

WATERLOO METRO QUARTER OVER STATION DEVELOPMENT

Environmental Impact Statement

Appendix U – Geotechnical Interpretive Report

SSD-79307746 Central Precinct

SSD-79307758 Northern Precinct

Detailed State Significant Development
Development Application

Prepared for **WL Developer Pty Ltd**

10 September 2025

Document distribution

WL Developer Pty Ltd

WATERLOO METRO QUARTER OVER STATION DEVELOPMENT

Geotechnical Interpretive Report

2025-09-10

Prepared for: Central Precinct SSD (SSD-79307746)

Northern Precinct SSD (SSD-79307758)

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Revisions

Rev	Date	Details
A	25.07.2025	Draft for Review
B	1.09.2025	SSDA Draft Submission
C	10.09.2025	SSDA Final Submission

Table of contents

Abbreviations and glossary	7
Executive summary	10
1. Introduction	11
2. The site	13
3. Background	15
3.1 About Sydney Metro	15
3.1.1 Sydney Metro North West	15
3.1.2 Sydney Metro City & Southwest	15
3.1.3 Sydney Metro West	15
3.1.4 Sydney Metro Greater West	15
3.2 Sydney Metro CSSI Approval (SSI 7400)	16
4. Proposed development	18
4.1 Waterloo Metro Quarter Development	18
5. Methodology	19
5.1 Available reports	19
5.2 Scope and objective	19
6. Desk study and site walkover	20
6.1 Existing geotechnical data	20
6.2 Geology	20
6.3 Acid Sulphate Soils	21
6.4 Soil Salinity	21
6.5 Site walkover	22
7. Ground conditions	23
7.1 Subsurface conditions	23
7.1.1 Fill, quaternary sediments and residual soils	24
7.1.2 Ashfield Shale	24
7.1.3 Mittagong Formation	24
7.1.4 Hawkesbury Sandstone	24
7.2 Geological structures	25
7.3 Groundwater	26

7.4	Cone Penetration Test (CPT) Data and Interpretation	28
8.	Geotechnical assessment	29
8.1	Geotechnical design parameters	29
8.2	Seismic design	31
8.2.1	Site subsoil class	31
8.2.2	Geotechnical seismic loading	31
9.	Surface and Groundwater Assessment	33
10.	Conclusion	34
11.	Limitations Statement	35
	Bibliography	38

Table 1.1	SEARS requirements	12
Table 7.1	Summary of ground conditions	23
Table 7.2	Summary of groundwater monitoring locations and observations	27
Table 7.3	Correlation between CPS and Relative Density in fine sand	28
Table 8.1	Geotechnical design parameters	30
Table 8.2	Geotechnical seismic loading inputs	32

Figure 2.1	Aerial image of the site	14
Figure 2.2	Waterloo Metro Quarter site, with sub-precincts applicable to the scope	14
Figure 3.1	Sydney Metro alignment map (source: Sydney Metro)	16
Figure 3.2	CSSI Approval scope of works (source: WL Developer Pty Ltd)	17
Figure 6.1	Existing geotechnical data available across the Waterloo Metro Quarter Development site	20
Figure 6.2	Acid Sulphate Soil map (eSPADE accessed 10/07/2025)	21
Figure 7.1	Exposed face of the excavation, depicting the Hawkesbury Sandstone formation	25
Figure 7.2	Section of exposed Hawkesbury Sandstone at the Southern Precinct	26
Figure 7.3	Groundwater levels and recorded rainfall (sourced from TSE Hydrogeological Interpretive Report, SMCSWTSE-JPS-TPW-GE-RPT-110003)	28

Appendix A – Borehole logs	
Appendix B – CPT Logs and Interpretation	
Appendix C – Geological Cross Sections	

Abbreviations and glossary

Abbreviations

Abbreviation	Description
ACHAR	Aboriginal Cultural Heritage Assessment Report
ADG	Apartment Design Guide
AHD	Australian height datum
AQIA	Air Quality Impact Assessment
BC Act	Biodiversity Conservation Act 2016
BCA	Building Code of Australia
BC Reg	Biodiversity Conservation Regulation 2017
BDAR	Biodiversity Development Assessment Report
CEEC	critically endangered ecological community
CFA	Continuous Flight Auger Piles
CIV	capital investment value
CMP	Construction Management Plan
Council	City of Sydney Council
CPTED	Crime Prevention Through Environmental Design
CSSI approval	critical State significant infrastructure approval
CTMP	Construction Traffic Management Plan
DA	development application
DPIE	NSW Department of Planning, Industry and Environment
DRP	Design Review Panel
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPA Regulation	Environmental Planning and Assessment Regulation 2000
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	ecologically sustainable design
GANSW	NSW Government Architect's Office
GFA	gross floor area
GIR	Geotechnical Interpretive Report
HIA	Heritage Impact Assessment

