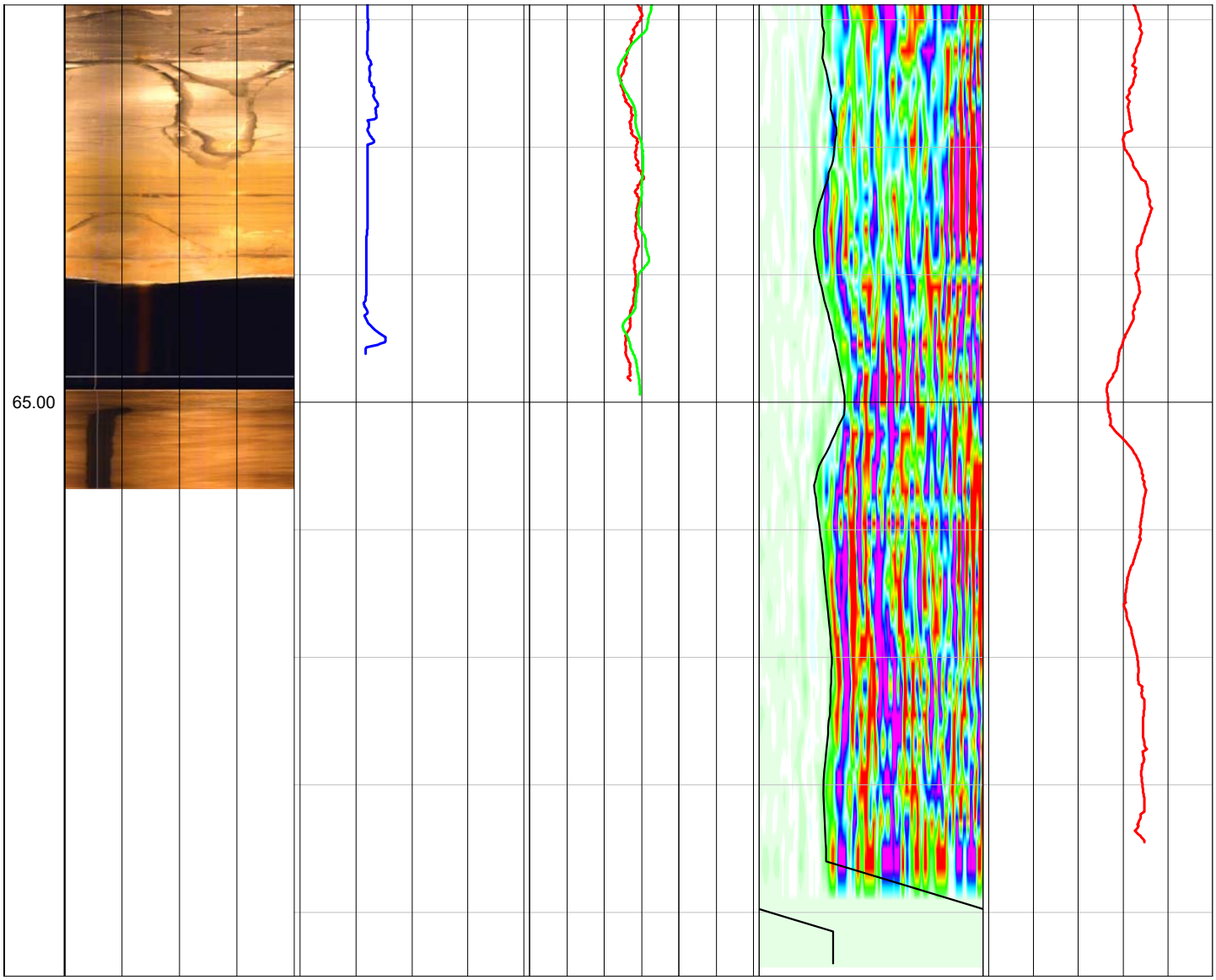
CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**Ground level**	**27.2**




35.00
40.00
45.00


50.00
55.00
60.00


65.00

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-21**

Log Type: ***Image***

Location: **A1 B2CH** Area: **Lamesley** Grid Ref: **425535E 558419N** Elevation: **22.44m**

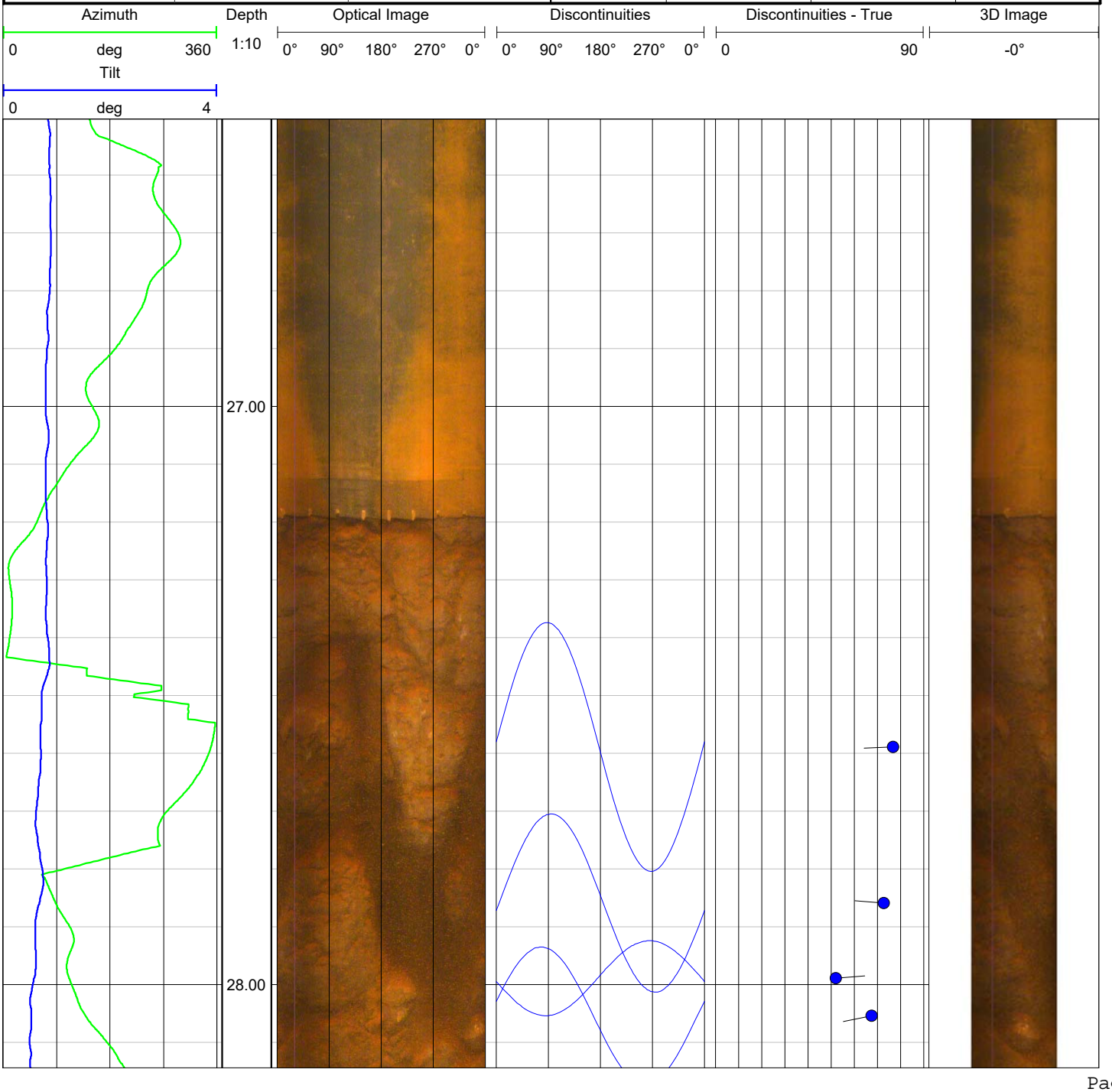
Drilled Depth: (m)	**70**	Date:	**10.05.2018**
Logged Depth: (m)	**65**	Recorded By:	**M. Hand/R. Jennins**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**27.2 - 65**		
Fluid Level: (m)	**Unknown**	**Ref:**	**CA B2C BH17-21 Image Final.WCL**

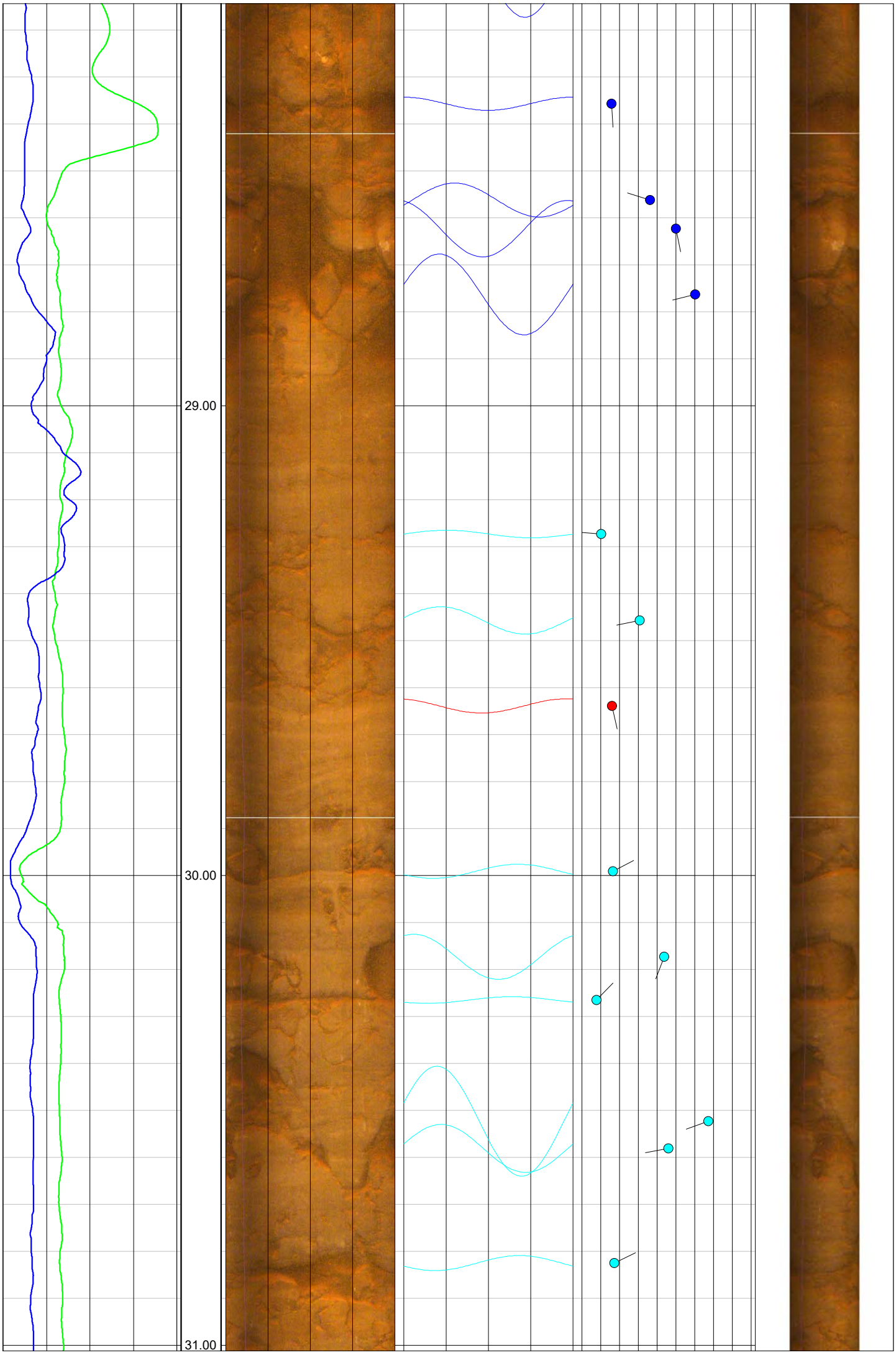
BOREHOLE RECORD

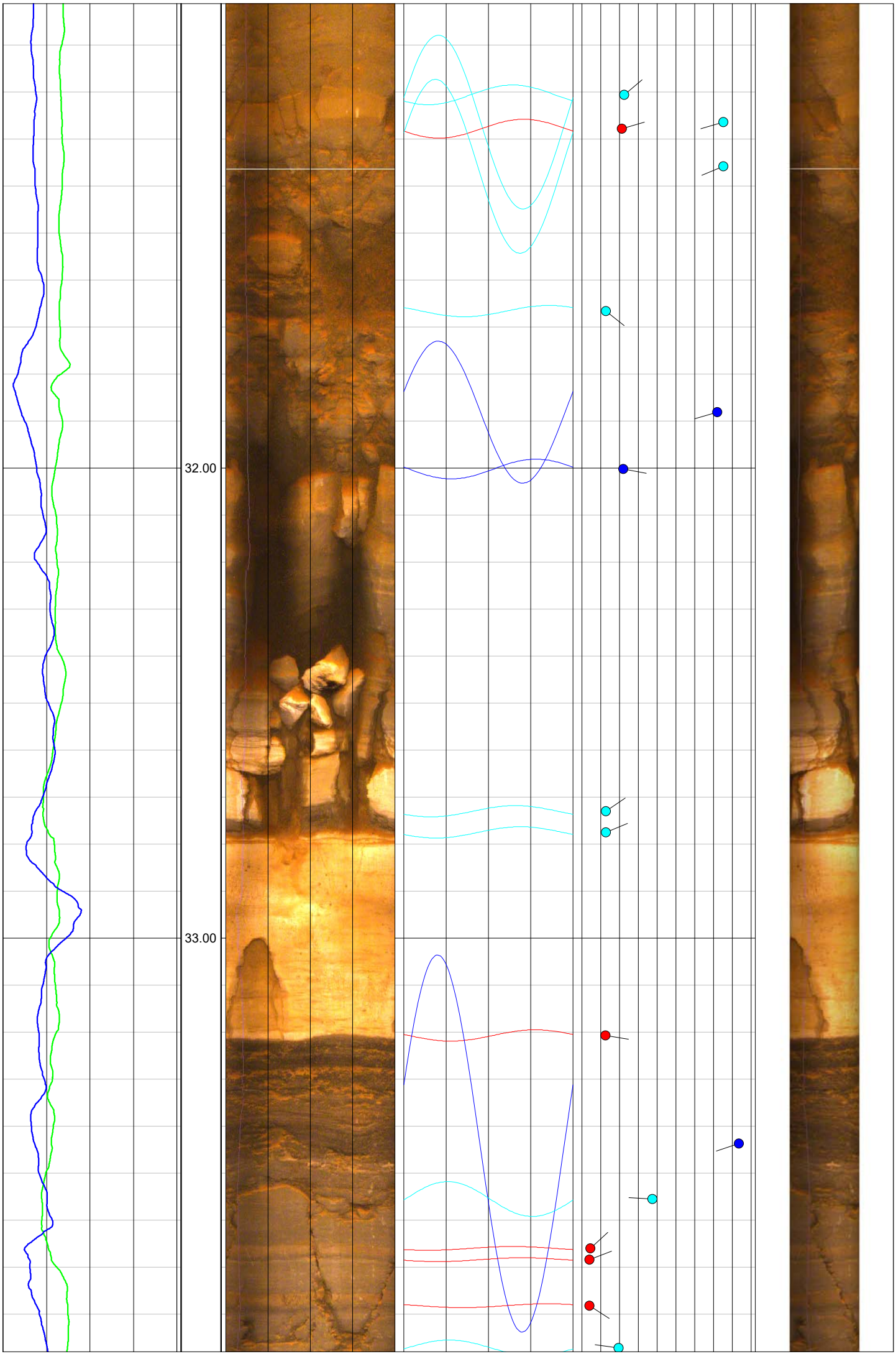
Bit: (mm)	From: (m)	To: (m)
Geobore S	**0**	**27.2**
PQ	**27.2**	**70**

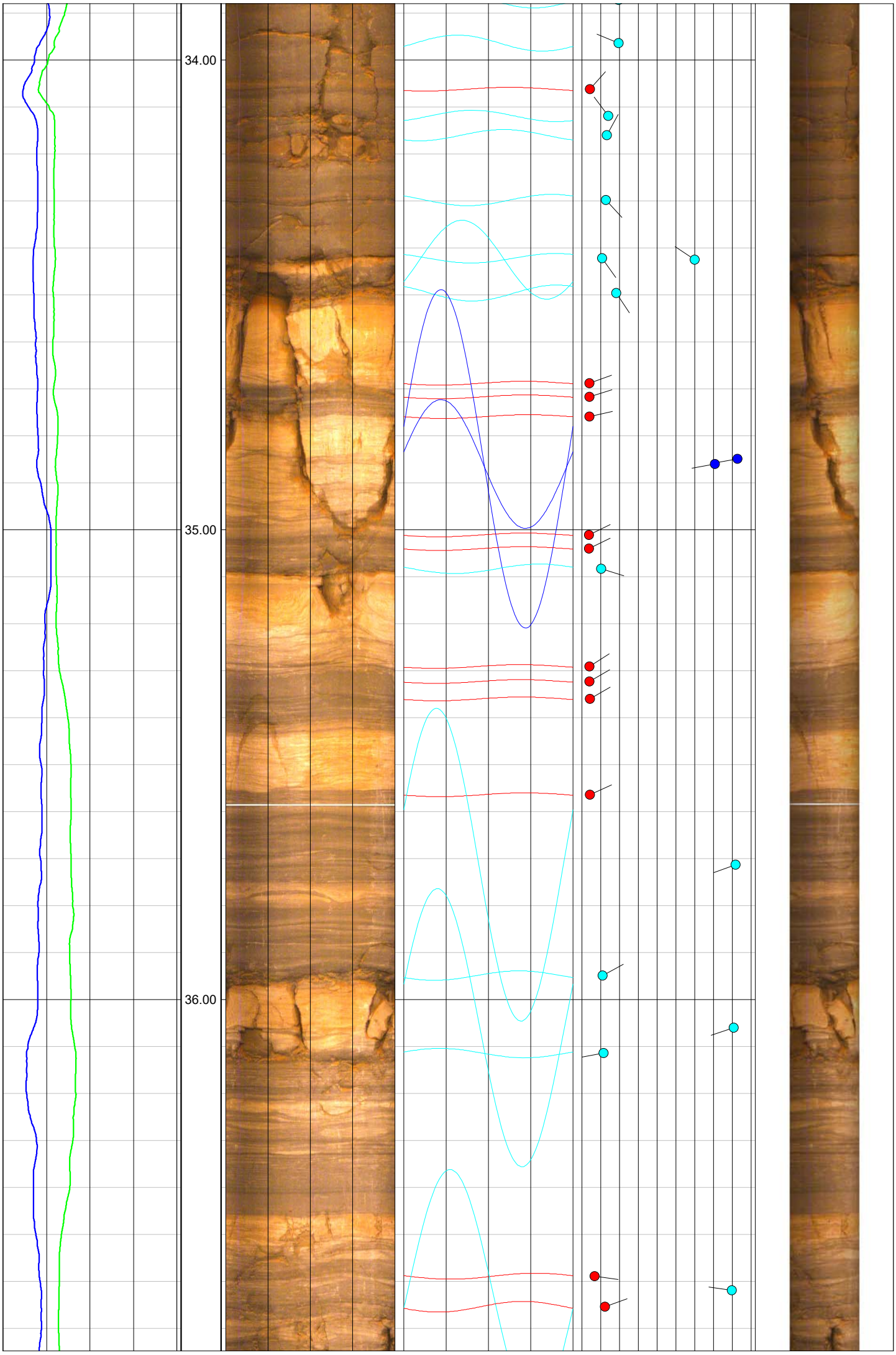
CASING RECORD

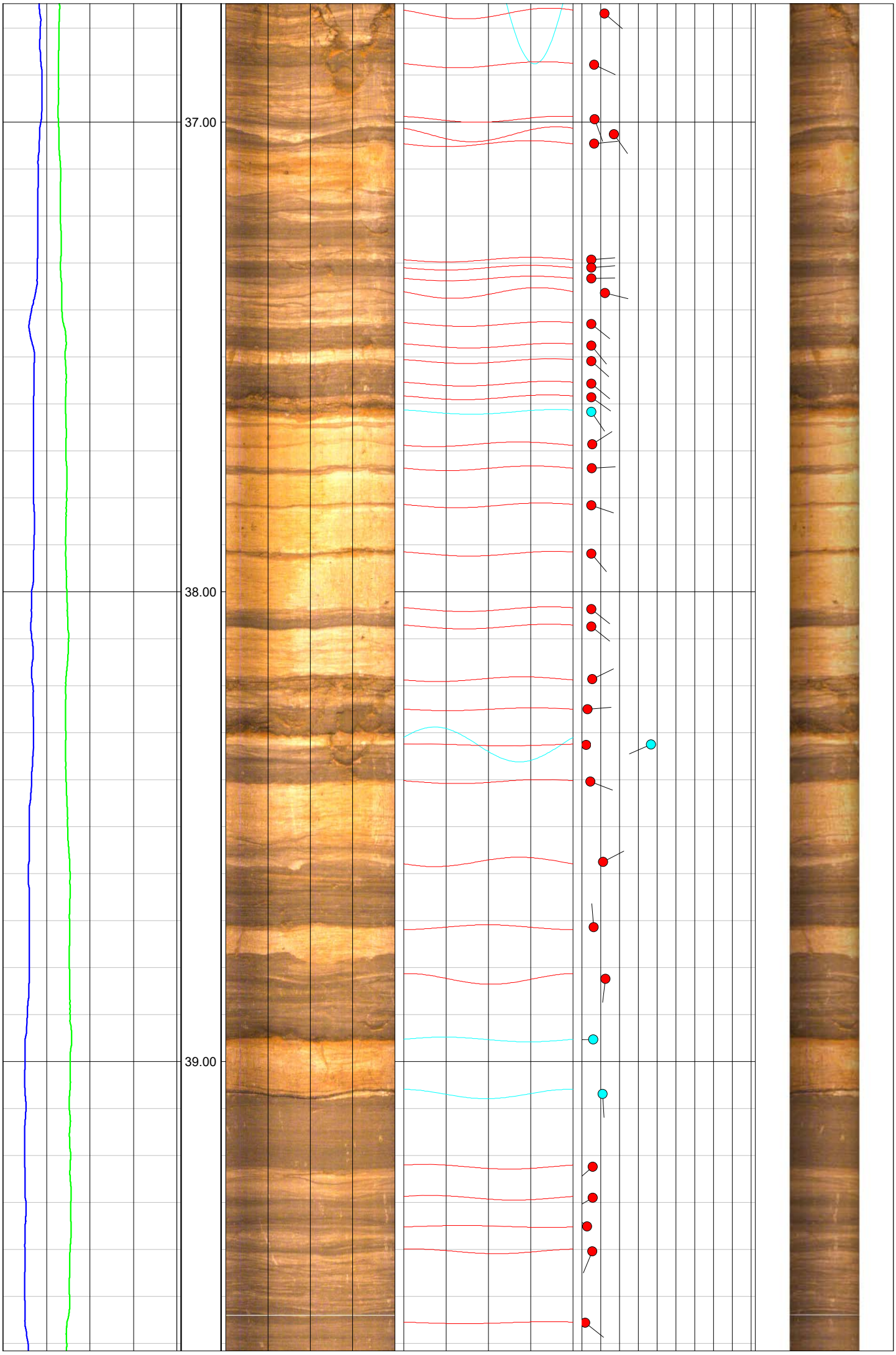
Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**Ground level**	**27.2**