Abbreviation	Description
IAP	Interchange Access Plan
LGA	Local Government Area
NCC	National Construction Code
OSD	over station development
PIR	Preferred Infrastructure Report
PGA	Peak ground acceleration
POM	Plan of Management
PSI	Preliminary Site Investigation
RMS	Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEPP 55	State Environmental Planning Policy No 55—Remediation of Land
SEPP 65	State Environmental Planning Policy No. 65 – Design Quality of Residential Apartment Development
SLS	Serviceability Limit State
SRD SEPP	State Environmental Planning Policy (State and Regional Development) 2009
SREP Sydney Harbour	State Regional Environmental Plan (Sydney Harbour Catchment) 2005
SSD	State significant development
SSD DA	State significant development application
SLEP	Sydney Local Environmental Plan 2012
Transport for NSW	Transport for New South Wales
TIA	Traffic Impact Assessment
TSE	Tunnel and station excavation stage
ULS	Ultimate limit state
VIA	Visual Impact Assessment
WMQ	Waterloo Metro Quarter
WMP	Waste Management Plan
WSUD	Water Sensitive Urban Design

Glossary of terms

Term	Explanation
Concept DA	A concept DA is a staged application often referred to as a 'Stage 1' DA. The subject application constitutes a detailed subsequent stage application to an approved concept DA lodged under section 4.22 of the EP&A Act.
The proposal	The proposed development which is the subject of the detailed SSD DA

Term	Explanation
The site	The site which is the subject of the detailed SSD DA

Executive summary

This Geotechnical Interpretive Report has been prepared by WSP Australia Pty Ltd to accompany the State Significant Development Applications (SSDAs) for the proposed Waterloo Metro Quarter Over Station Development, specifically addressing the Northern Precinct (SSD-79307758) and Central Precinct (SSD-79307746) at 150 Cope Street, Waterloo (the site). The applications seek consent for mixed-use and residential developments as part of the broader Waterloo Metro Quarter project, as outlined in Section 1 of this report.

The report addresses Item 14 (Ground and Water Conditions) of the Secretary's Environmental Assessment Requirements (SEARs) issued for the project. Its scope is limited to the Northern and Central Precincts, noting that these developments do not involve any below-ground works.

Accordingly, this report is primarily intended to describe the ground conditions and provide geotechnical design inputs to support the civil design works within each precinct, along with any associated temporary works that may be required during construction.

Based on a review of existing geotechnical data, site walkovers, and previous investigations, the site is considered suitable for the proposed development, provided the design parameters and recommendations presented herein are adopted. No additional site investigations are proposed at this stage.

1. Introduction

This report has been prepared by WSP Australia Pty Ltd on behalf of WL Developer Pty Ltd (the applicant) to accompany a State Significant Development Applications (SSDAs) for Waterloo Metro Quarter (WMQ) located at 150 Cope Street, Waterloo (the site), as follows:

Northern Precinct SSD-79307758

The proposal comprises a 4-storey retail and commercial podium, with residential towers above. The two buildings have a total height of 29 storeys and 26 storeys (including plant).

Specifically, the proposal comprises:

- A podium containing:
 - Vehicle entrance and loading dock facilities accessed off Botany Road
 - Ground level retail tenancies, commercial and residential lobbies
 - Three levels of commercial office floorspace, totalling around 5,100sqm
- Two residential apartment towers with a total of 314 units, including 39 affordable housing units and 275 market units,
 - Building 1A: 24 residential storeys (top of plant approx. RL116.9)
 - Building 1B: 21 residential storeys (top of plant approx. RL 107.5)
 - Communal open space located on the roof of the Metro box connected to Northern Precinct via a bridge link over Raglan Walk
- Delivery of a pedestrian thoroughfare through the site, landscaping and public domain works.
- Indicative building signage zones

Central Precinct SSD-79307746

This application seeks consent for the design, construction and operation of a 26 storey (including plant level) mixed use building within the Central Precinct (the site) of the WMQ estate. The proposal comprises a Co-living housing tower above a three-storey podium containing retail and community facility in the form of a childcare centre. Specifically, the proposal comprises:

- Ground level retail tenancies, community facility and childcare, co-living and shared basement access lobbies
- Community centre in the form of a childcare at Level 1 and Level 2
- A Co-living housing tower from Levels 3 to 24 comprising:
 - Self-contained co-living accommodation rooms across 20 levels, with capacity for around 500 rooms

- Indoor and outdoor communal amenity at Levels 3 and 24
- Communal space also provided on each accommodation level
- Ground level vehicular access from Church Square shared zone to the shared basement, delivery of a pedestrian thoroughfare through the site, landscaping and public domain works.
- Indicative building signage zones

This report has been prepared to respond to Item 14 of the Planning Secretary’s Environmental Assessment Requirements (SEARs) issued by Department of Planning, Infrastructure and Housing (DPHI) on 13 February 2025.

Table 1.1 SEARS requirements

Item	Description of requirement	Section reference (this report)
14. Ground and Water Conditions	<p>Assess potential impacts on soil resources and related infrastructure and riparian lands on and near the site, including soil erosion, salinity and acid sulfate soils. Provide a Surface and Groundwater Impact Assessment that assesses potential impacts on:</p> <ul style="list-style-type: none"> ▪ surface water resources (quality and quantity) including related infrastructure, hydrology, dependent ecosystems, drainage lines, downstream assets and watercourses. ▪ groundwater resources in accordance with the Groundwater Guidelines. 	Section 6 and 7 and 8

2. The site

The site is located within the City of Sydney Local Government Area (LGA). The site is situated about 3.3 kilometres south of Sydney CBD and eight kilometres northeast of Sydney International Airport within the suburb of Waterloo.