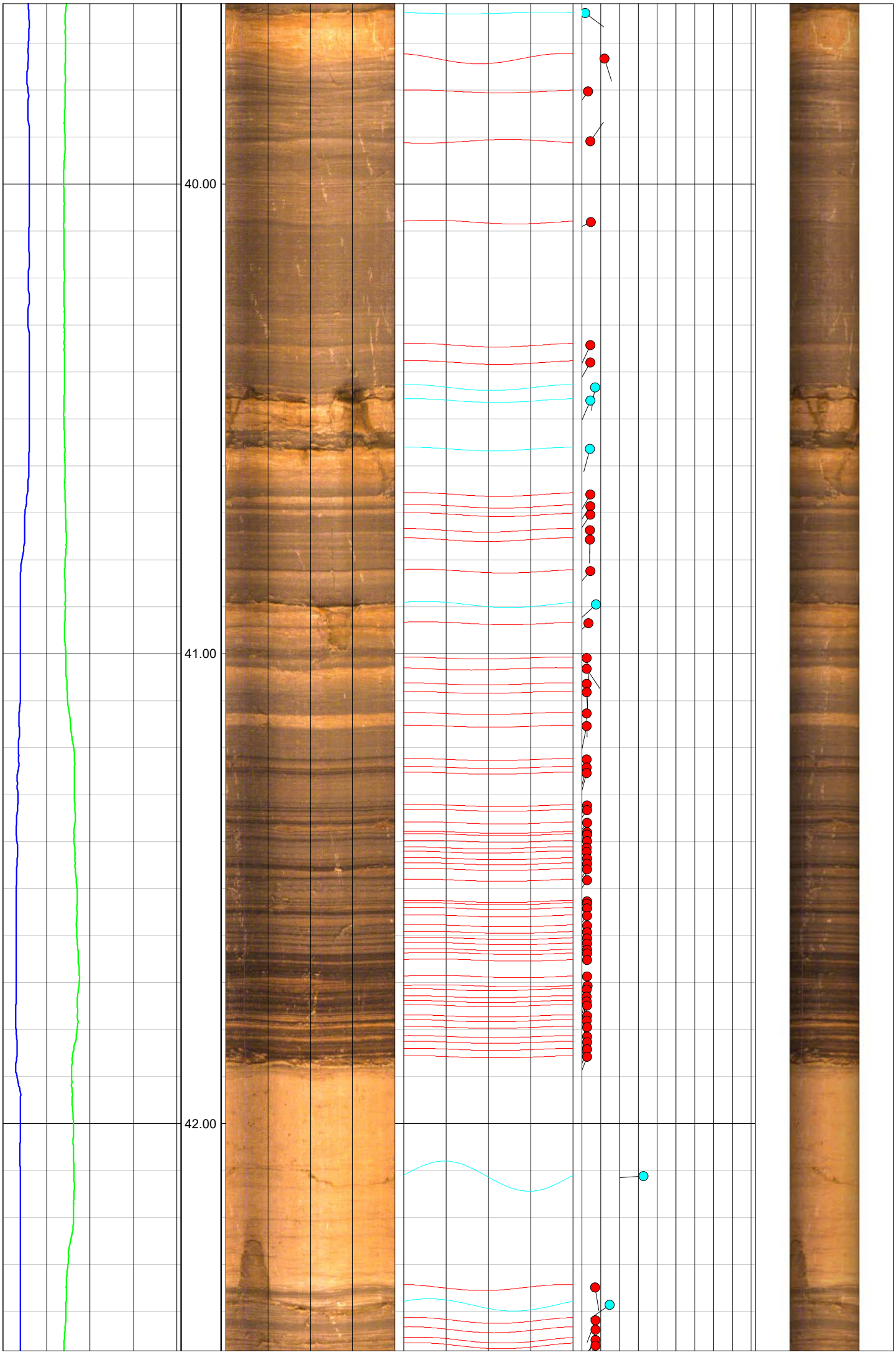


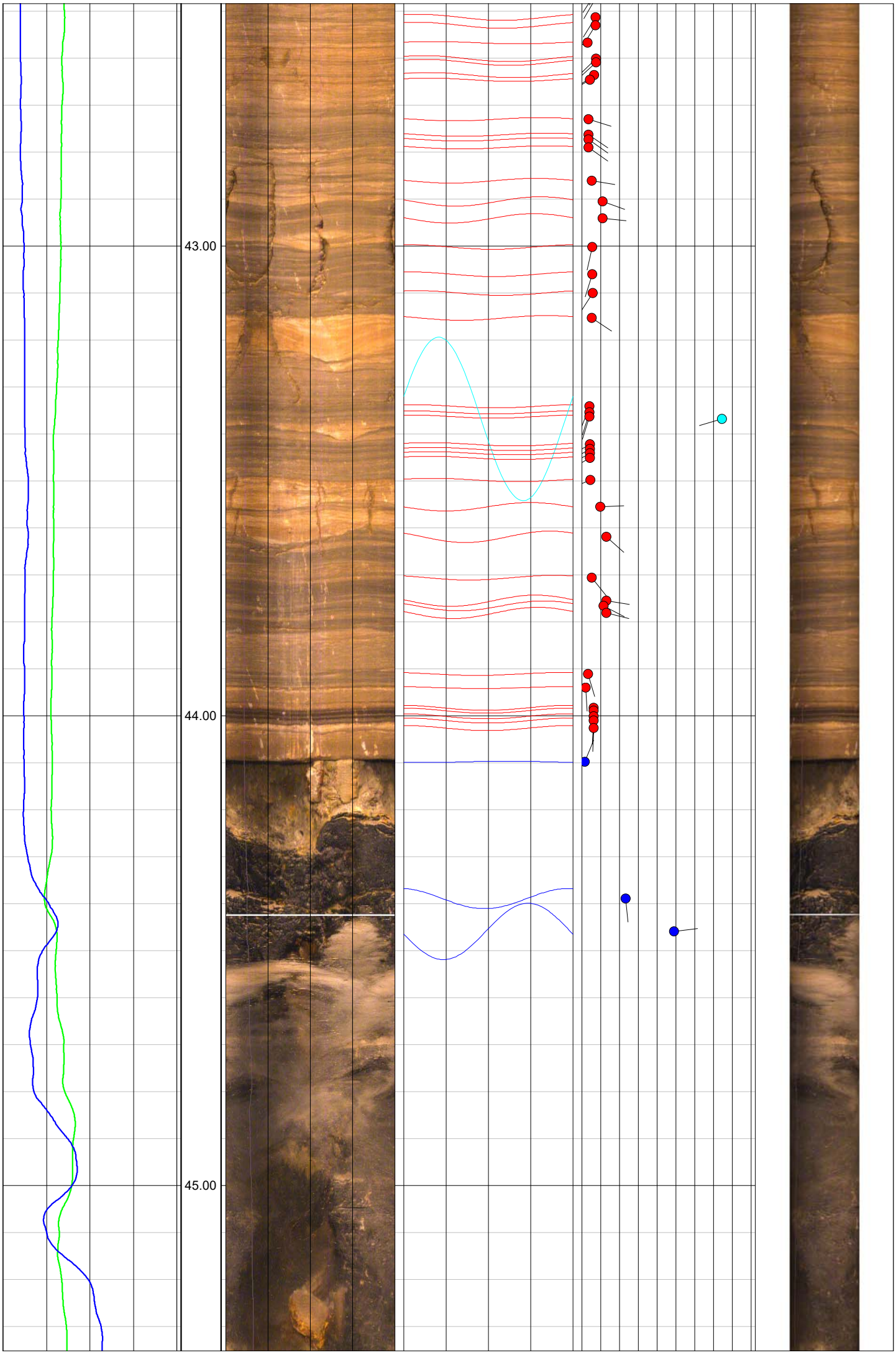

29.00
30.00
31.00

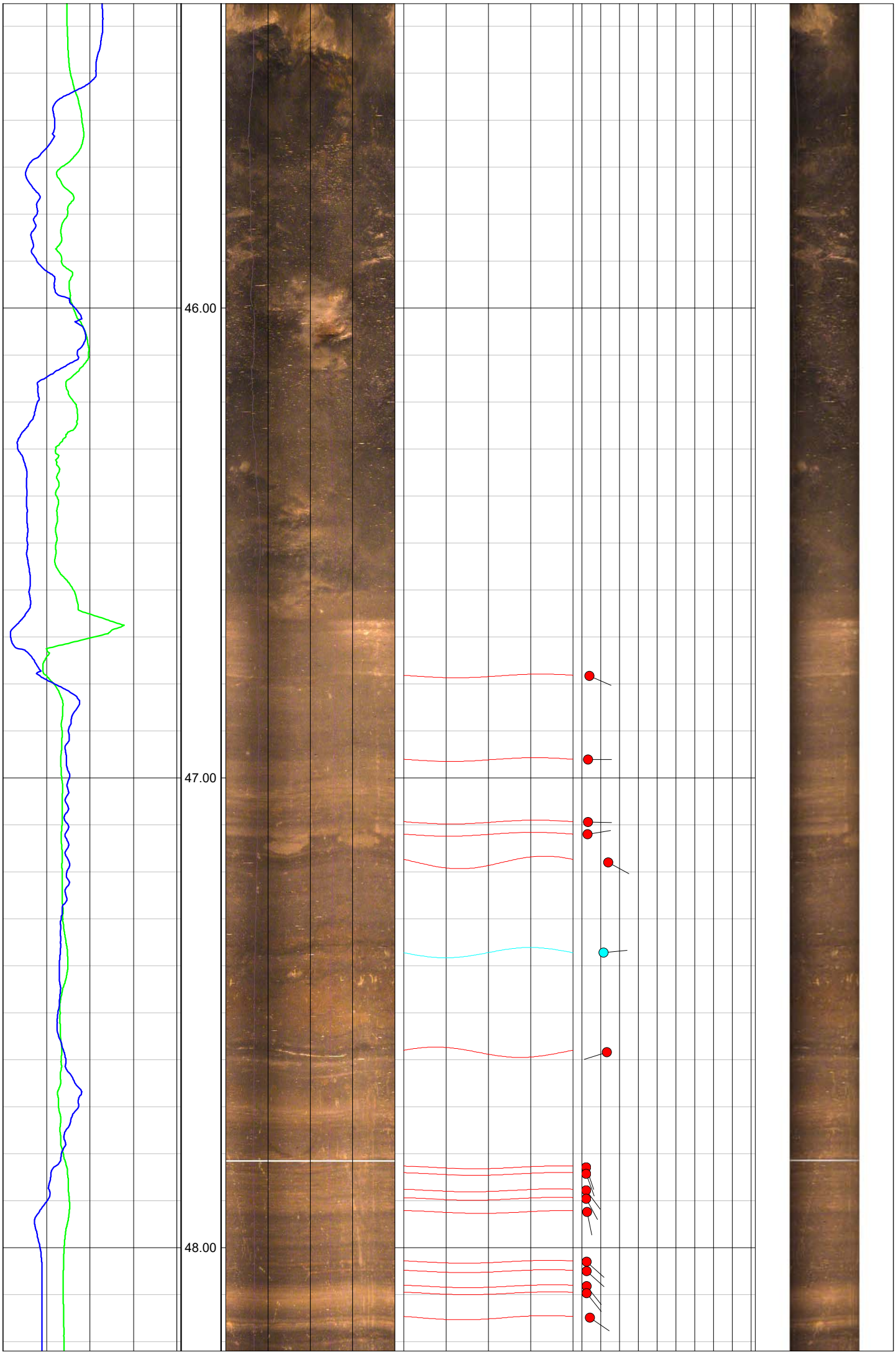

32.00
33.00

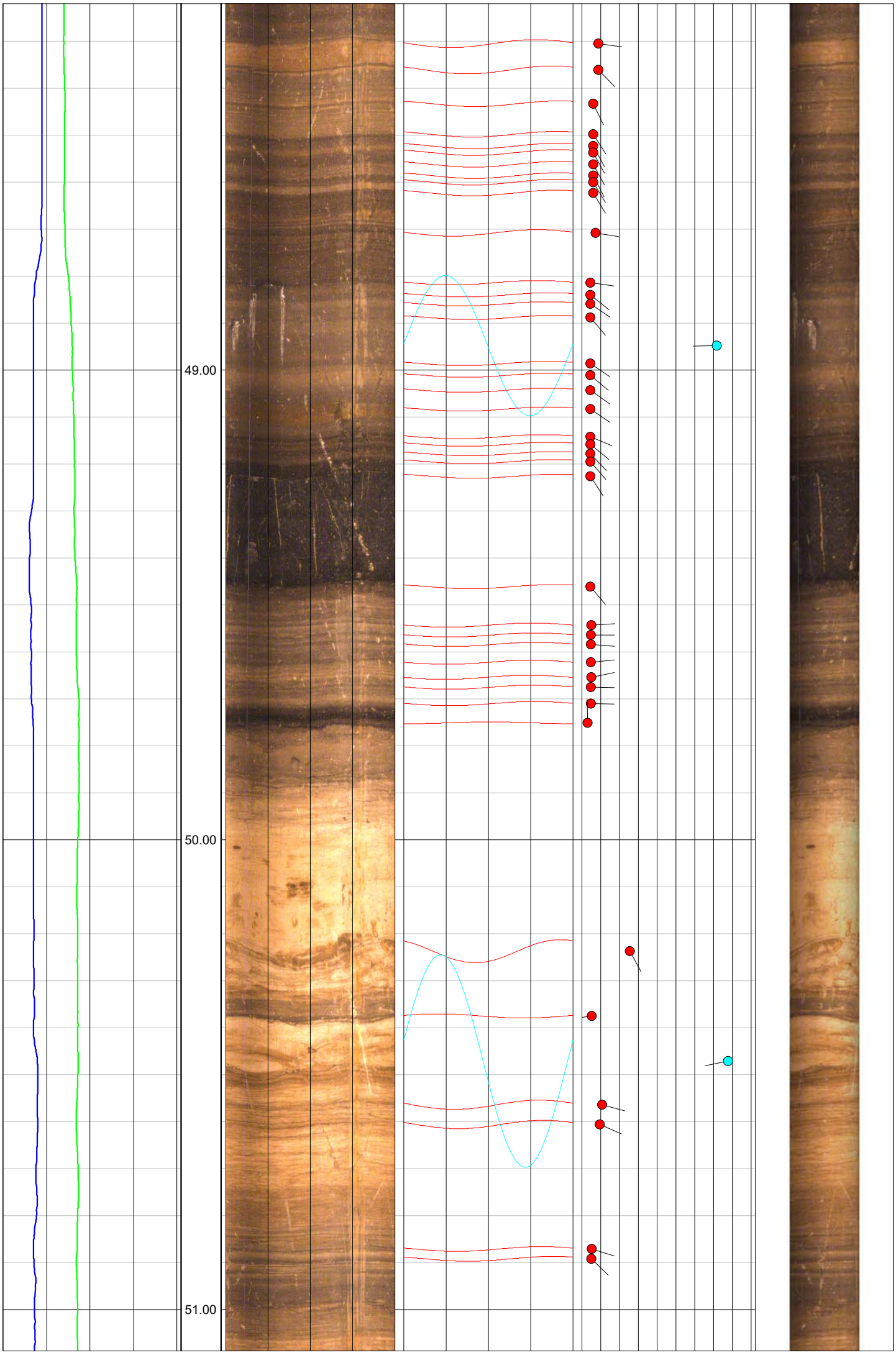

34.00
35.00
36.00

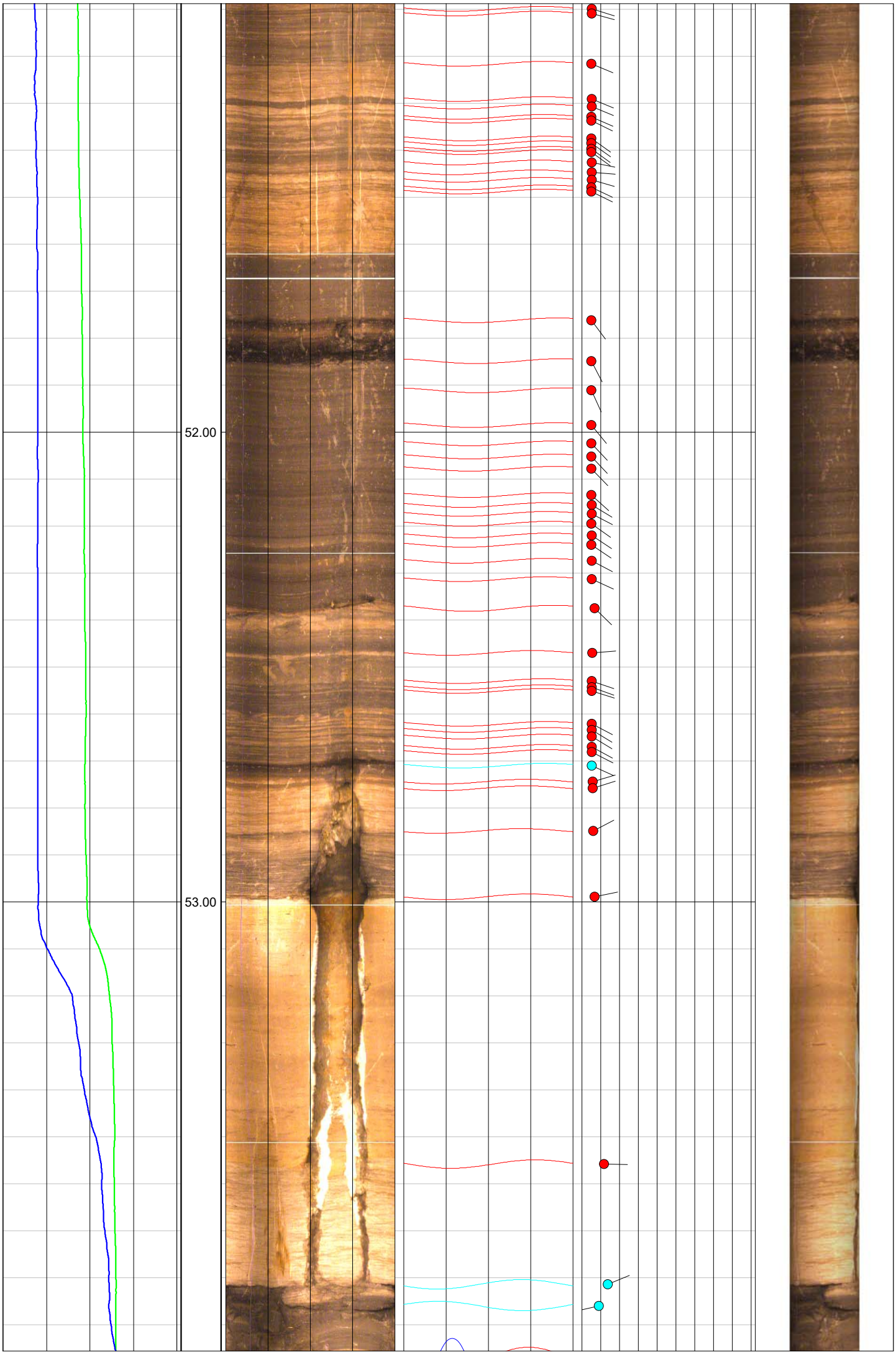

37.00
38.00
39.00

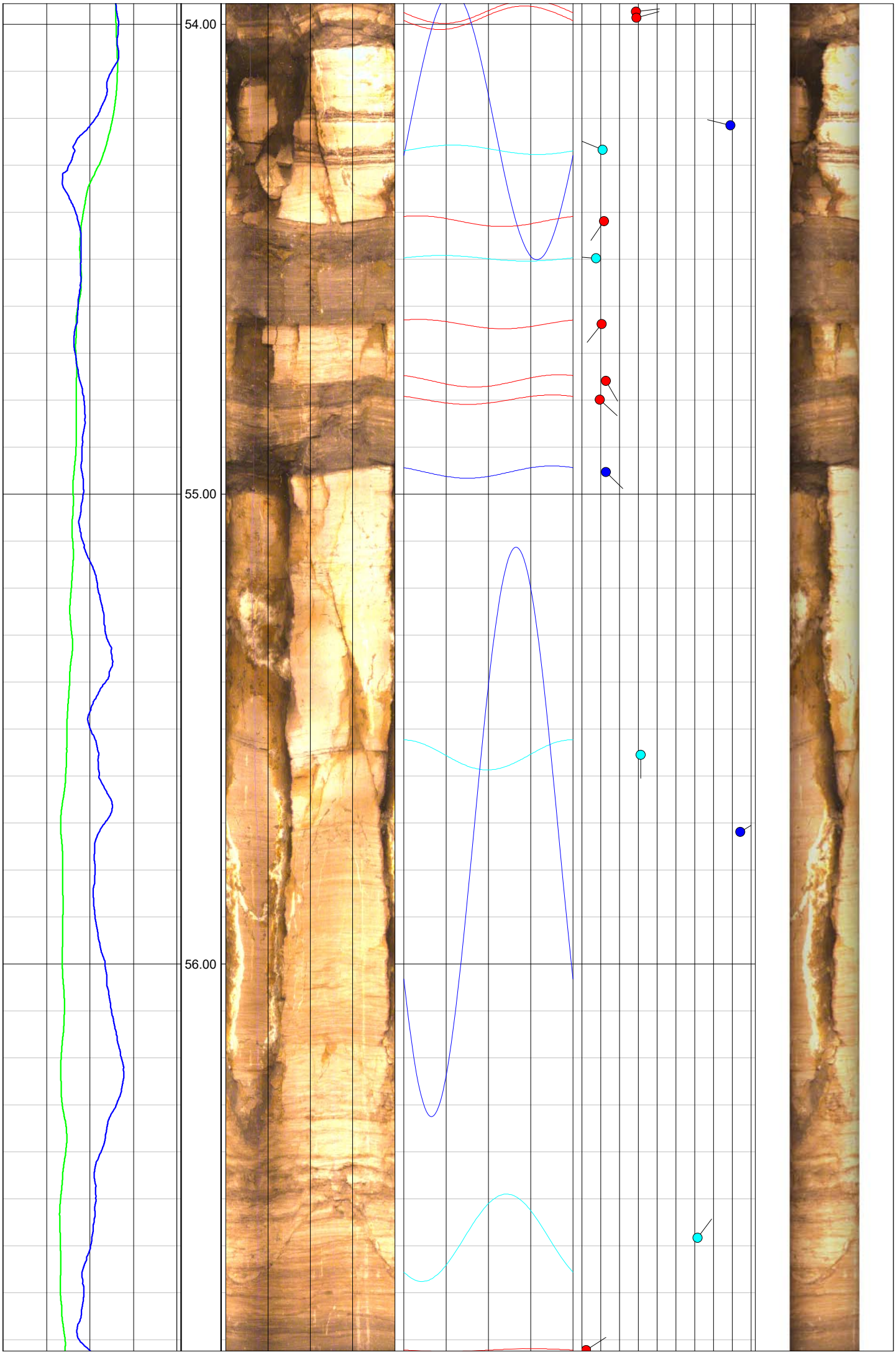

40.00
41.00
42.00

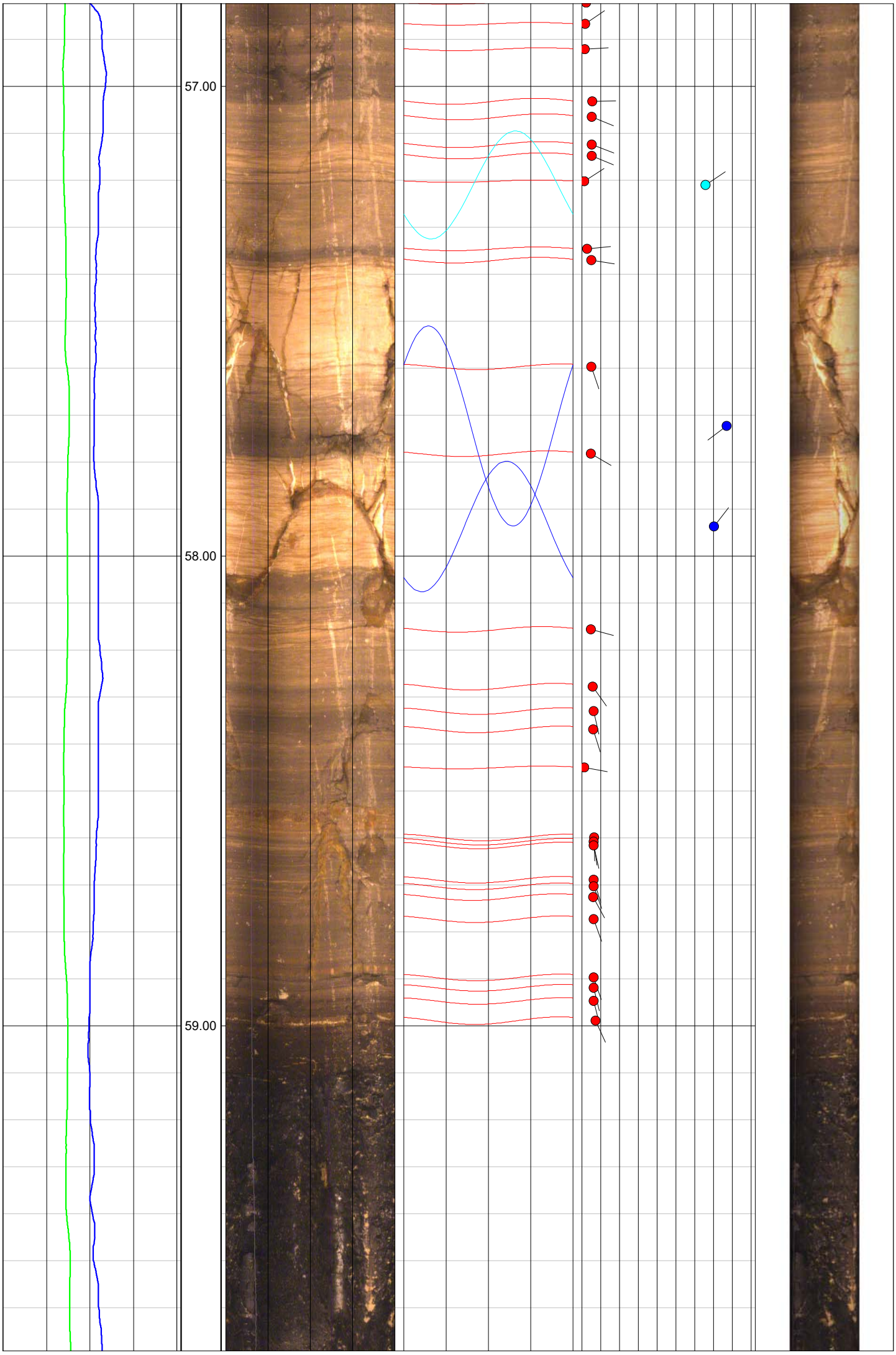

43.00
44.00
45.00

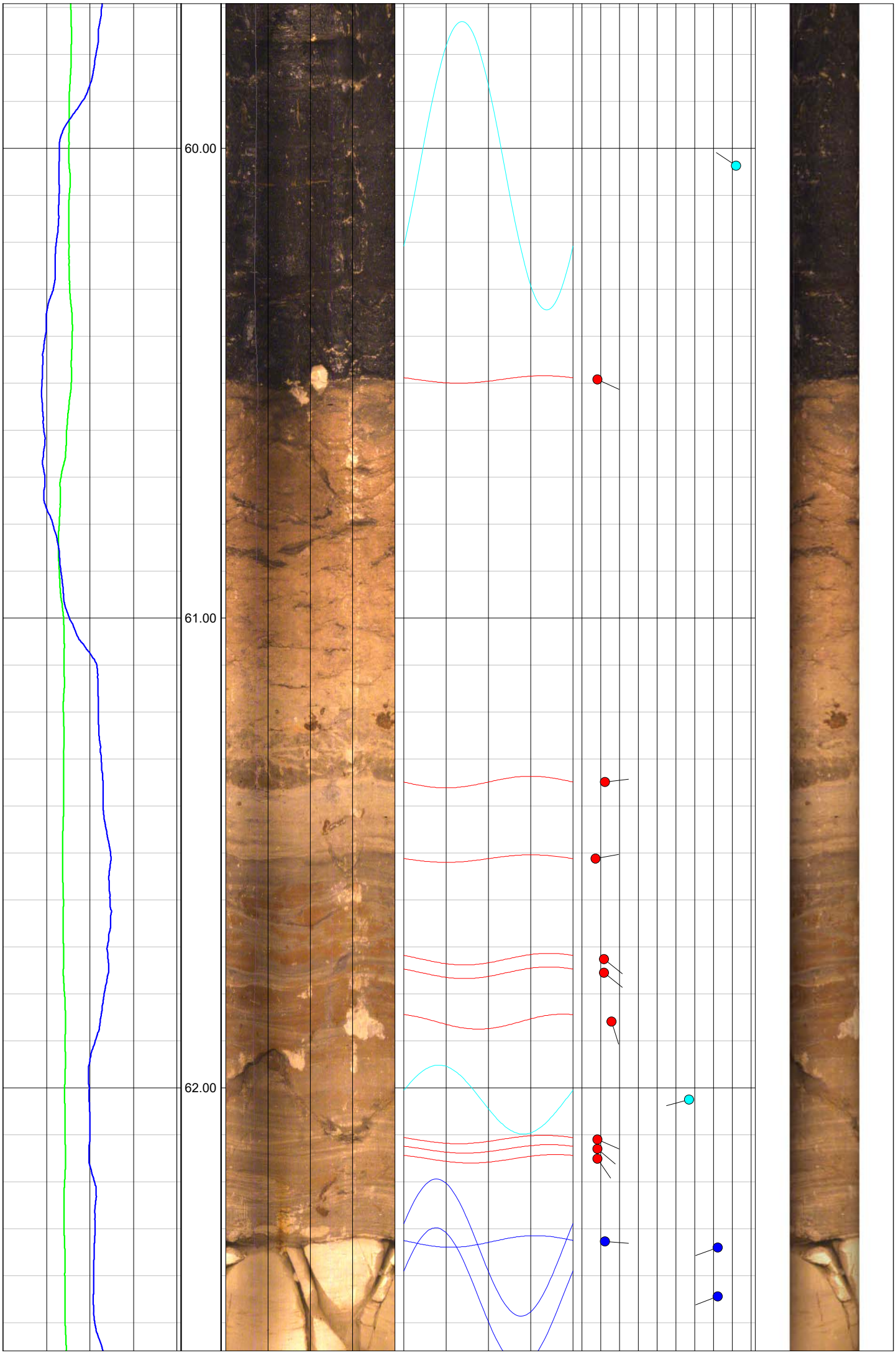

46.00
47.00
48.00

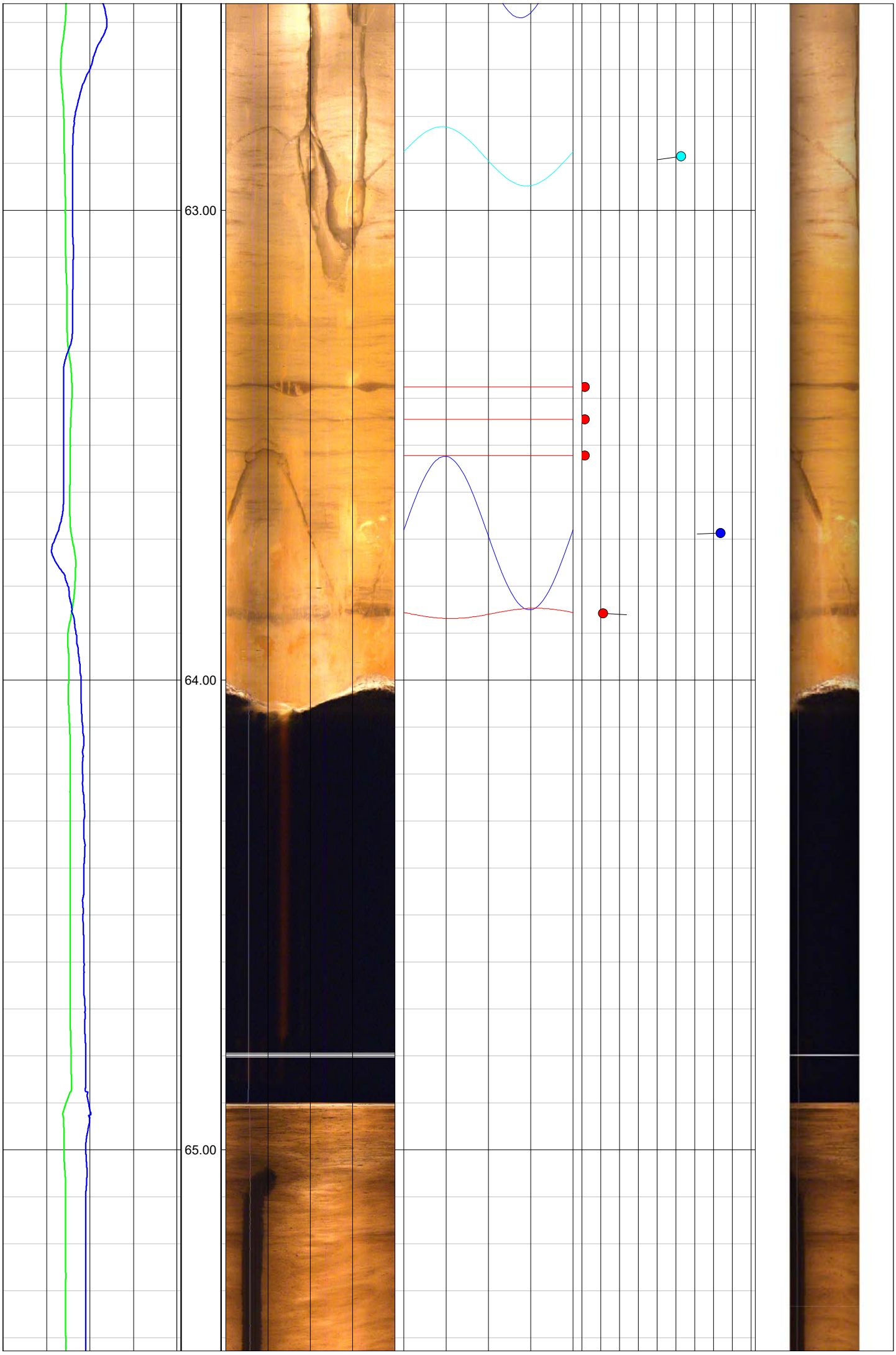

49.00
50.00
51.00


52.00
53.00


54.00
55.00
56.00


57.00
58.00
59.00


60.00
61.00
62.00


63.00
64.00
65.00

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-22**

Log Type: ***Composite***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425544E 558397N** Elevation: **21.937m**

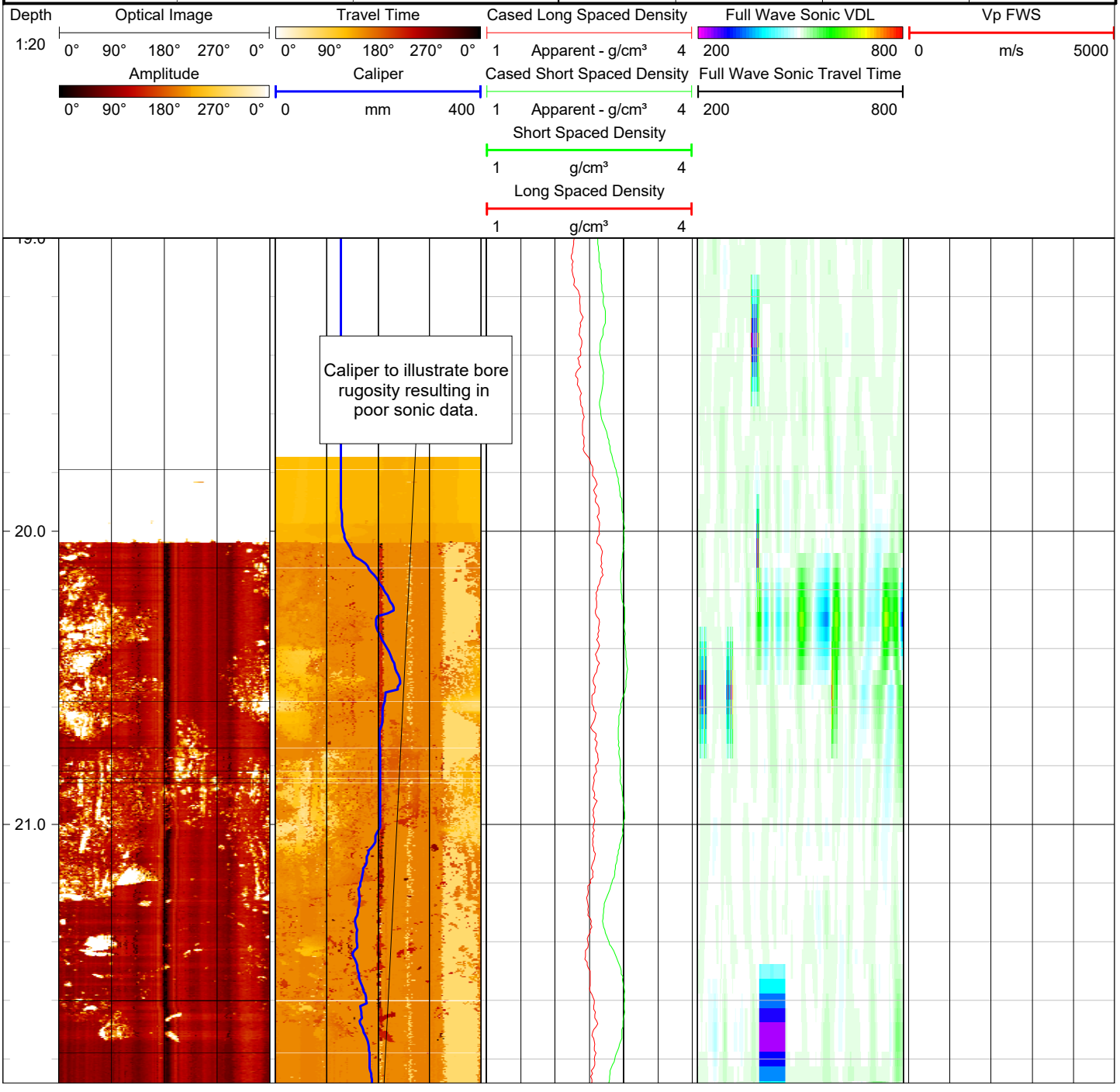
Drilled Depth: (m)	**70.0***	Date:	**02.05.18 & 10.05.18**
Logged Depth: (m)	**61.56**	Recorded By:	**M. Hand/R. Jennins**
Logging Datum:	**Ground Level**	Remarks:	
Logged Interval: (m)	**34.8 - 62.4**		
Fluid Level: (m)	**26.1**	**Ref:**	**CA B2C BH17-22 Composite Field.WCL**

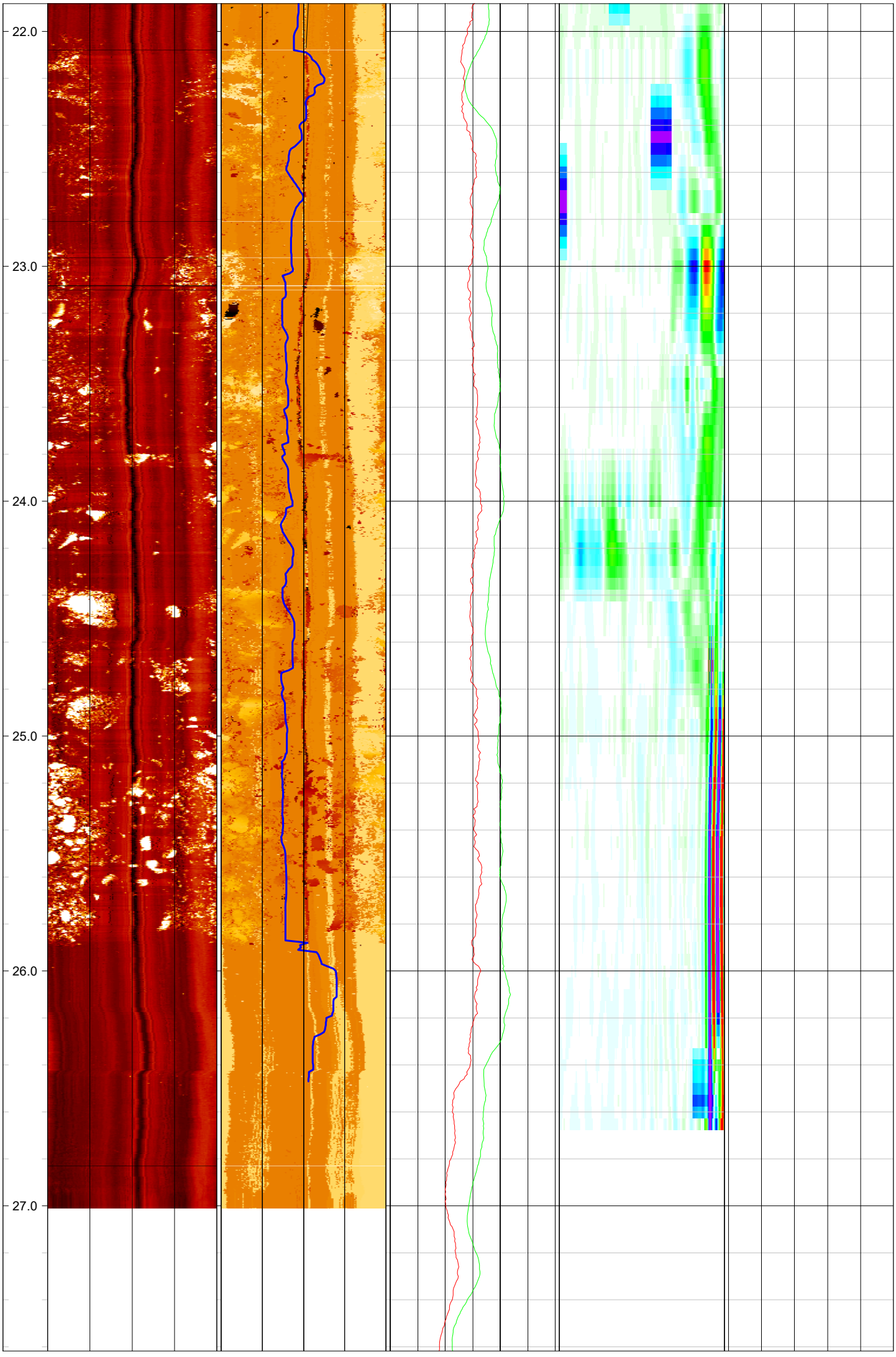
BOREHOLE RECORD

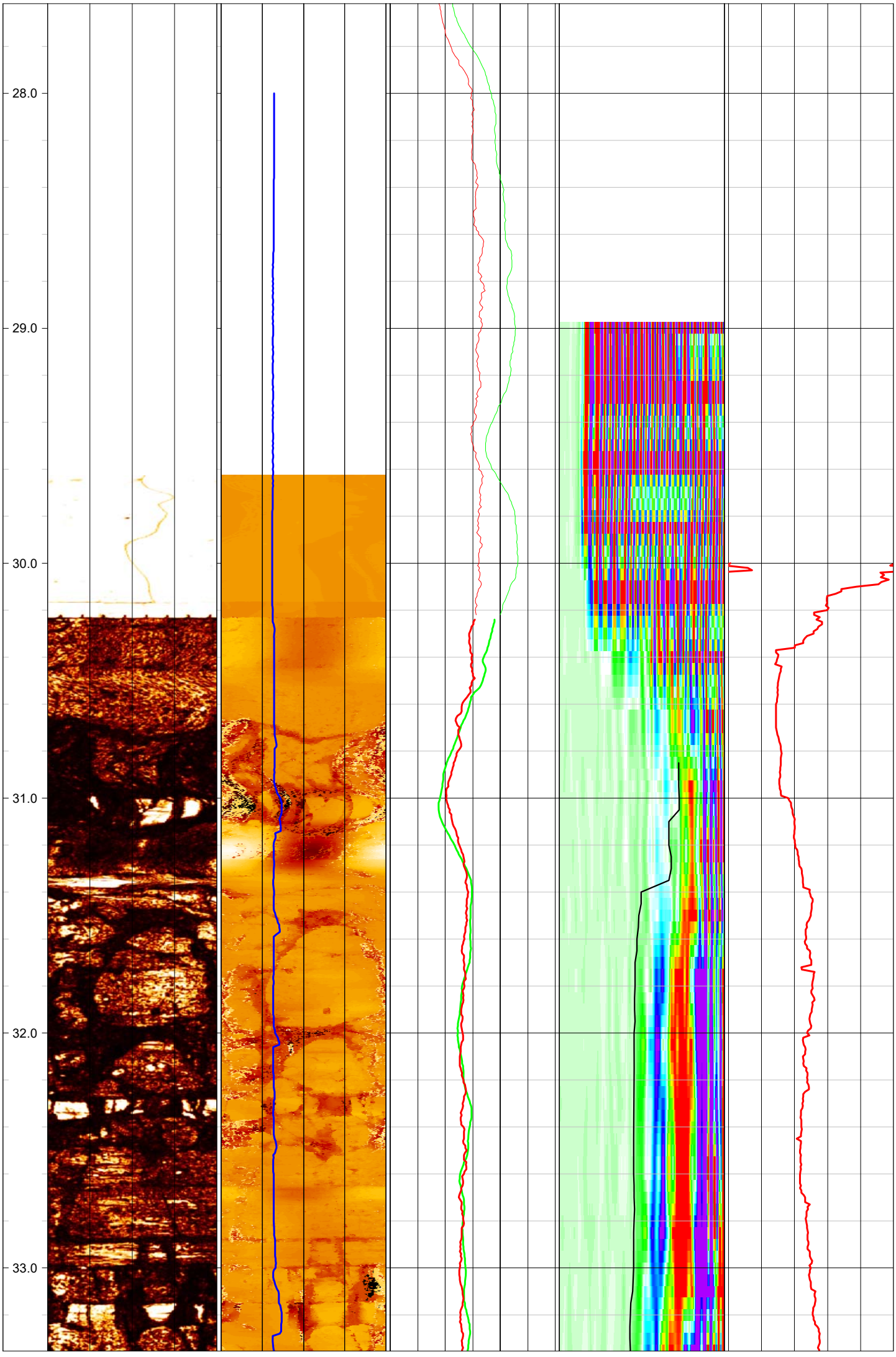
Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**20**
123	**20**	**45.8**
101	**45.8**	**70.0**

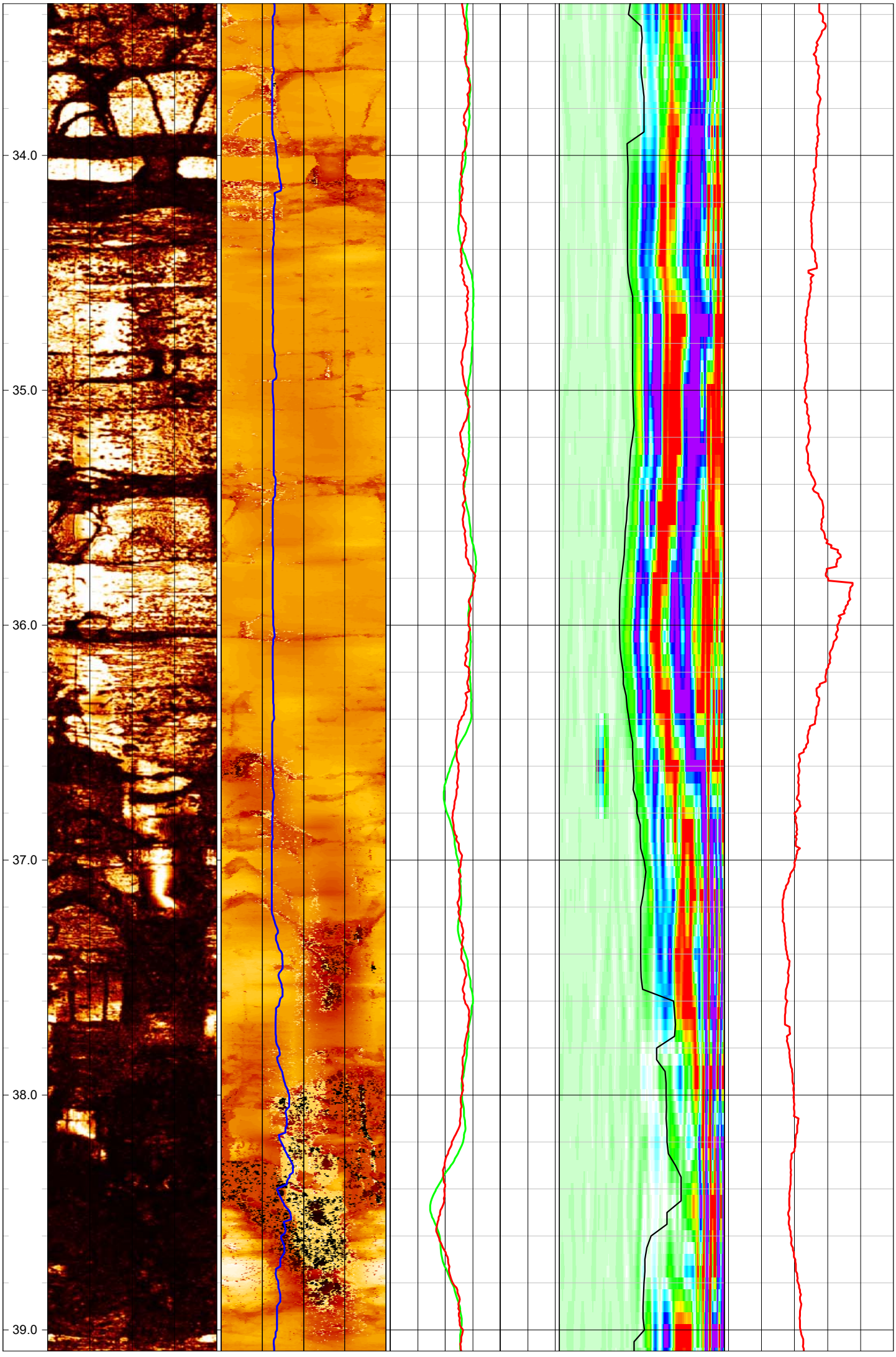
CASING RECORD

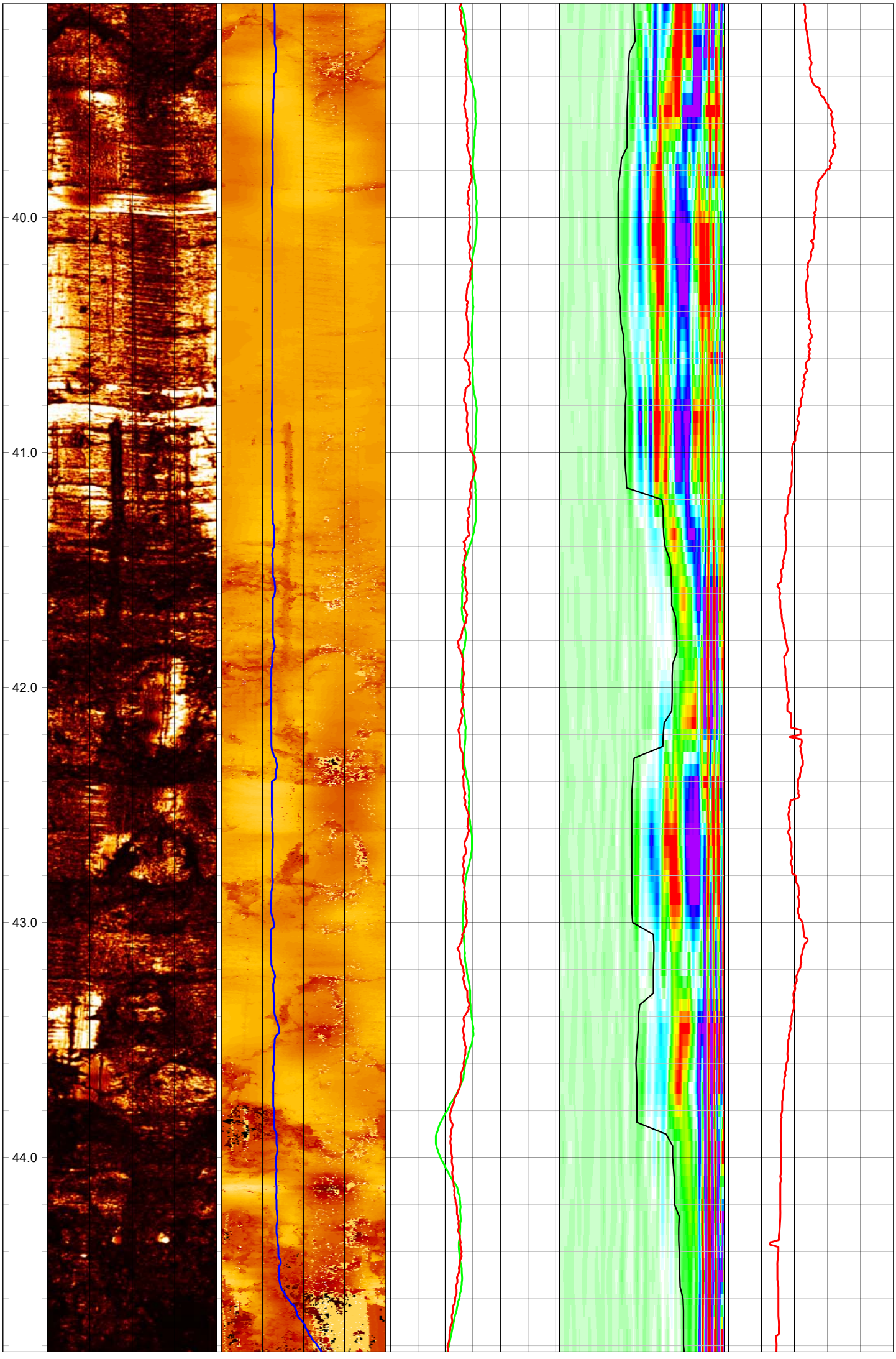
Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**0**	**20**