The Waterloo Metro Quarter site comprises land to the west of Cope Street, east of Botany Road, south of Raglan Street and north of Wellington Street (refer to Figure 2.1). The heritage-listed Waterloo Congregational Church at 103–105 Botany Road is within this street block but does not form a part of the Waterloo Metro Quarter site boundaries.

The Waterloo Metro Quarter site is a rectangular shaped allotment with an overall site area of approximately 1.287 hectares.

The boundaries of the overall site are identified at Figure 2.1, and the outline of the SSDA's plans are presented at Figure 2.2. The site is reasonably flat with a slight fall to the south.

The site previously included three to five-storey commercial, light industrial and mixed-use residential buildings. All previous structures have been demolished to facilitate construction of the new Sydney Metro Waterloo station. As such the existing site is predominately being used as a construction site with Buildings 3 and 4 nearly completed at the time of writing this report.

Construction of Sydney Metro and Waterloo Station has been completed in accordance with the Critical State Significant Infrastructure approval (CSSI 7400). The Waterloo Station is located to the east of the site and is now operational.



Figure 2.1 Aerial image of the site

The area surrounding the site consists of commercial premises to the north, light industrial and mixed-use development to the south, residential development to the east and predominantly commercial and light industry uses to the west.

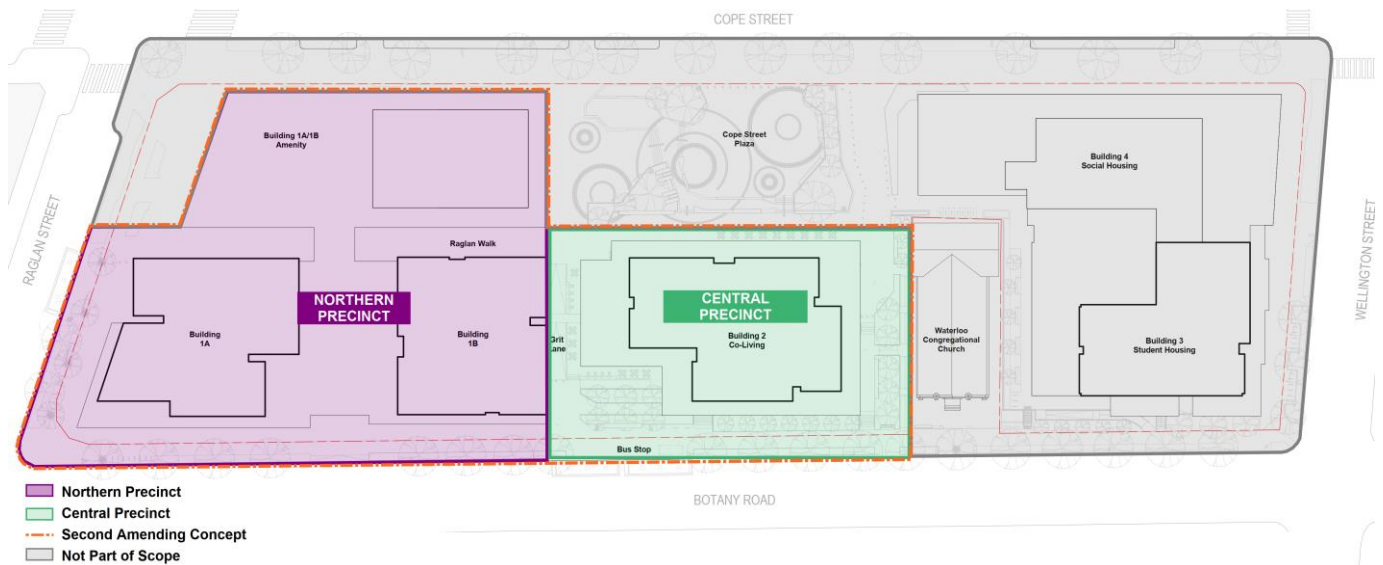


Figure 2.2 Waterloo Metro Quarter site, with sub-precincts applicable to the scope

3. Background

3.1 About Sydney Metro

Sydney Metro is Australia's biggest public transport project. Services commenced in May 2019 in the city's North West with trains every four minutes in the peak. As a new standalone railway, this 21st-century network has transformed the way Sydney travels and continues to expand across the metropolitan area.

There are four core components:

3.1.1 Sydney Metro North West

This project is now complete, and passenger services commenced in May 2019 between Rouse Hill and Chatswood, with a metro train every four minutes in the peak. The project was delivered on time and \$1 billion under budget.

3.1.2 Sydney Metro City & Southwest

Sydney Metro City & Southwest project includes a 30km metro line extending metro rail from the end of Metro Northwest at Chatswood, under Sydney Harbour, through new CBD stations and southwest to Bankstown.

Sydney Metro City & Southwest has now delivered new metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo as well as new underground metro platforms at Central Station. In addition, all 11 stations between Sydenham and Bankstown have been upgraded or converted to metro standards.