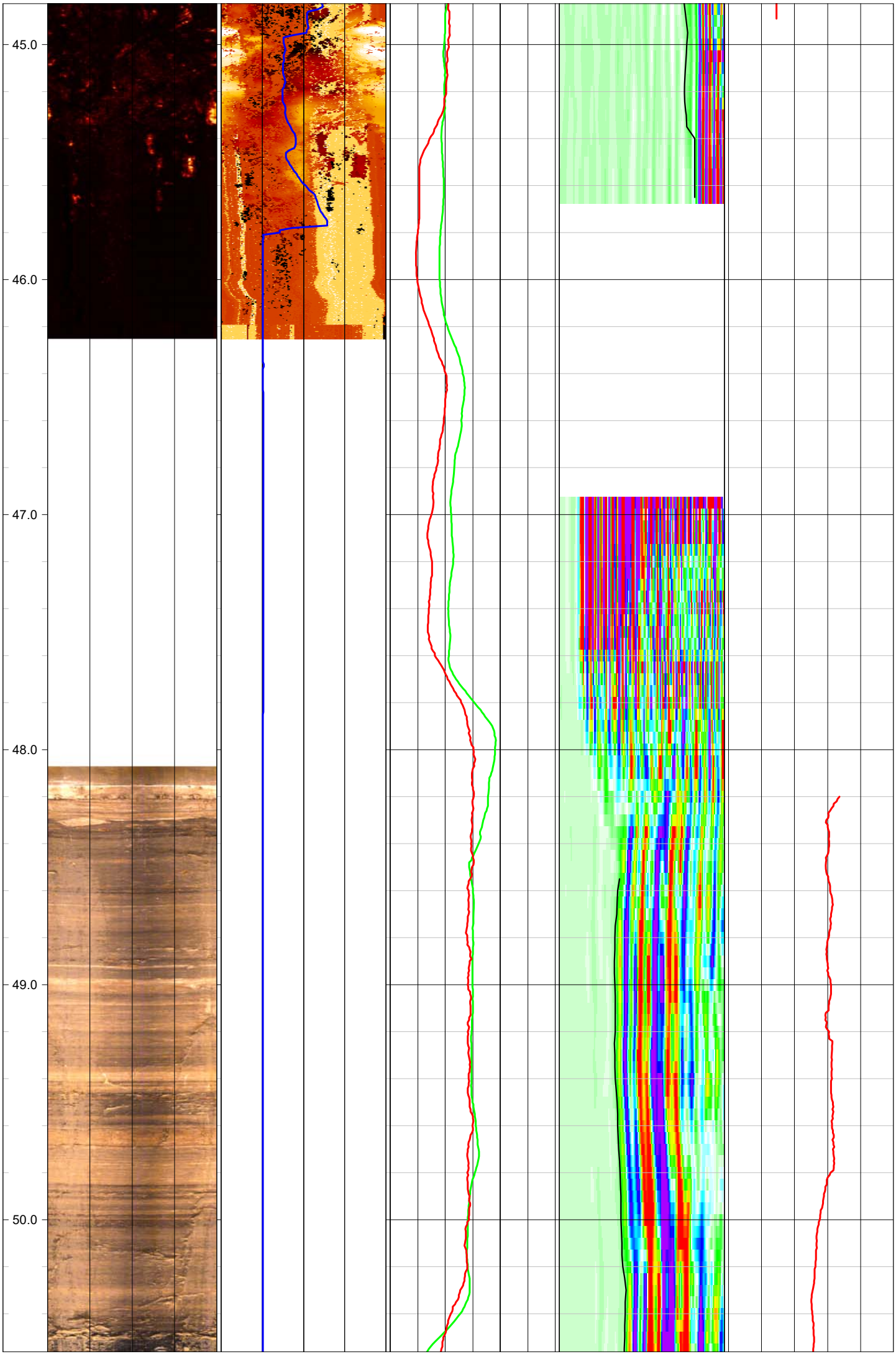


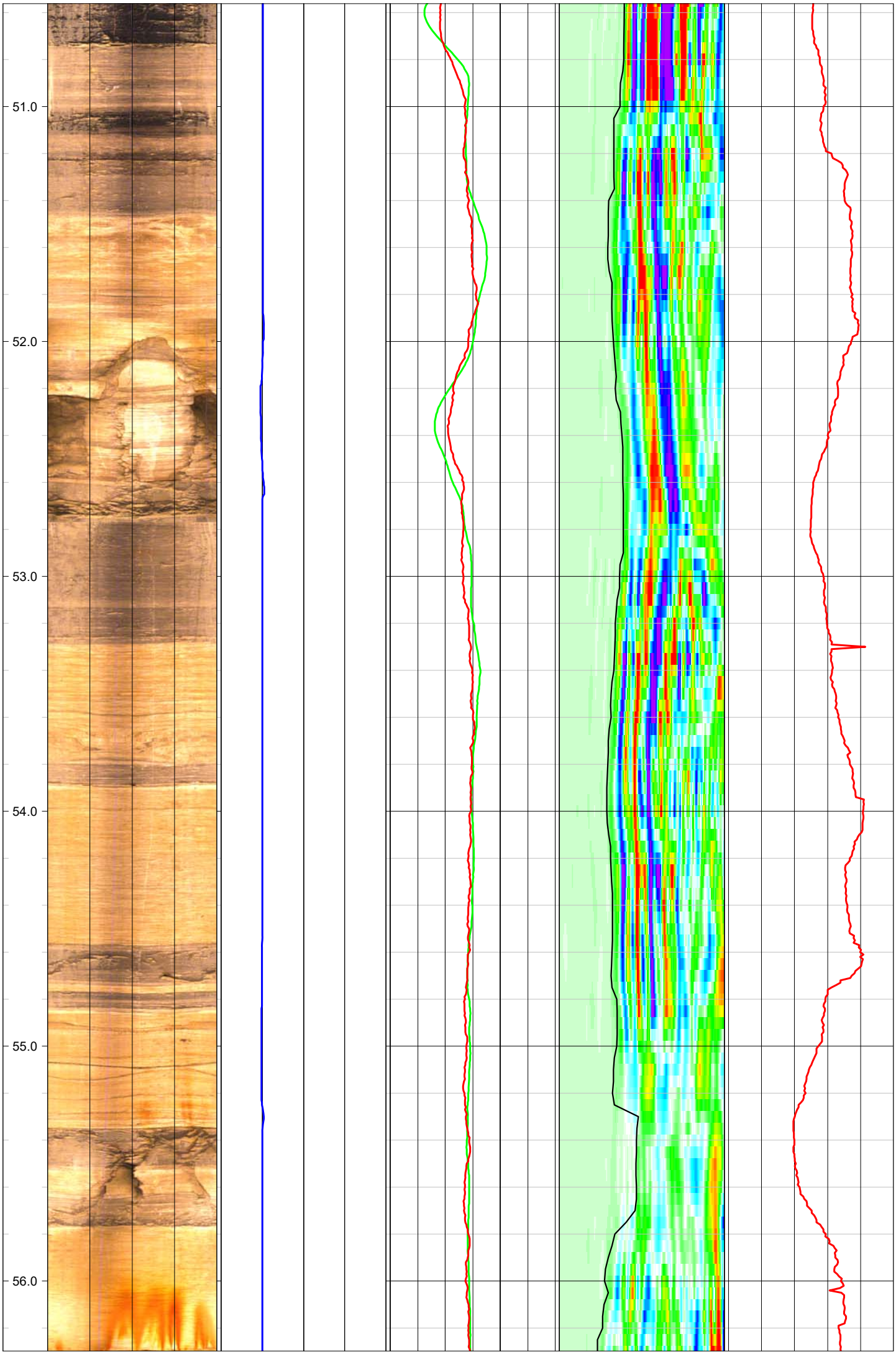

22.0
23.0
24.0
25.0
26.0
27.0

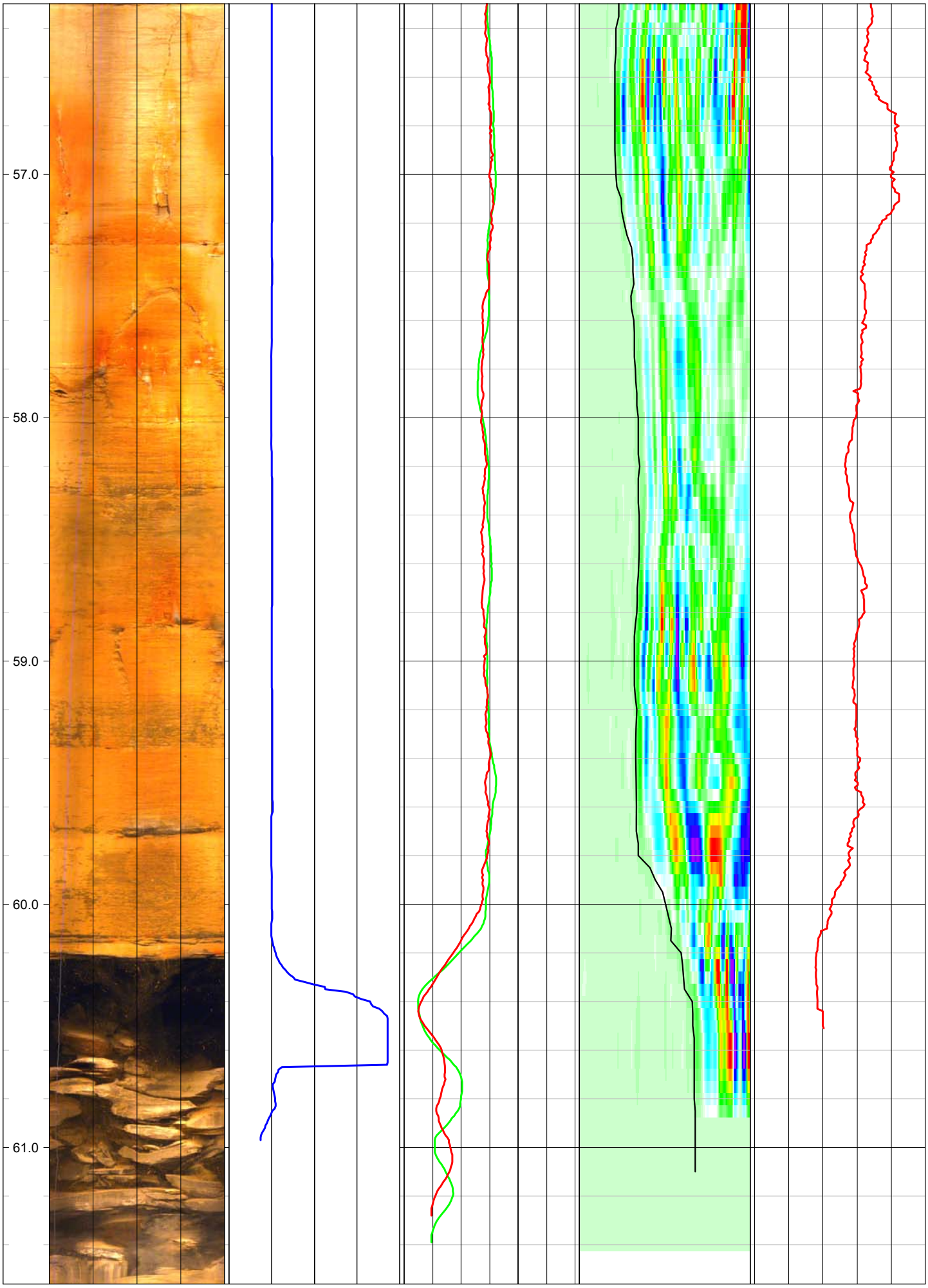

28.0
29.0
30.0
31.0
32.0
33.0


34.0
35.0
36.0
37.0
38.0
39.0


40.0
41.0
42.0
43.0
44.0


45.0
46.0
47.0
48.0
49.0
50.0


51.0
52.0
53.0
54.0
55.0
56.0


57.0
58.0
59.0
60.0
61.0

EUROPEAN GEOPHYSICAL SERVICES LTD

Client: **Central Alliance**

Borehole: **BH17-22**

Log Type: ***Image***

Location: **A1 B2CH** Area: **Gateshead** Grid Ref: **425544E 558397N** Elevation: **21.937m**

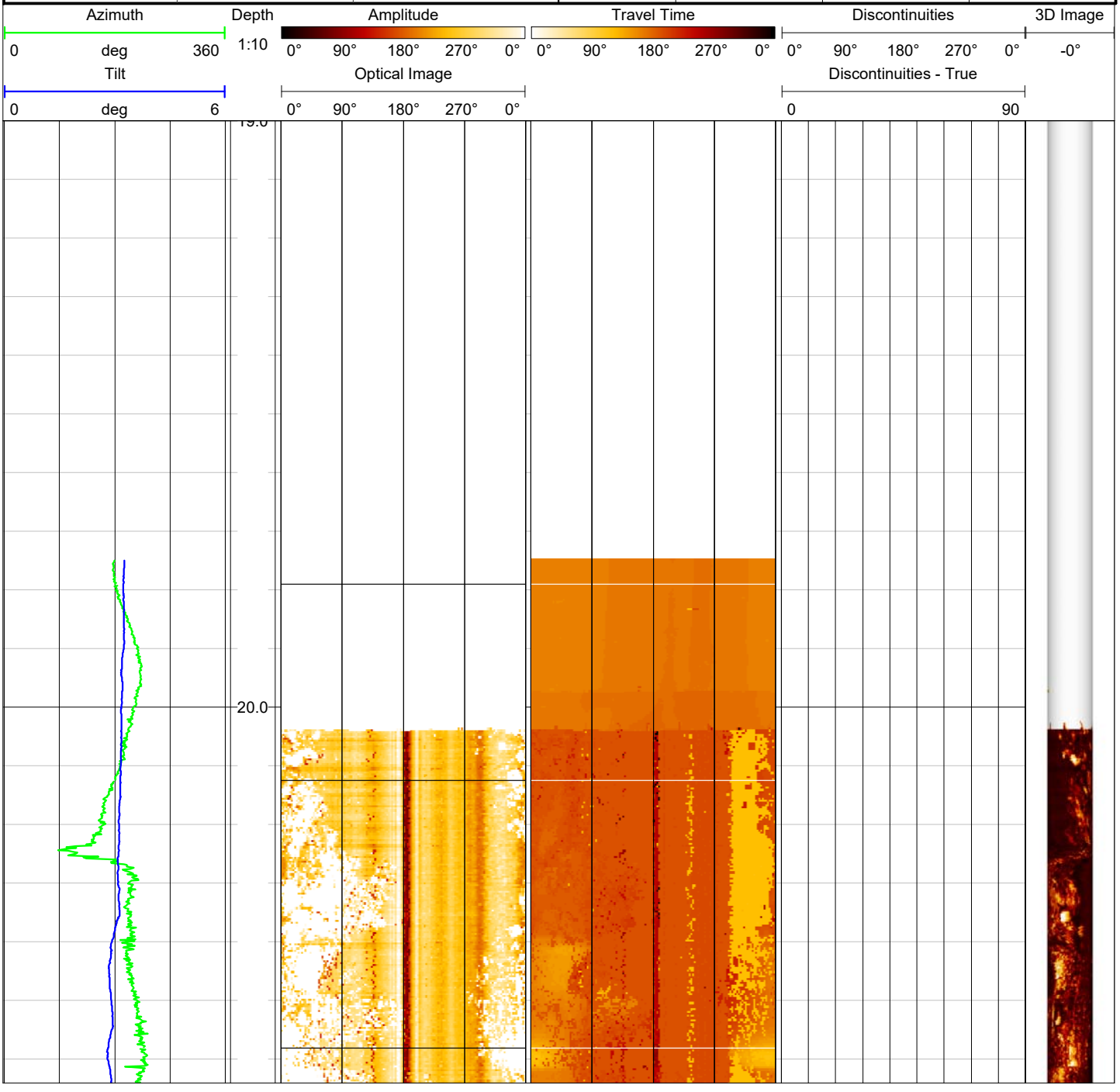
Drilled Depth: (m)	**70.0***	Date:	**02.05.18 & 10.02.18**
Logged Depth: (m)	**61.56**	Recorded By:	**M. Hand/R. Jennins**
Logging Datum:	**Ground Level**	Remarks:	Density not run between 20 - 27m due to BH instability
Logged Interval: (m)	**0 - 61.56**		
Fluid Level: (m)	**Variable**	**Ref:**	**CA B2C BH17-22 Image Field.wcl**