3.1.3 Sydney Metro West

Sydney Metro West is a new underground railway connecting Greater Parramatta and the Sydney CBD. This once-in-a-century infrastructure investment is underway and will transform Sydney for generations to come, doubling rail capacity between these two areas, linking new communities to rail services and supporting employment growth and housing supply between the two CBDs.

The locations of seven proposed metro stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays.

The NSW Government is assessing an optional station at Pyrmont and further planning is underway to determine the location of a new metro station in the Sydney CBD.

3.1.4 Sydney Metro Greater West

Metro rail will also service Greater Western Sydney and the new Western Sydney International (Nancy Bird Walton) Airport. The new railway line will become the transport spine for the Western Parkland

City’s growth for generations to come, connecting communities and travellers with the rest of Sydney’s public transport system with a fast, safe and easy metro service.

The Australian and NSW governments are equal partners in the delivery of this new railway.

The Sydney Metro project is illustrated below.

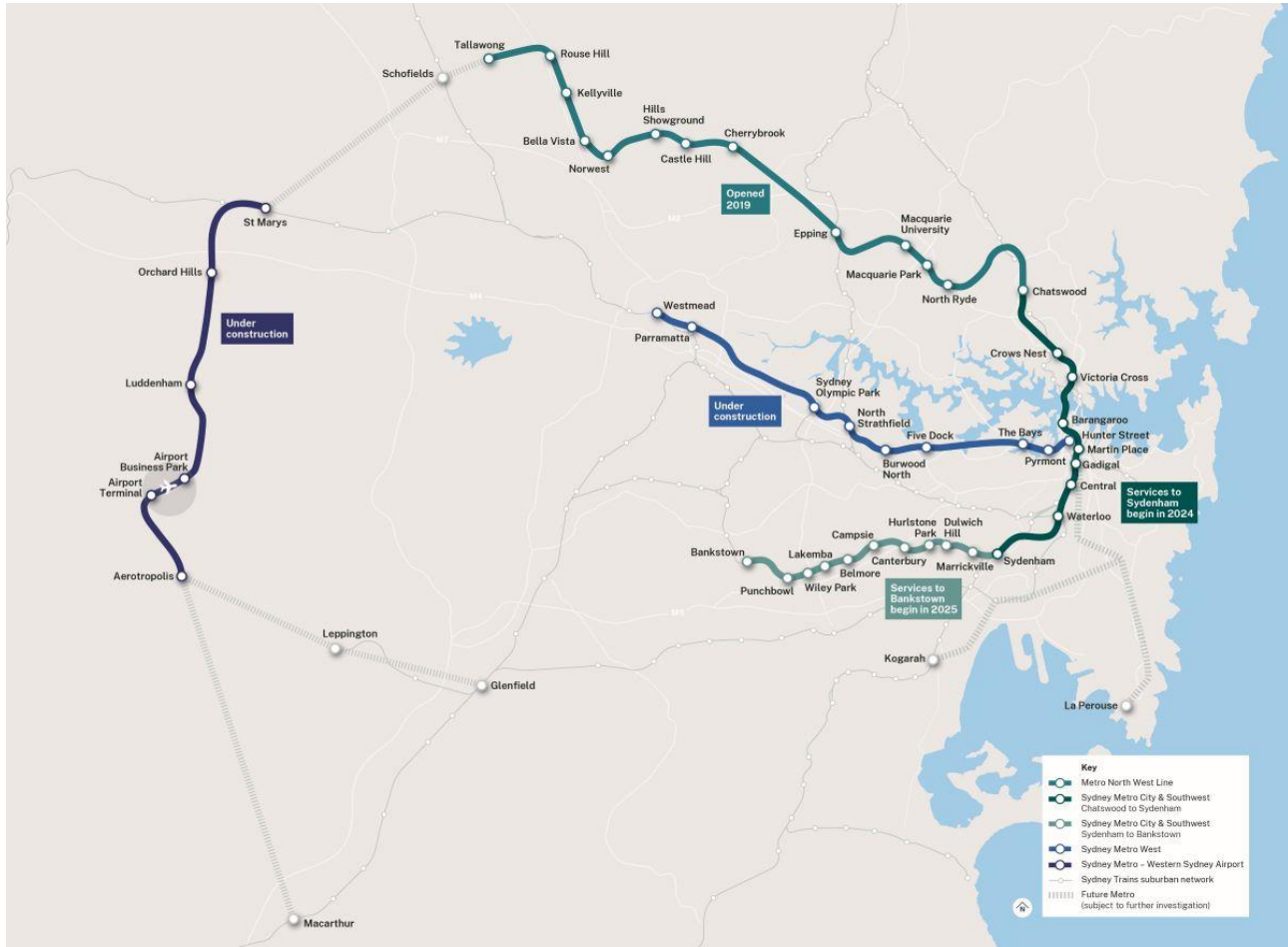


Figure 3.1 Sydney Metro alignment map (source: Sydney Metro)

3.2 Sydney Metro CSSI Approval (SSI 7400)

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham project as a critical State significant infrastructure (CSSI) project (reference SSI 7400) (CSSI approval). The terms of the CSSI approval includes all works required to construct the Sydney Metro Waterloo Station. The CSSI approval also includes the construction of below and above ground works within the metro station structure for appropriate integration with the OSD.

With regards to CSSI related works, any changes to the ‘metro station box’ envelope and public domain will be pursued in satisfaction of the CSSI conditions of approval and do not form part of the scope of the concept SSD DA or detailed SSD DA for the OSD.

Except to the extent described in the EIS or Preferred Infrastructure Report (PIR) submitted with the CSSI application, any OSD buildings and uses do not form part of the CSSI approval and will be subject to the relevant assessment pathway prescribed by the EP&A Act.

The delineation between the approved Sydney Metro works, generally described as within the two ‘metro station boxes’ and surrounding public domain works, and the OSD elements are illustrated in Figure 3.2.

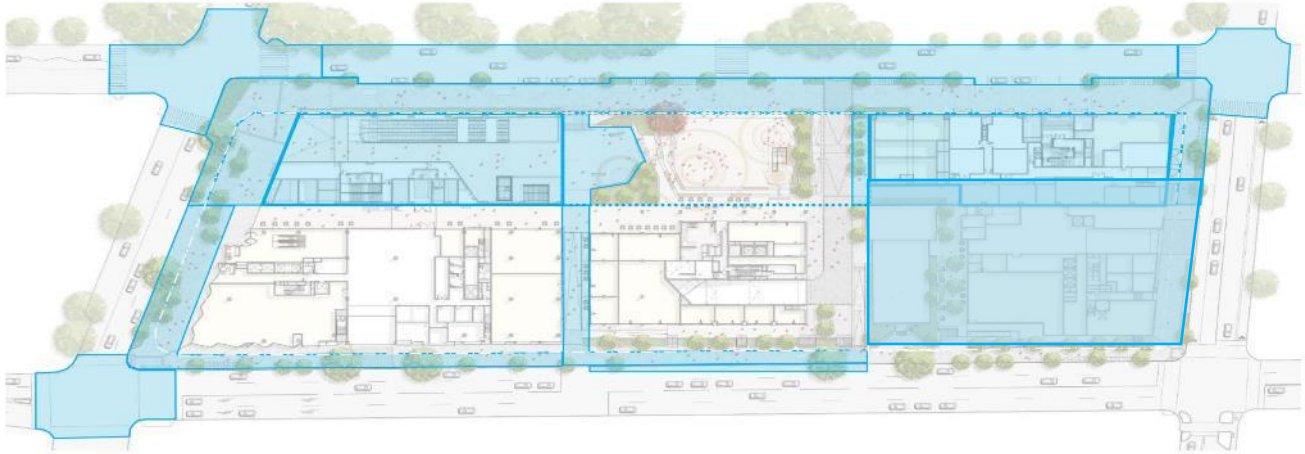


Figure 3.2 CSSI Approval scope of works (source: WL Developer Pty Ltd)

4. Proposed development

4.1 Waterloo Metro Quarter Development

The Waterloo Metro Quarter OSD comprises four separate buildings, a basement carpark and public domain works adjacent to the Waterloo Metro station. The Southern precinct is approved and currently under construction. In addition, the basement car park is approved, and a separate modification application will be submitted to seek changes to the basement design. Three new applications will be concurrently lodged, which relates to:

- Second amended concept SSD relating to Northern and Central precinct
- Detailed SSD for Central Precinct
- Detailed SSD for Northern Precinct

5. Methodology

5.1 Available reports

The following data has been reviewed in preparation of this Geotechnical Interpretive Report (GIR):

- Waterloo TAN WSP 013 / Rev 1, dated 13/02/2019 by WSP Australia Pty Limited.
- Waterloo TAN WSP 016 / Rev 0, dated 5/03/2019 by WSP Australia Pty Limited.
- Sydney Metro – City & Southwest Geotechnical Interpretive Report – City, Reference Design, NWRLSRT-PBA-SRT-GE-REP-000004, dated 29/11/2016 by AECOM Australia Pty Limited and Parsons Brinckerhoff Australia Pty Limited.
- Geotechnical Interpretive Report System Wide – Stage 1 Design, NWRLSRT-MET-SRT-GE-REP-000001, dated 31/01/2018 by Metron.
- Geotechnical Interpretive Report Waterloo Station, PS117919-GEO-REP-668A Rev C, dated 19/02/2020 by WSP Australia Pty Ltd.
- MQD Enabling Works Basis of Design report, SMCSW-RBG-SWL-ST-REP-120003 Rev C, dated 22/06/2020 by RBG.
- Waterloo Metro Quarter Over Station Development-Geotechnical Interpretive Report for Southern Precinct and Basement Car Park, WMQ-SITE-WSP-GT-RPT-001[G], dated 21/04/2023 by WSP Australia Pty Ltd.

5.2 Scope and objective

The purpose of this geotechnical interpretive report is to summarise the existing geotechnical data pertaining to the Waterloo Metro Quarter Development, and to provide information on the ground model and geotechnical design parameters to inform the structural design of Metro Quarter Development, specifically for northern and central precinct.