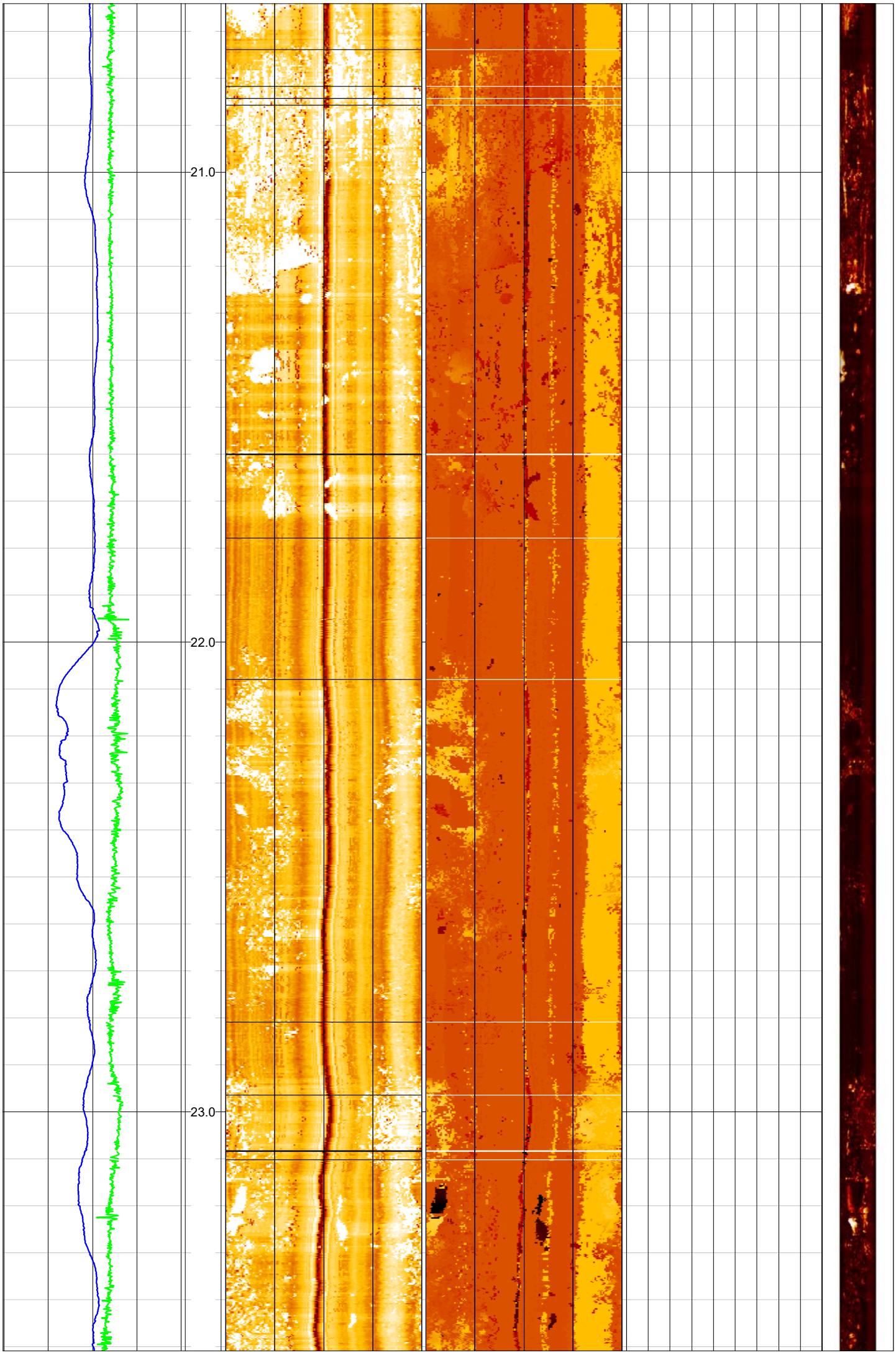
BOREHOLE RECORD

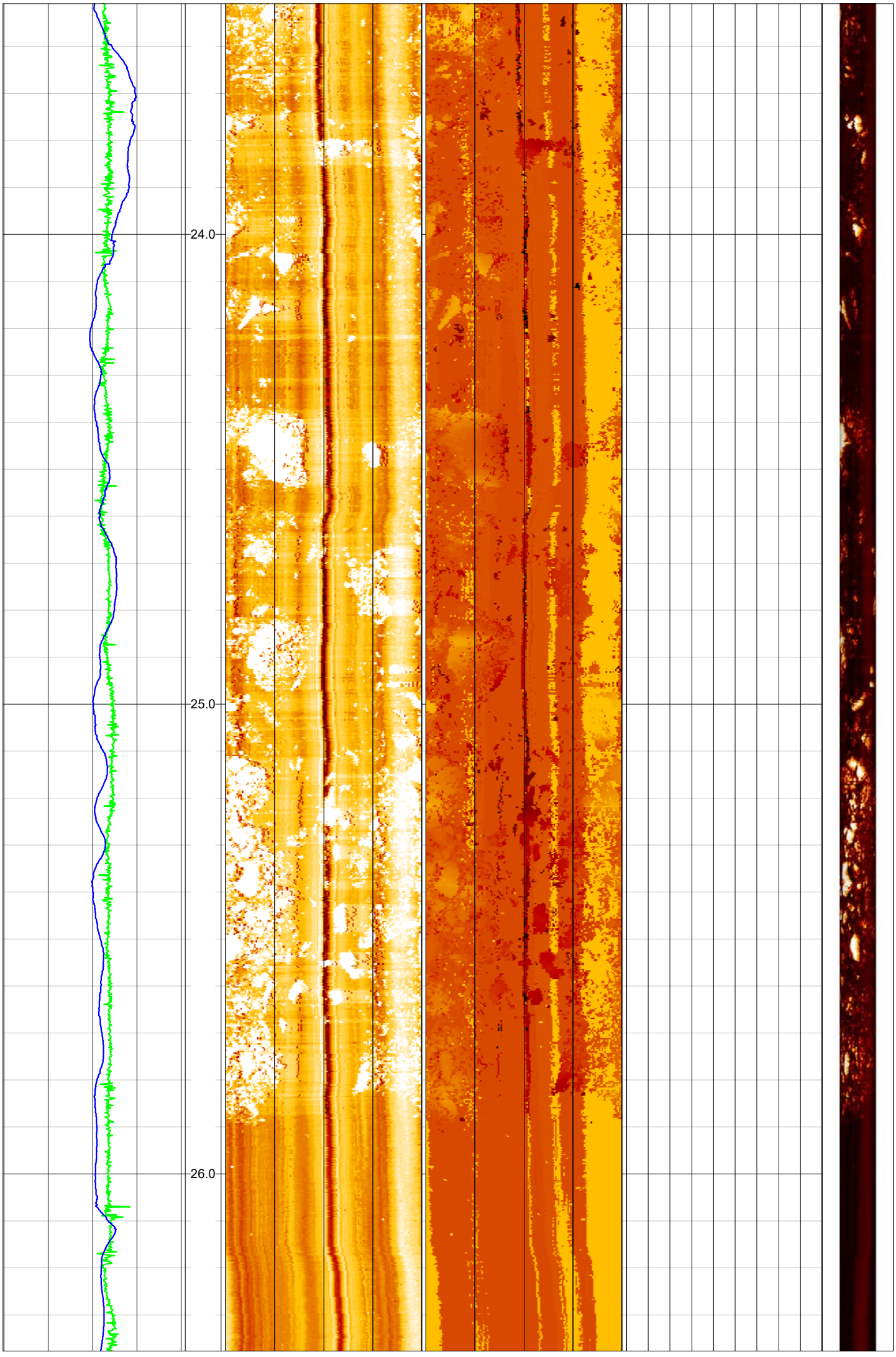
Bit: (mm)	From: (m)	To: (m)
146	**0.0**	**20**
123	**20**	**45.8**
101	**45.8**	**70.0**

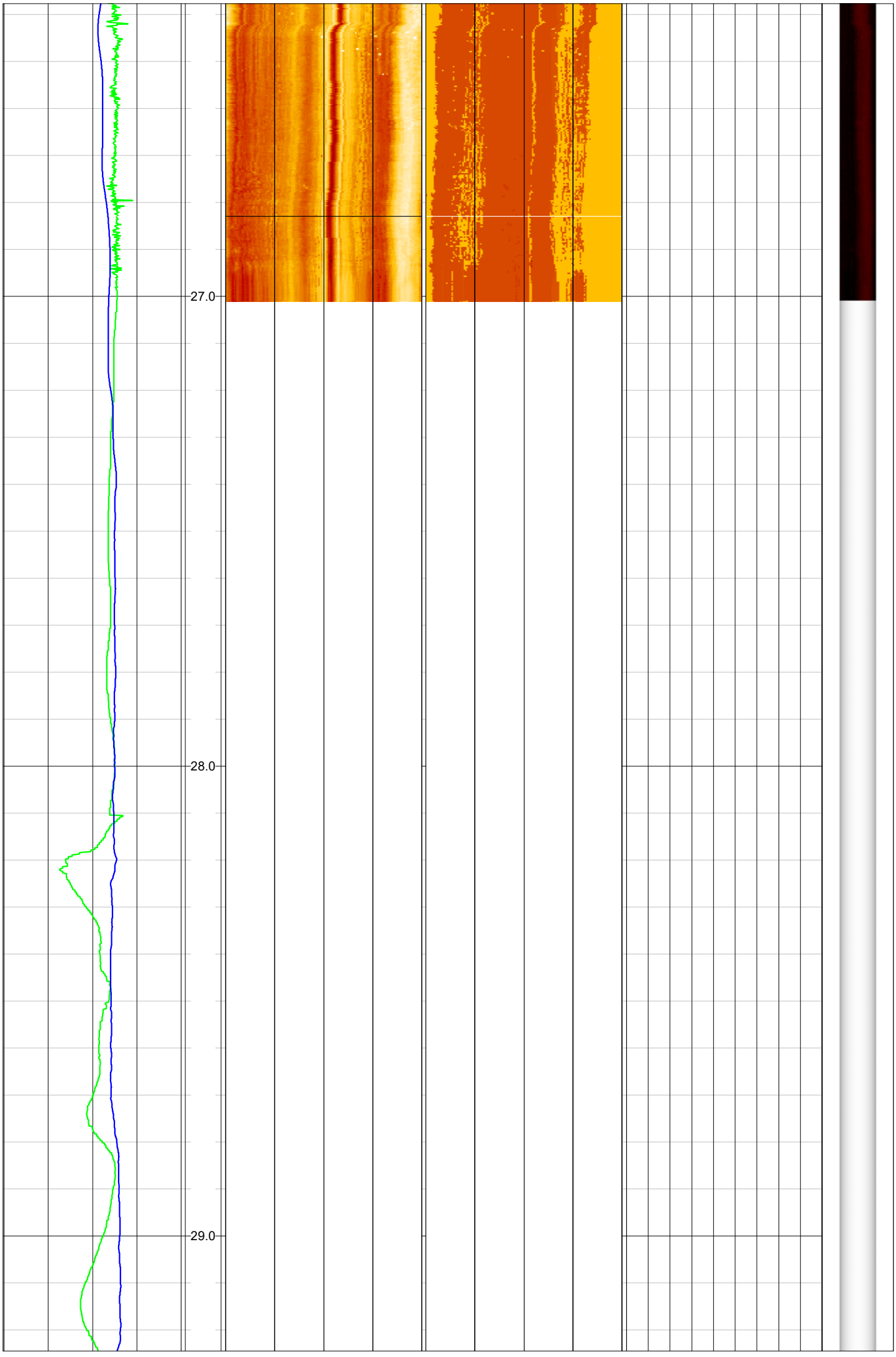
CASING RECORD

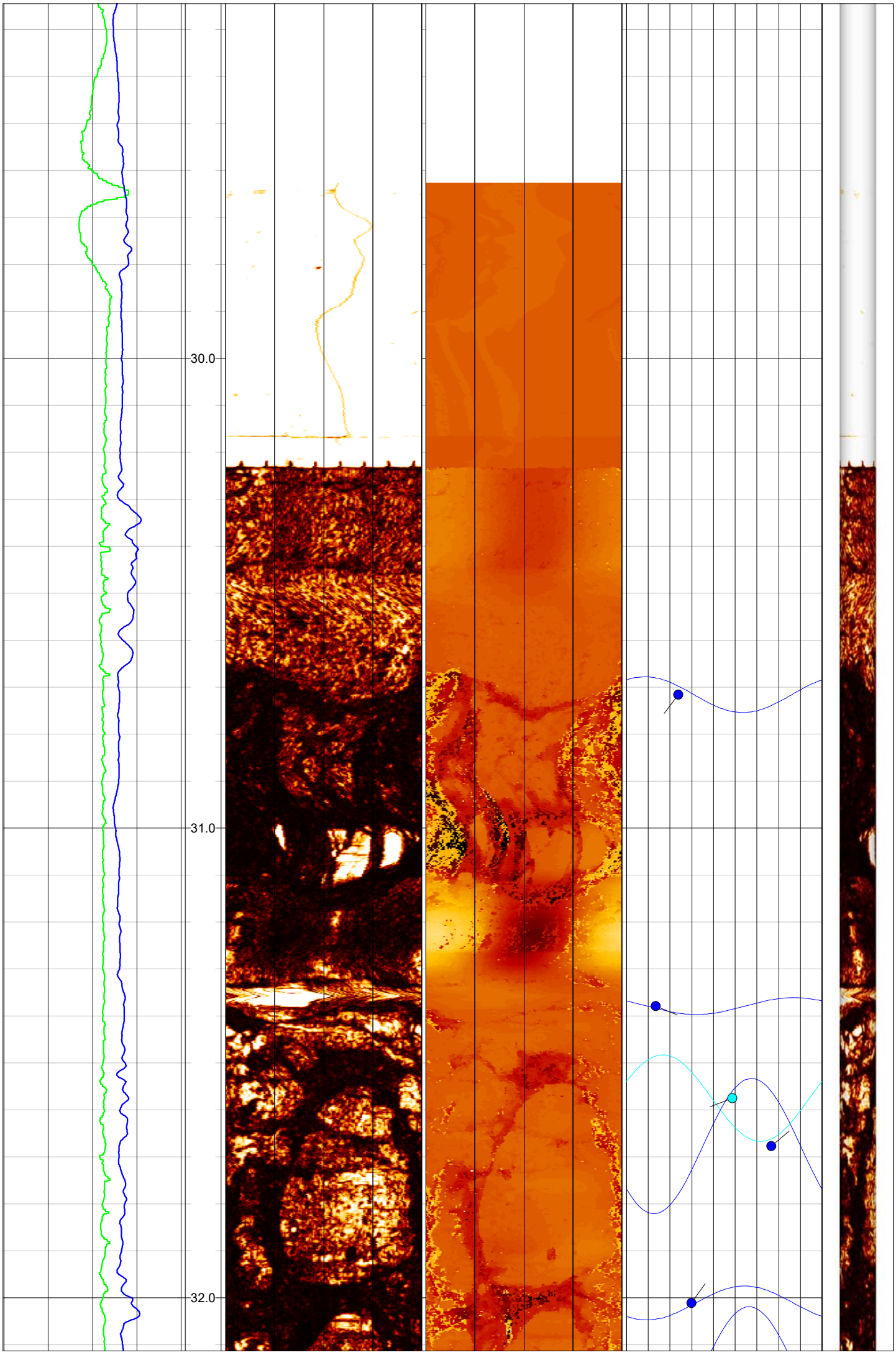
Type	Size: (mm)	From: (m)	To: (m)
Steel	**146**	**0**	**20**