The interpretation contained within this report is based on existing geotechnical investigation data from the Waterloo Station site, provided information by the Tunnels Station and Excavation (TSE) contractor of the Waterloo Station and a site visit undertaken on 18 December 2019 of the base of the excavation. No additional site investigations or tests have been undertaken.

6. Desk study and site walkover

6.1 Existing geotechnical data

WSP has extensive geotechnical information within the site and surrounding areas, which include 22 boreholes, nine cone penetration tests and laboratory tests, from investigations carried out by WSP and others. The figure below shows the locations of the undertaken geotechnical investigations, of which the data has been captured in the previous reports mentioned in Section 5.1. Selected borehole logs are presented in Appendix A.



Figure 6.1 Existing geotechnical data available across the Waterloo Metro Quarter Development site

6.2 Geology

The 1:100,000 Geological map of Sydney indicates that the site is underlain by a layer of Quaternary sand deposits of fine to medium grain size, which are interpreted to be wind-blown (aeolian) deposits. This aeolian sand layer is underlain by residually weathered material of the Ashfield Shale, Mittagong Formation and basal Hawkesbury Sandstone. The Ashfield Shale is described as black to dark grey shale and laminate, whilst the Hawkesbury Sandstone is described as medium to coarse grained quartz sandstone with very minor shale and laminate lenses. At the interface between Ashfield shale and the Hawkesbury Sandstone, the Mittagong Formation is also encountered and is characterised by interbedded sandstones and shales.

6.3 Acid Sulphate Soils

Acid Sulphate Soils are typically associated with marine or estuarine sediments and are generally found in areas within five metres of mean sea level.

Figure 6.2 shows ASS mapping in the vicinity of the Site. Approximately 400 m south, the mapping indicates an X4 rating, suggesting a potential for ASS at depths greater than 4 m below ground level in disturbed or reworked materials. However, no ASS has been identified on the Site itself, and the risk of occurrence is considered very low.



Figure 6.2 Acid Sulphate Soil map (eSPADE accessed 10/07/2025)

6.4 Soil Salinity

The Aeolian sands in the area typically exhibit high permeability and good drainage characteristics, which suggests a low inherent risk of salinity accumulation in the surface layers. However, in low-lying or poorly drained areas—particularly where shallow groundwater is present—there may be some potential for localised salt accumulation. Overall, the risk of saline soils across the site is considered to be very low.

6.5 Site walkover

A site walkover was undertaken by a senior principal engineering geologist and a technical executive geotechnical engineer on 18 December 2019 at the base of the Waterloo station box excavation, adjacent to the proposed Waterloo Metro Quarter Development. There was no rain recorded in Sydney in the three weeks preceding the site visit, and weather condition on the day was noted to be fine.

The purpose of the site walkover was to confirm the following:

- Ground conditions at the base of the excavation.
- Confirmation of the Woolloomooloo Fault Zone along the southern zone of the project site.
- Observations of groundwater.

During the site walkover, shotcrete panels obscured the view of the rock behind the temporary shoring, and only the lower sections of the walls and the base of the excavations were exposed, which revealed Class I Hawkesbury Sandstone. The ground conditions overlying the Class I sandstone were completely obscured by the reinforced shotcrete facing, and the ground conditions overlying were unable to be confirmed. However, data from the TSE secant pile drilling and geological mapping undertaken during the TSE excavation would be able to supplement this. Towards the southern zone of the station box excavation, the Woolloomooloo Fault Zone was only noted to be present in the form of a few localised joints and was not as widely spread and weathered as initially assumed.

Groundwater stains were noted at several locations along the anchor heads from the second and third rows of anchors, as well as more significantly from below the shotcrete facing.

The above observations were validated during multiple site visits undertaken by WSP engineers during the construction of the existing basement excavation, its retention system, and pile hole inspections as part of works performed under the original SSD-10438 approval for the Basement Carpark.

7. Ground conditions

7.1 Subsurface conditions

A variable thin layer of fill comprising a mixture of sand and gravel occurs across the Waterloo Metro Quarter Development site, underlain by Quaternary deposits which are interpreted as wind-blown (aeolian) sands. Underlying the sands are residual soils comprising silty clay which forms part of the weathered Ashfield Shale horizon. Localised thickening may be associated with fault/joint structures that have been identified within the region.

The Ashfield Shale is a highly to slightly weathered siltstone, below which the Mittagong Formation is encountered which comprises siltstone with variably thick laminations of fine-grained sandstone. It grades sharply into the Hawkesbury Sandstone, which can be described as a fine to medium grained moderately cross bedded quartzose sandstone, with some light carbonaceous laminations.

The interpreted ground conditions across the Waterloo Metro Quarter Development are summarised in the geotechnical longitudinal and cross sections presented in Appendix A. The geotechnical model has been developed based on the provided information from the Sydney Metro geotechnical investigations (SRT series), including 4 boreholes completed for the Waterloo Metro Quarter Development works that were provided in February 2019, observations from the recently undertaken site visit of the excavation and geological mapping sheets provided by the TSE contractor during the excavation of the station box. The anticipated sub-surface profile across the project site is presented in the table below. The depth to top of rock generally dips towards the north-west, with soil thicknesses increasing from approximately 7 m to 13 m.

Table 7.1 Summary of ground conditions

Geotechnical Unit	Description	Variability of Elevation at Top of Unit (RL m AHD)	Thickness Variability (m)
Fill	Sand and gravel	15 to 17	1 to 2
Quaternary Sediments (Aeolian Sand)	Sand, loose to medium dense	14 to 16	3 to 7
Residual soil	Silty clay, stiff to very stiff	8.5 to 12.5	4 to 8
Ashfield Shale	Shale (Class IV and V)	3 to 7	1 to 3
	Shale (Class III or better)	1 to 6	2 to 7
Mittagong Formation	Sandstone (Class I/II)	0.5 to -2.5	2
Hawkesbury Sandstone	Sandstone (Class I/II)	-0.8 to -4.8	N/A

The following geotechnical units are described as below.

7.1.1 Fill, quaternary sediments and residual soils

A variable thin (typically 0.5 m to 1.5m in depth) layer of fill comprising a mixture of sand and gravel occurs across the station box. Below this fill are quaternary sand deposits which are interpreted as Aeolian sand deposits and are intersected between approximately RL 8.5 m to 12.0 m AHD. Underlying the sands are residual soils comprising silty clay that persist to between RL 3 m to 7 m AHD. The residual layer forms part of the weathered Ashfield Shale rock.

7.1.2 Ashfield Shale

The Ashfield Shale was encountered within the deeper boreholes undertaken, below the residual layer, and was recorded as a highly to slightly weathered siltstone of the Rouse Hill Member, interpreted as a Class IV/V shale to RL 1.5 m to 6.0 m AHD. Below this layer lies a variable Class III to Class I shale that persists down to approximately RL -2.5 m to 1.0 m AHD, where the Mittagong Formation is encountered.

7.1.3 Mittagong Formation

The Mittagong Formation has been encountered as sandstone with variably thick laminations of siltstone and is generally thin (about 2 m in thickness). It grades sharply into the Hawkesbury Sandstone at approximately RL 1.0 m AHD at the north end of the project site (BLD 1) and RL5.0 m AHD at the south of the project site (BLD 3).

7.1.4 Hawkesbury Sandstone

Underlying the Mittagong Formation is the Hawkesbury Sandstone, which can be described as a fine to medium grained, moderately cross bedded, quartzose sandstone, with some light carbonaceous laminations. The sandstone that was encountered within the deeper boreholes were logged as fresh, cross bedded sandstone with no obvious geological structure. During the site walkover of the excavation, the formation was visible at the exposed faces near the base of the excavation, as shown in Figure 7.1.



Figure 7.1 Exposed face of the excavation, depicting the Hawkesbury Sandstone formation

7.2 Geological structures

Regional geological mapping (Och et al, 2009) initially indicated that a projection of the Woolloomooloo Fault Zone extended across the southern end of the project site. The inclined borehole undertaken along Cope St, adjacent to the southern zone of the station box excavation (SRT_BH605), encountered discrete low angle structures (shears and joints) mainly within the Ashfield Shale, which had been interpreted to be associated with this fault zone. However, observations from the site walkover of the station box excavation did not reveal any significant geological structures associated with a typical fault zone. Only localised, discrete joints were present in the exposed Hawkesbury Class I/II Sandstone, at the southern zone of the excavation, where the Woolloomooloo Fault Zone was predicted to be present as shown in Figure 7.2. The rock mass in that area was typically observed to be slightly to unweathered and inferred to be of a high Geological Strength Index (GSI).