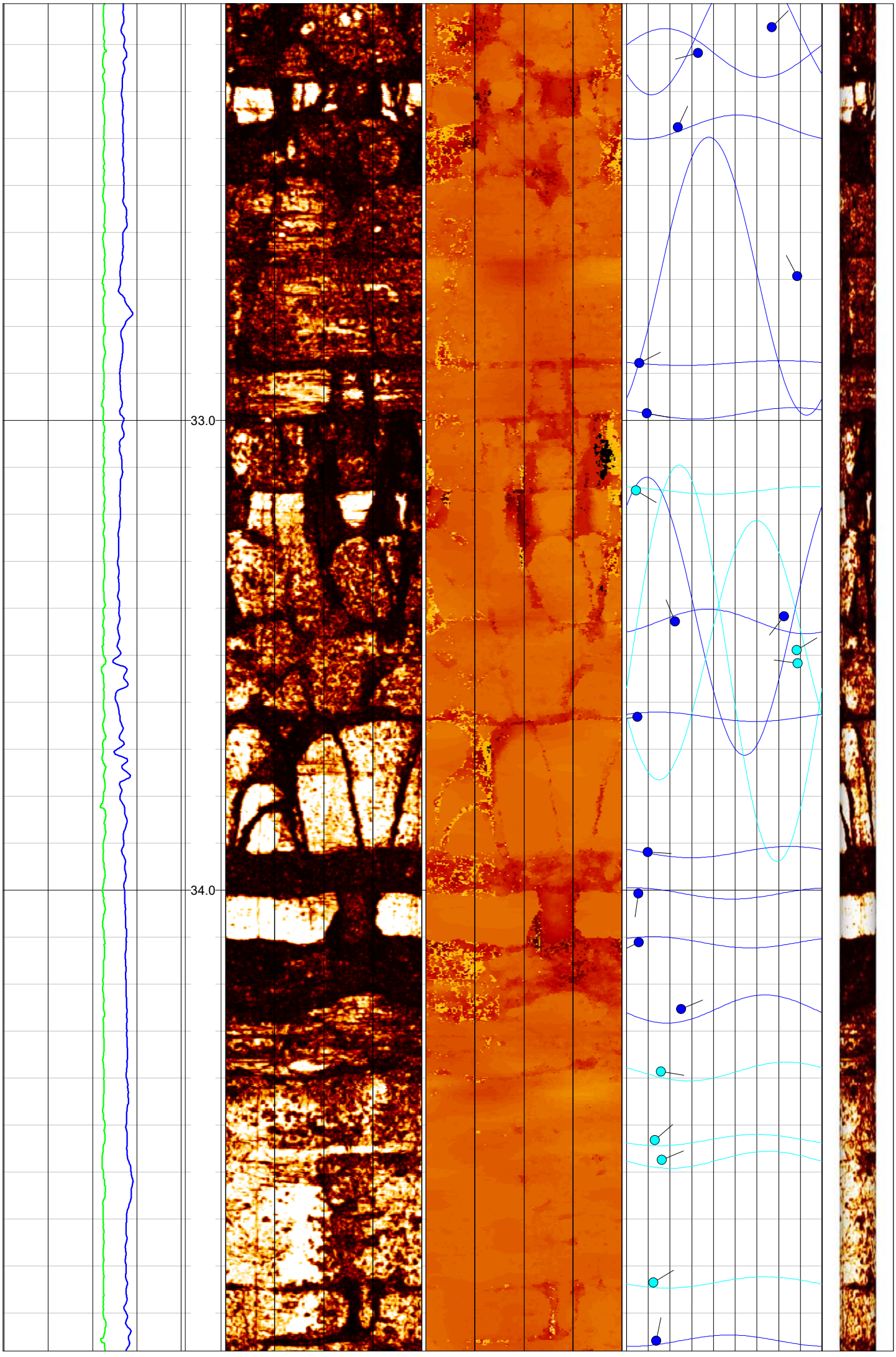


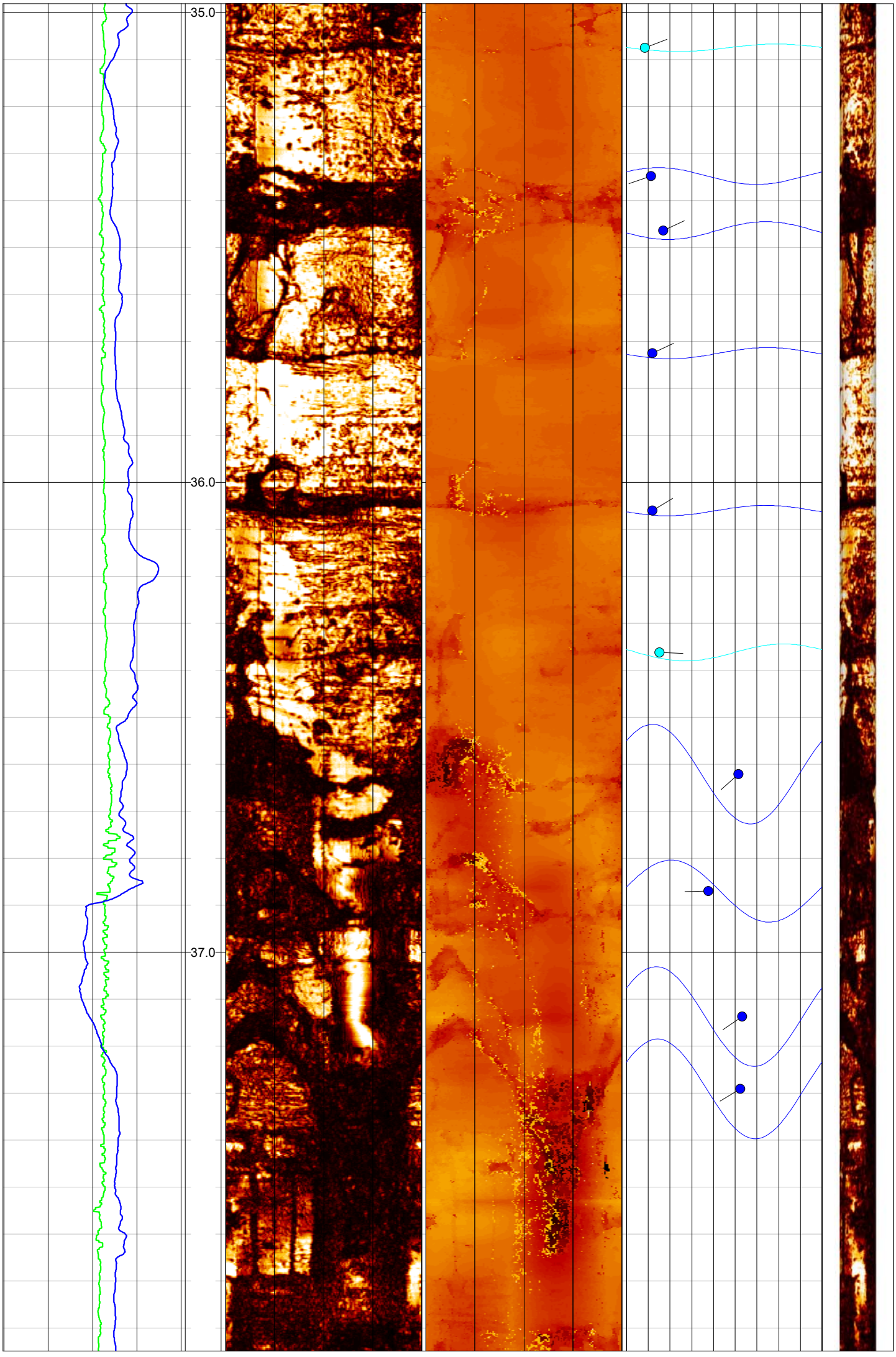

21.0
22.0
23.0

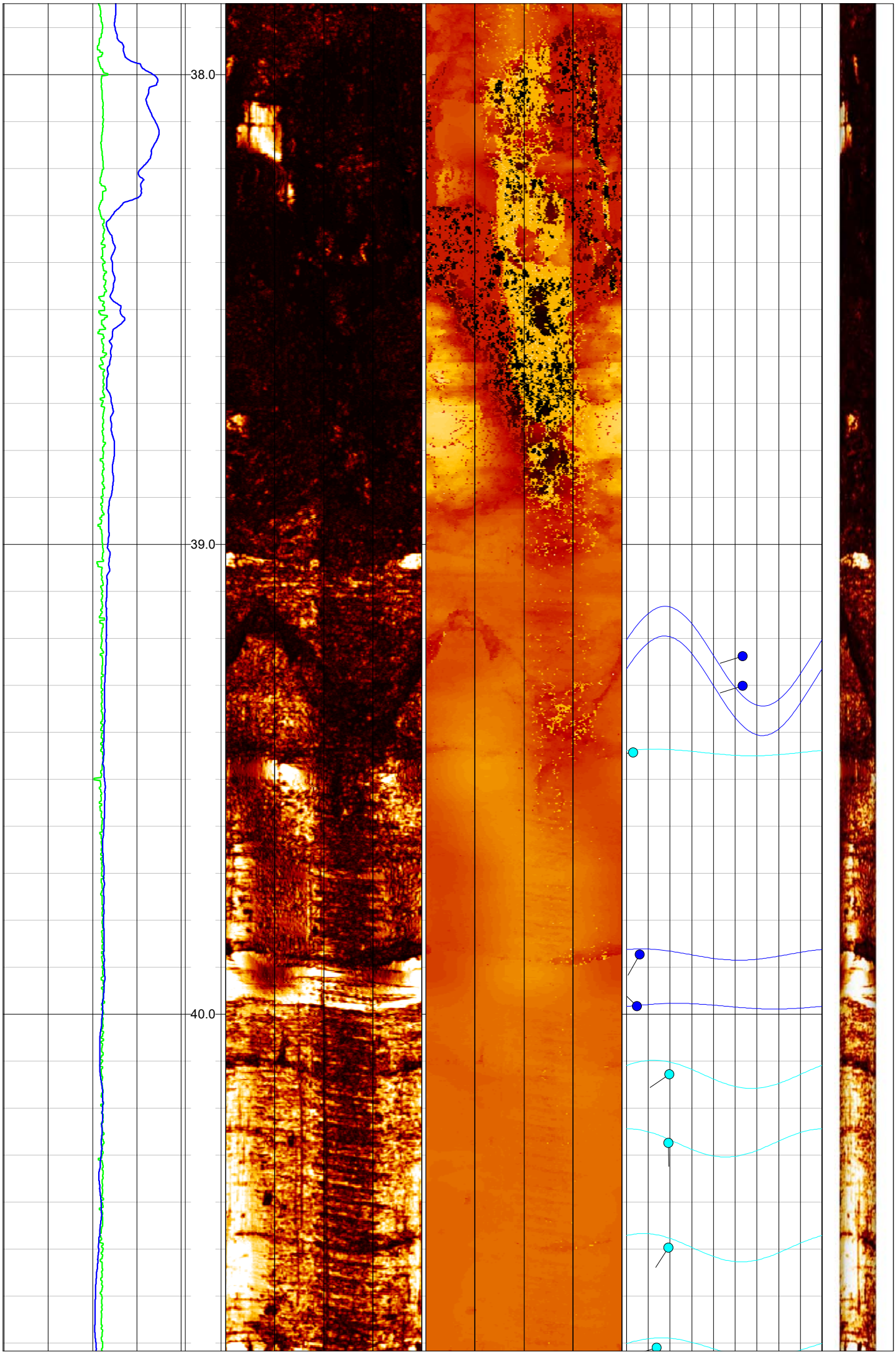

24.0
25.0
26.0

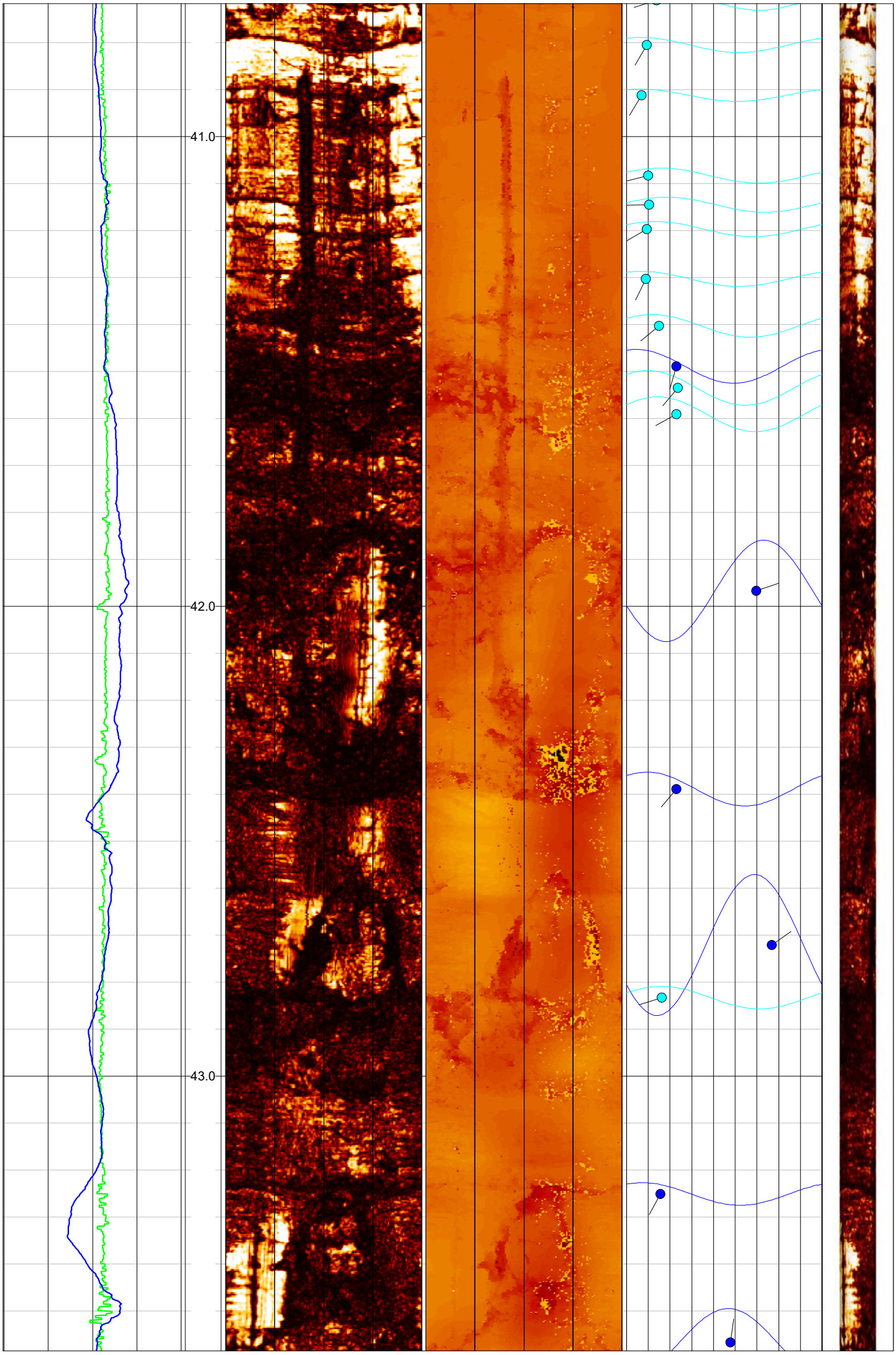

27.0
28.0
29.0

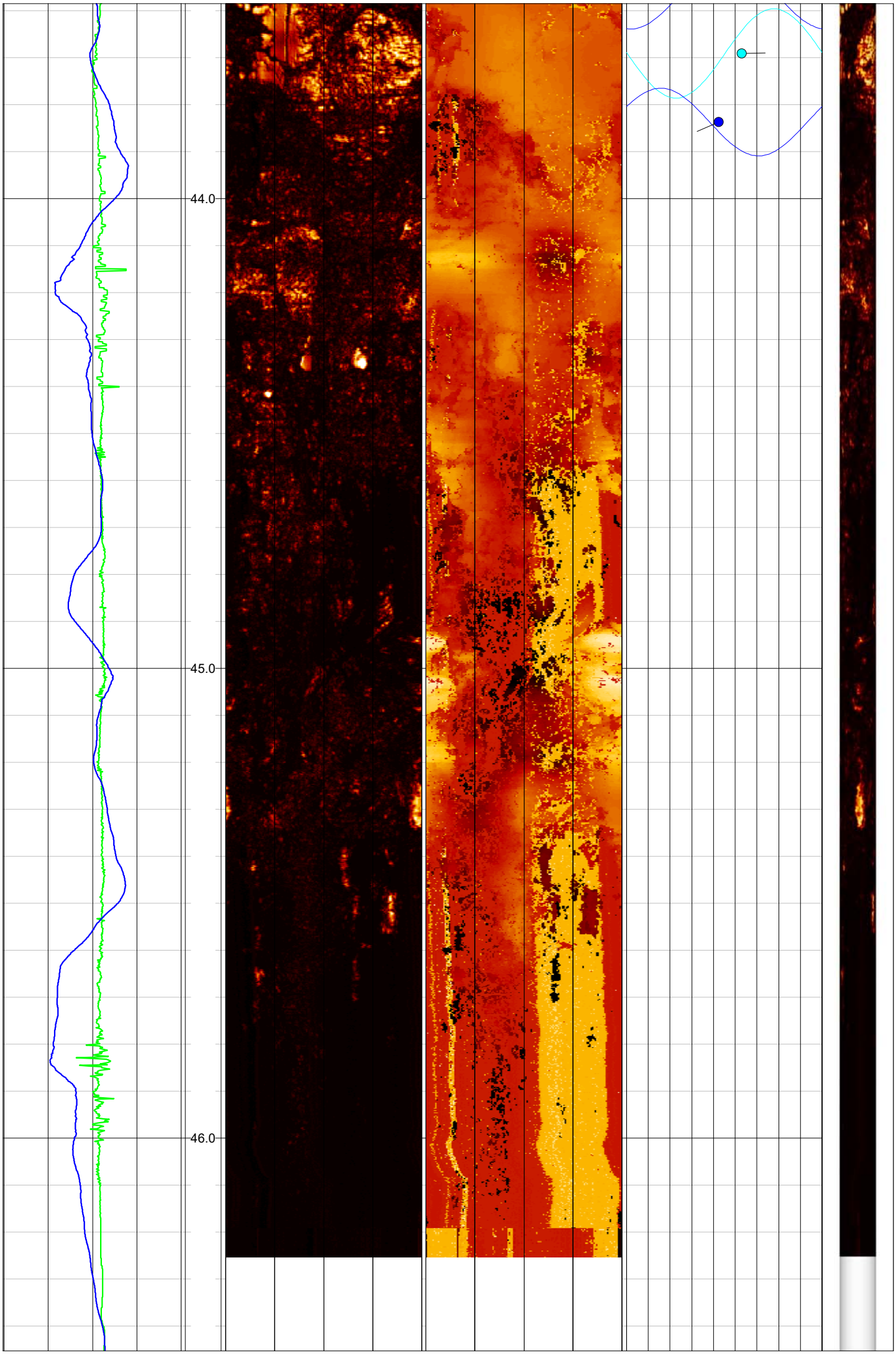

30.0
31.0
32.0

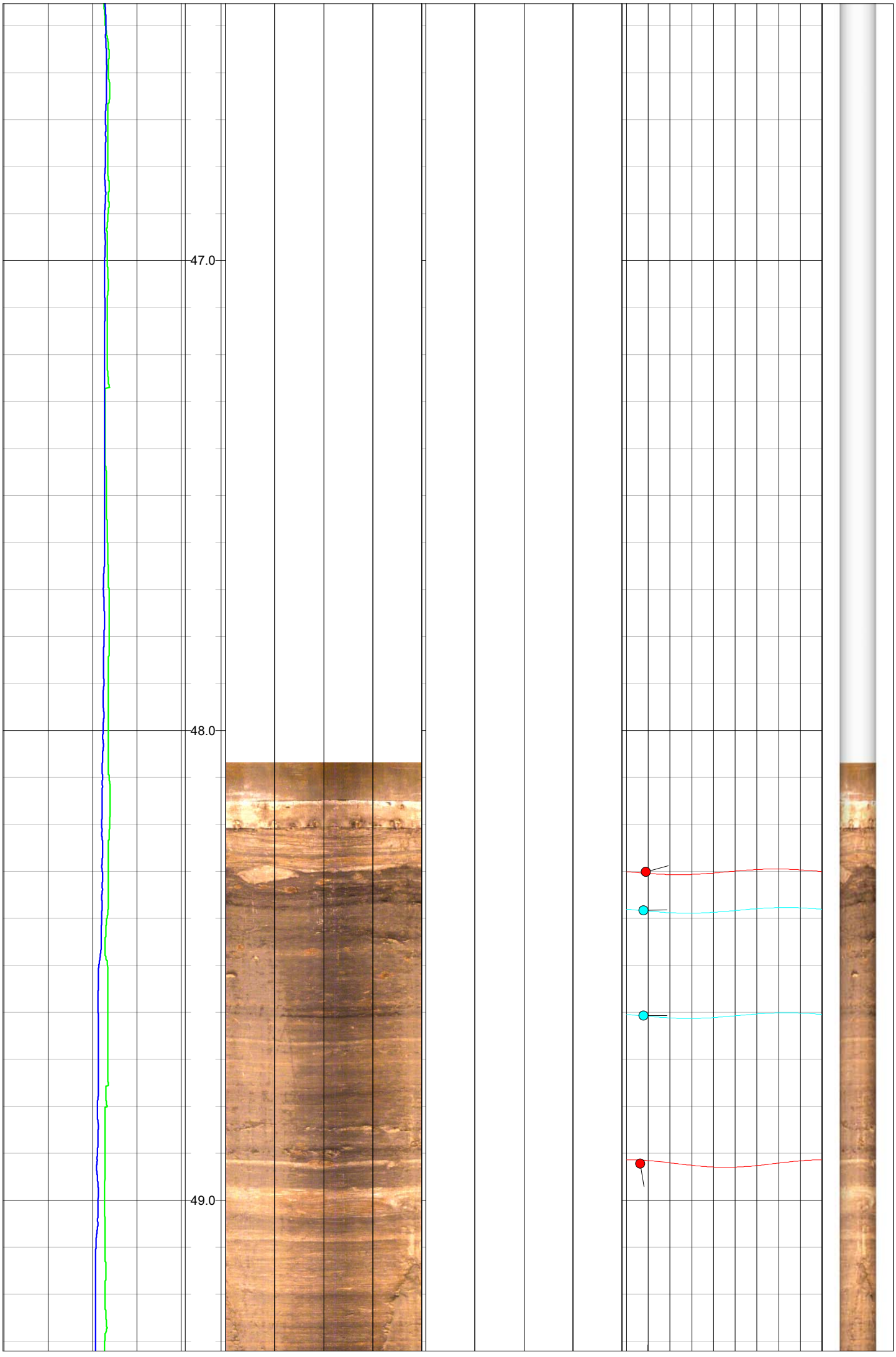

33.0
34.0

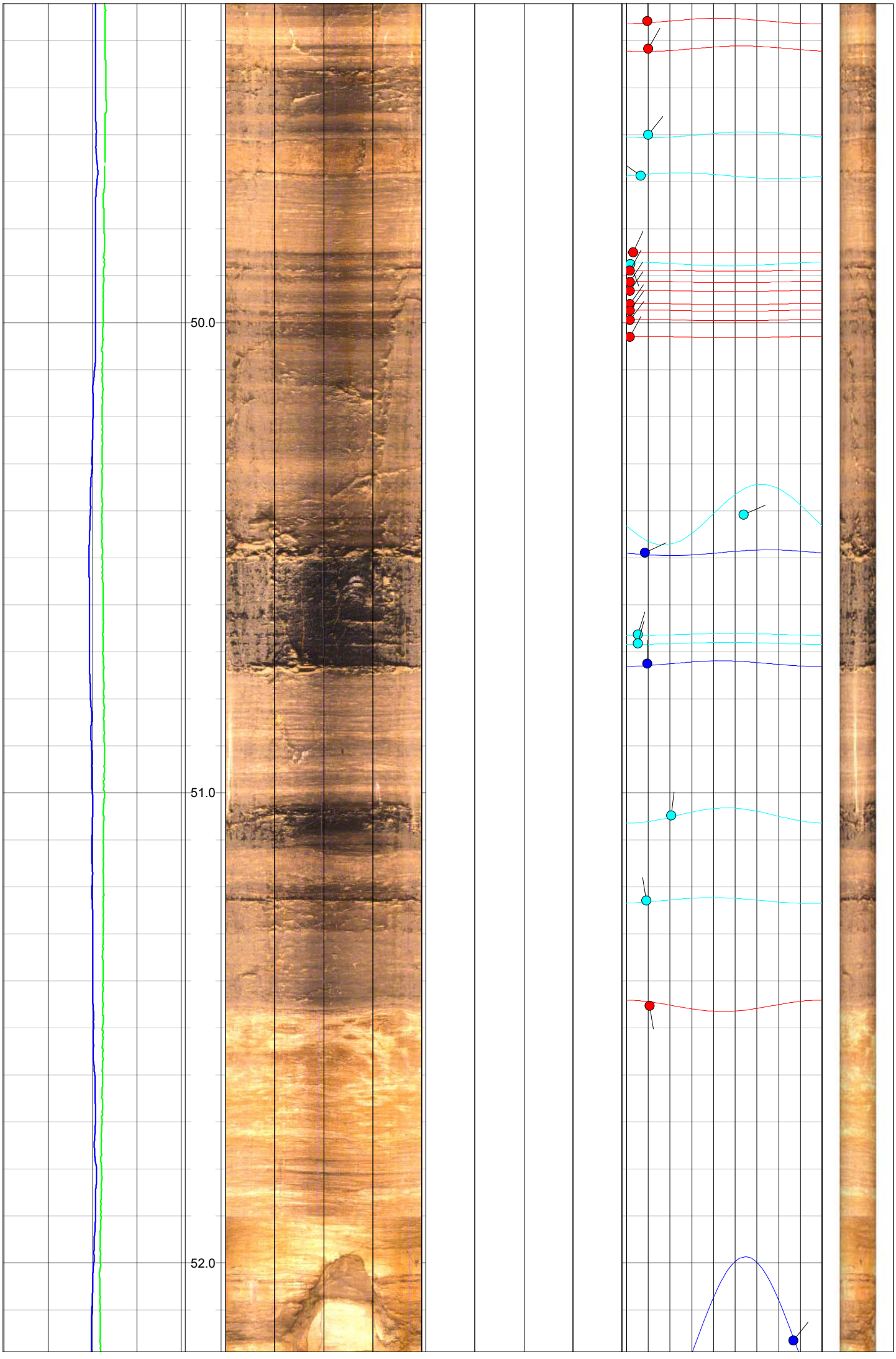

35.0
36.0
37.0

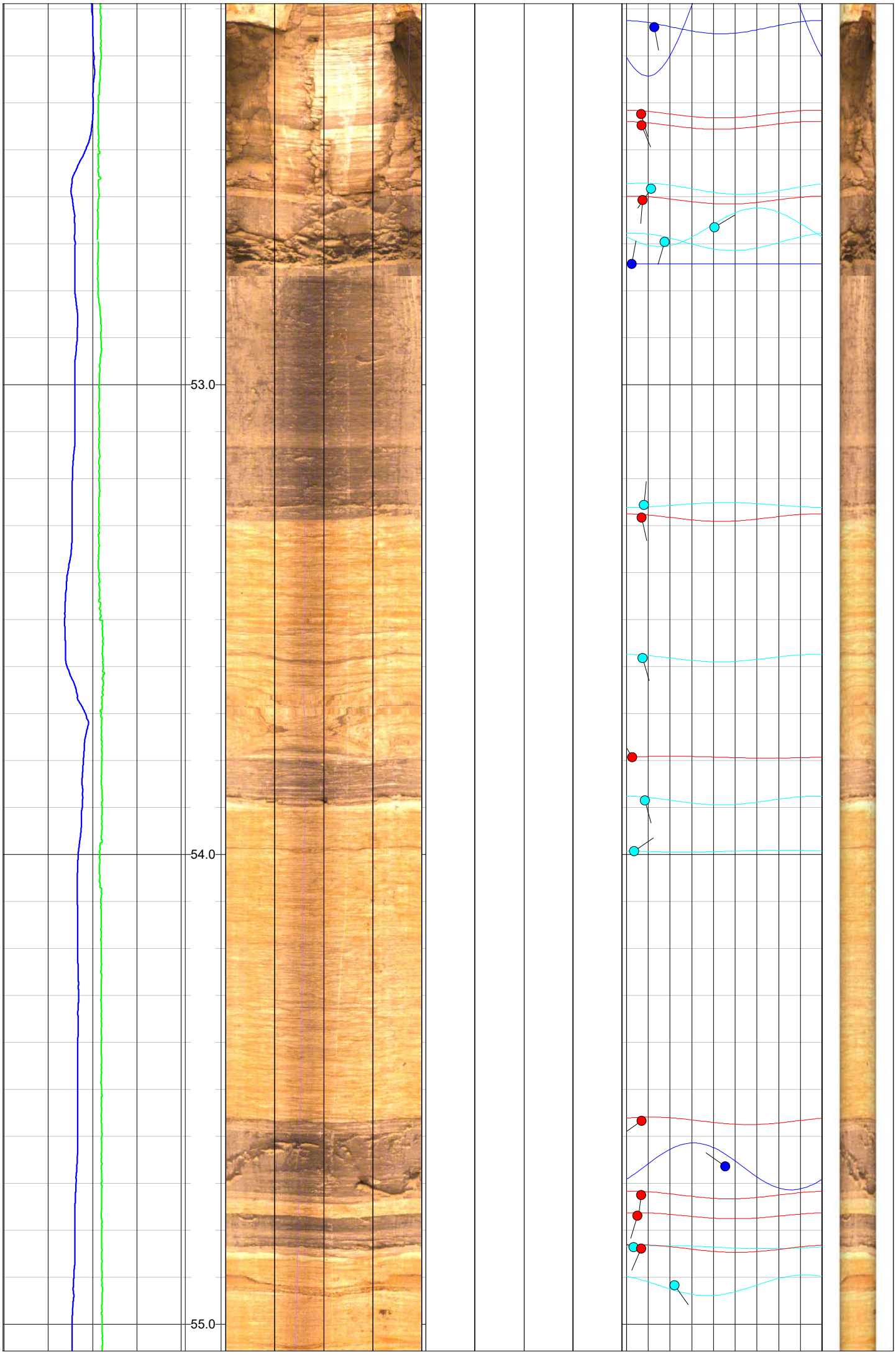

38.0
39.0
40.0

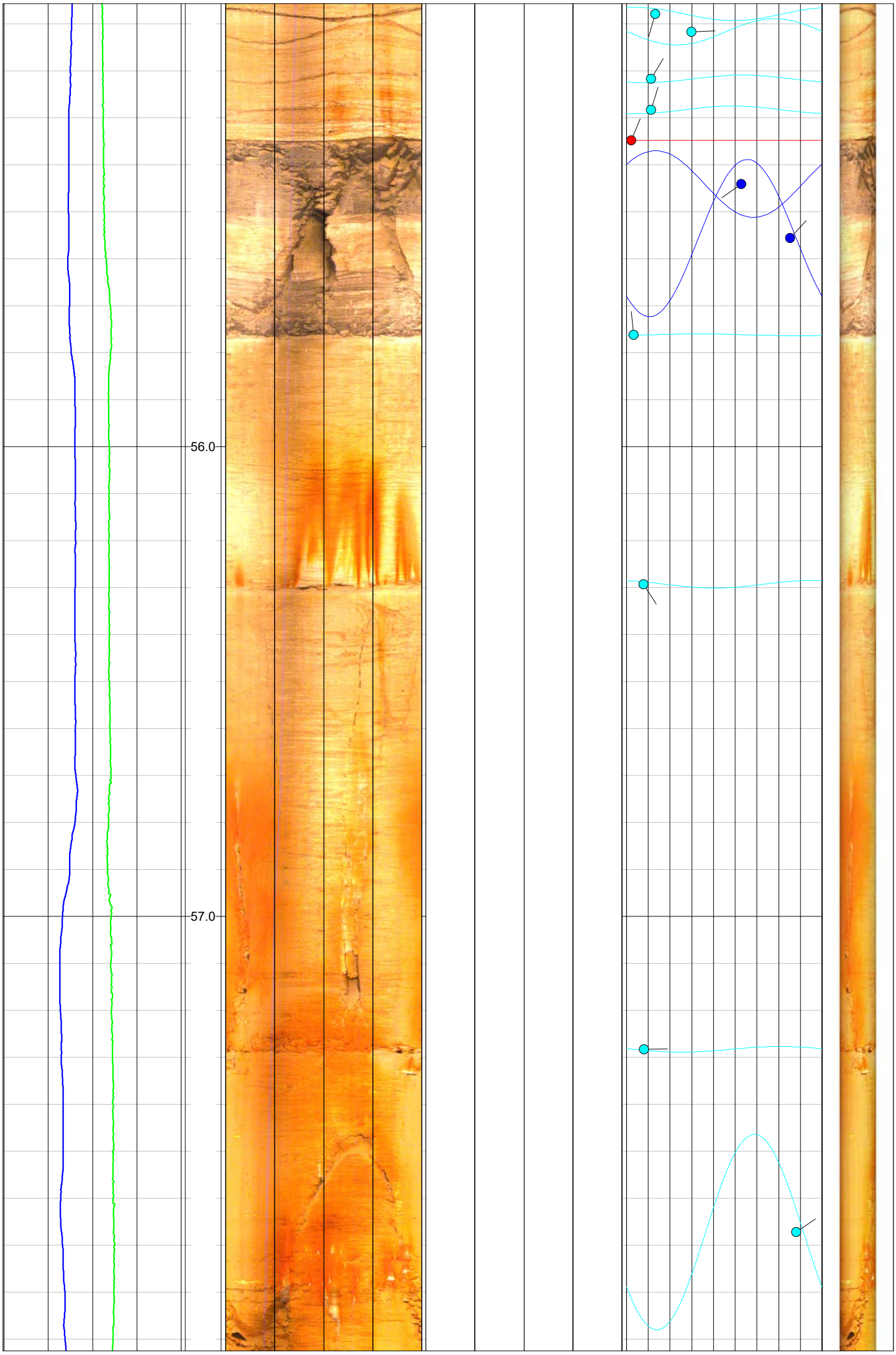

41.0
42.0
43.0

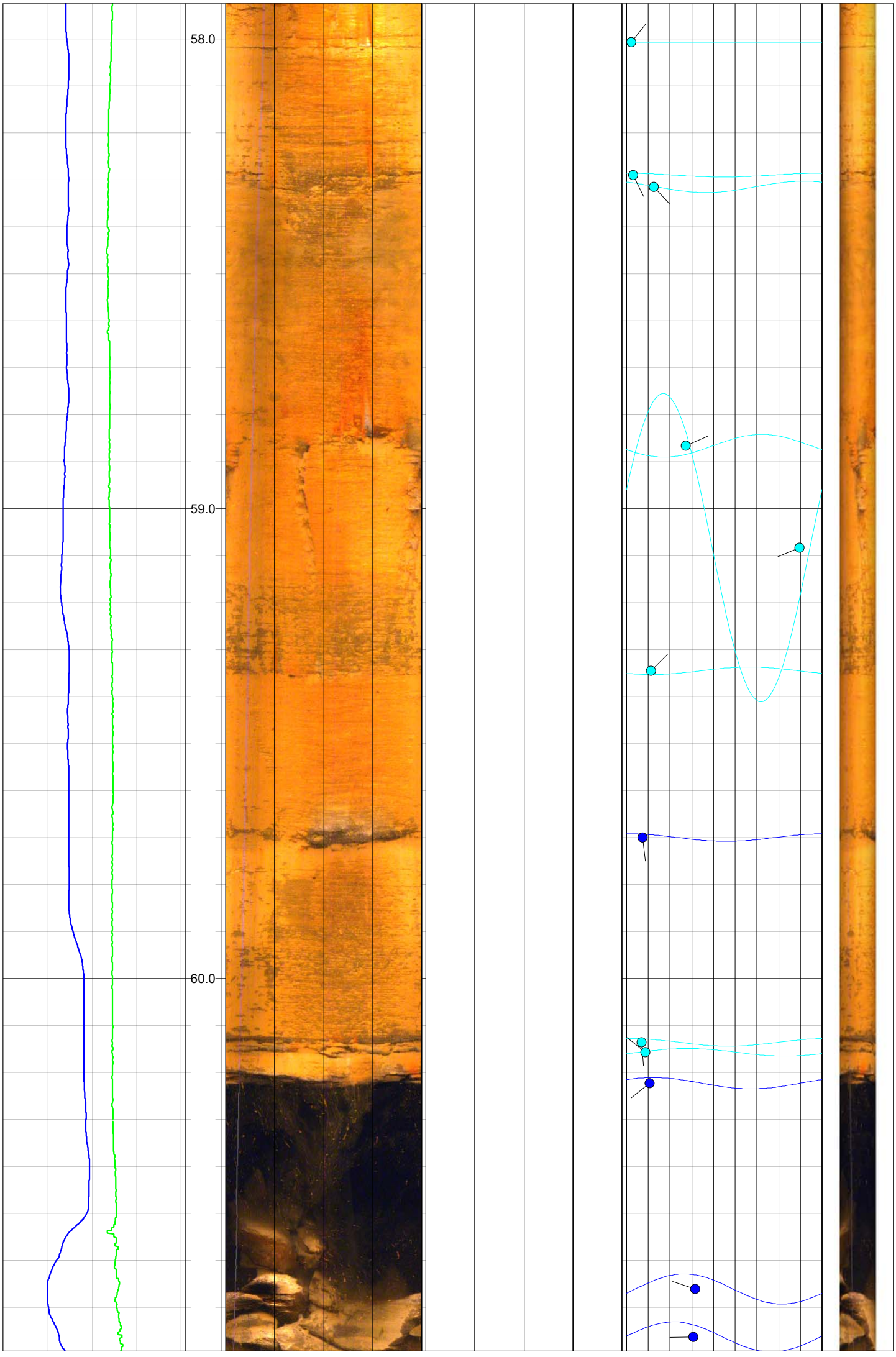

44.0
45.0
46.0

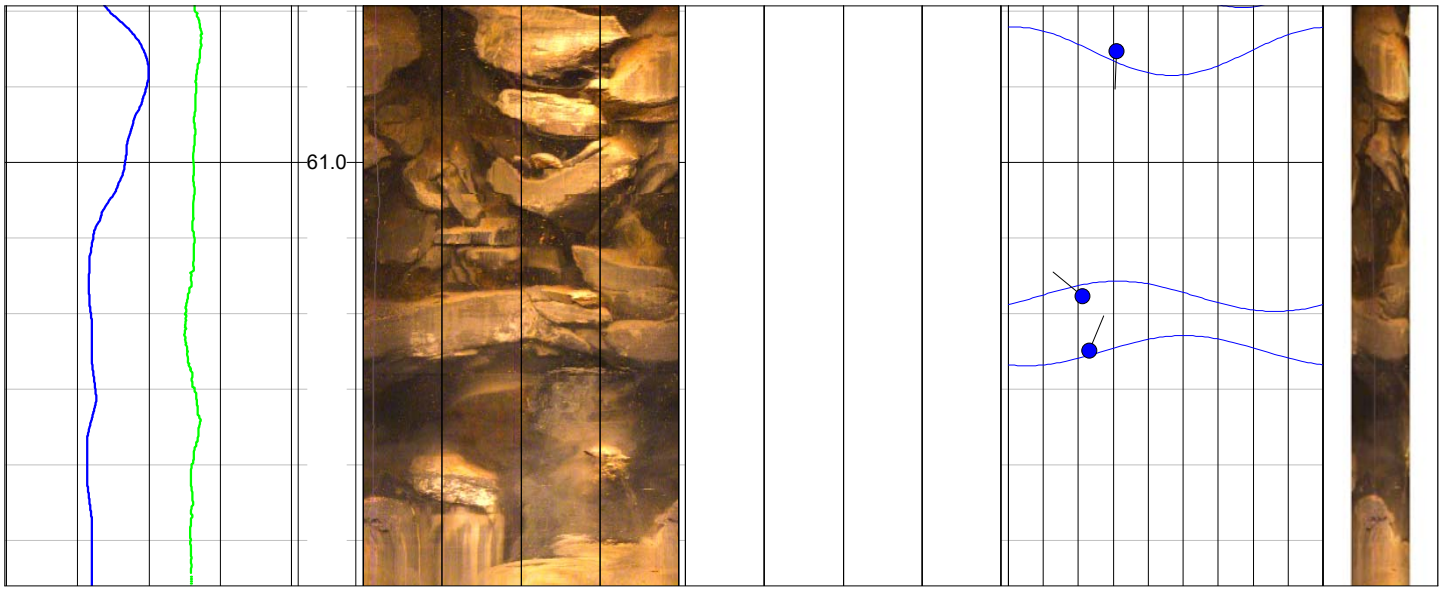

47.0
48.0
49.0


50.0
51.0
52.0


53.0
54.0
55.0


56.0
57.0


58.0
59.0
60.0


61.0

APPENDIX E
MINESHAFT SURVEY REPORTS

If you need help accessing this or any other Highways England information, please call **0300 470 4580** and we will help you.

This document is also available on our website at **www.gov.uk /highways**

If you have any enquiries about this document A1BirtleytoCoalhouse@highwaysengland.co.uk or call **0300 470 4580***.

*Calls to 03 numbers cost no more than a national rate call to an 01 or 02 number and must count towards any inclusive minutes in the same way as 01 and 02 calls.
These rules apply to calls from any type of line including mobile, BT, other fixed line or payphone. Calls may be recorded or monitored.

Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ
Highways England Company Limited registered in England and Wales number 09346363