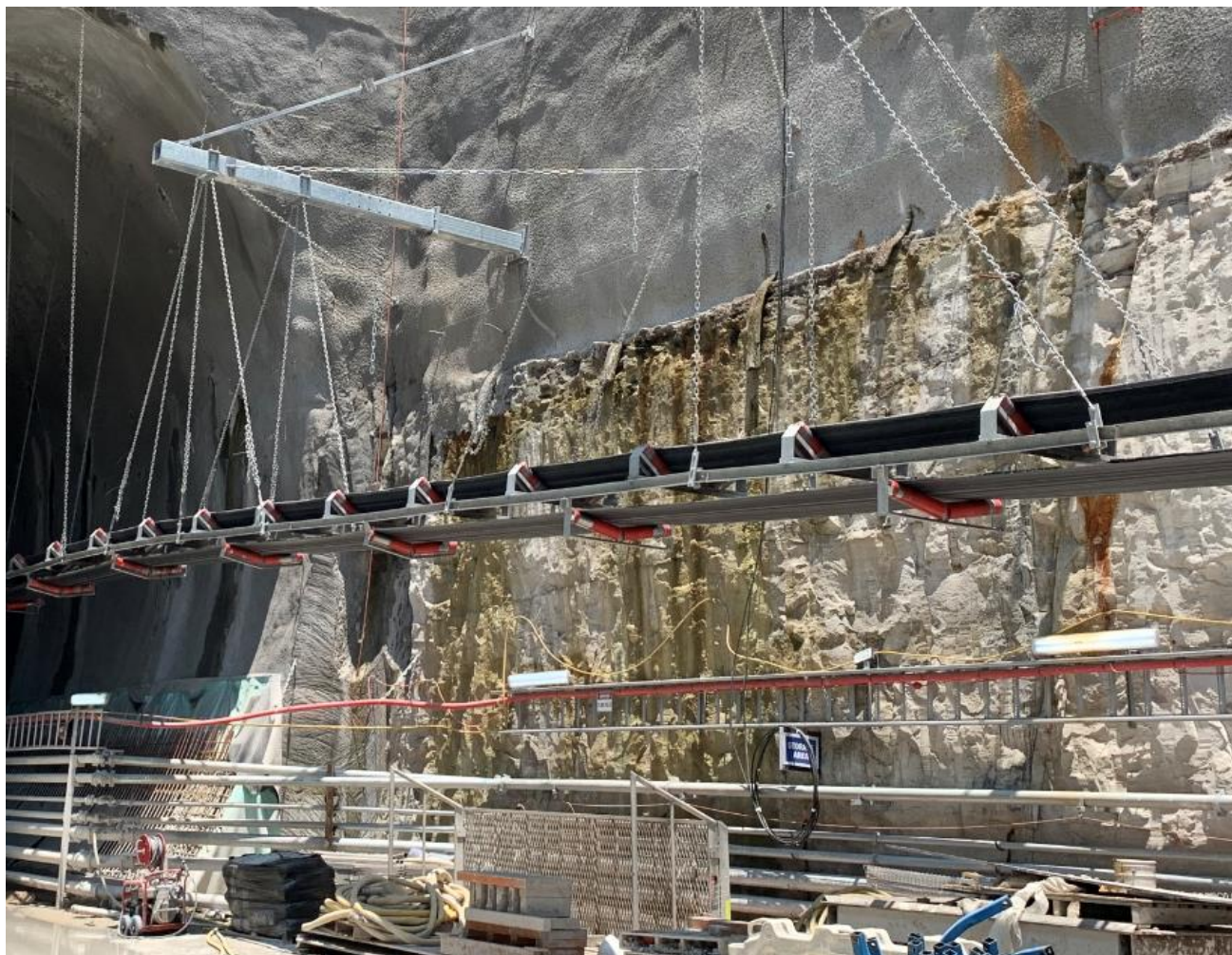


Figure 7.2 Section of exposed Hawkesbury Sandstone at the Southern Precinct

7.3 Groundwater

Piezometers for groundwater monitoring have previously been installed at 9 locations in the project site vicinity, with observed groundwater levels summarised in Table 7.2. The monitoring results indicate that the groundwater levels are typically between 3m to 5m below ground level (RL of 10 to 12 m AHD) within the Quaternary sands. It is possible that the groundwater table in the sand is perched at some locations. Figure 7.3 contains a hydrograph showing recorded groundwater levels and rainfall over the period September 2015 to September 2017. An additional 3 standpipes were installed in October 2018 at SRT_BH409, SRT_BH419 and SRT_BH420. Groundwater inflows were recorded at approximately 4m below ground level (RL 12 m AHD) during drilling.

The highest level of groundwater seepage stains along the western boundary of the station box interface observed during the site walkover was noted to be along the second row of anchors, which were installed between RL 8.5 m to 9.5 m AHD. Most of the top level of ground anchors, which were installed between RL 12.5 m to 13.42 m AHD did not exhibit groundwater seepage stains. However, it is noted that below average levels of rainfall were recorded in Sydney in the months preceding the site visit and has caused the groundwater table to be depressed below original design groundwater levels. Notwithstanding this, due to the high permeability of the sands, the serviceable design (permanent)

groundwater level for the station box design was taken at the ground level, as there is potential for groundwater level to rise very quickly during flood events, as per clause 2.3.6 of Appendix B2 of the SWTC. For ultimate limit state design, the groundwater level is understood to be set at the Probable Maximum Flood (PMF) levels, to be confirmed within the SWTC requirements. It is understood that the Waterloo Metro Quarter Development will follow the same design standards as the station box.

Table 7.2 Summary of groundwater monitoring locations and observations

Monitoring Bore	Date of construction	Date of last observation	Screened unit	Average groundwater depth (MBGL)	Average groundwater level (M AHD)
SRT_BH403	18/06/2015	June 2016	Sandstone Class I/II	3.4	11.6
SRT_BH404	26/06/2015	June 2016	Sandstone Class I/II	6.0	9.3
SRT_BH405	2/08/2016	September 2017	Sandstone Class I/II	6.7	9.9
SRT_BH406	2/08/2016	September 2017	Sand / Residual Soil	3.1	12.3
SRT_BH605	2/11/2016	May 2017	Shale Class III	4.1	10.8
JCG_BH1120	7/08/2017	September 2017	Shale Class V	5.0	10.4
			Sandstone Class I	9.9	5.5
JCG_BH1121	26/10/2016	September 2017	Sand	3.2	12.2
R469_BH101M	19/10/2015	October 2015	Sand	3.3	12.8
R469_BH102M	19/10/2015	October 2015	Sand	3.0	13.1

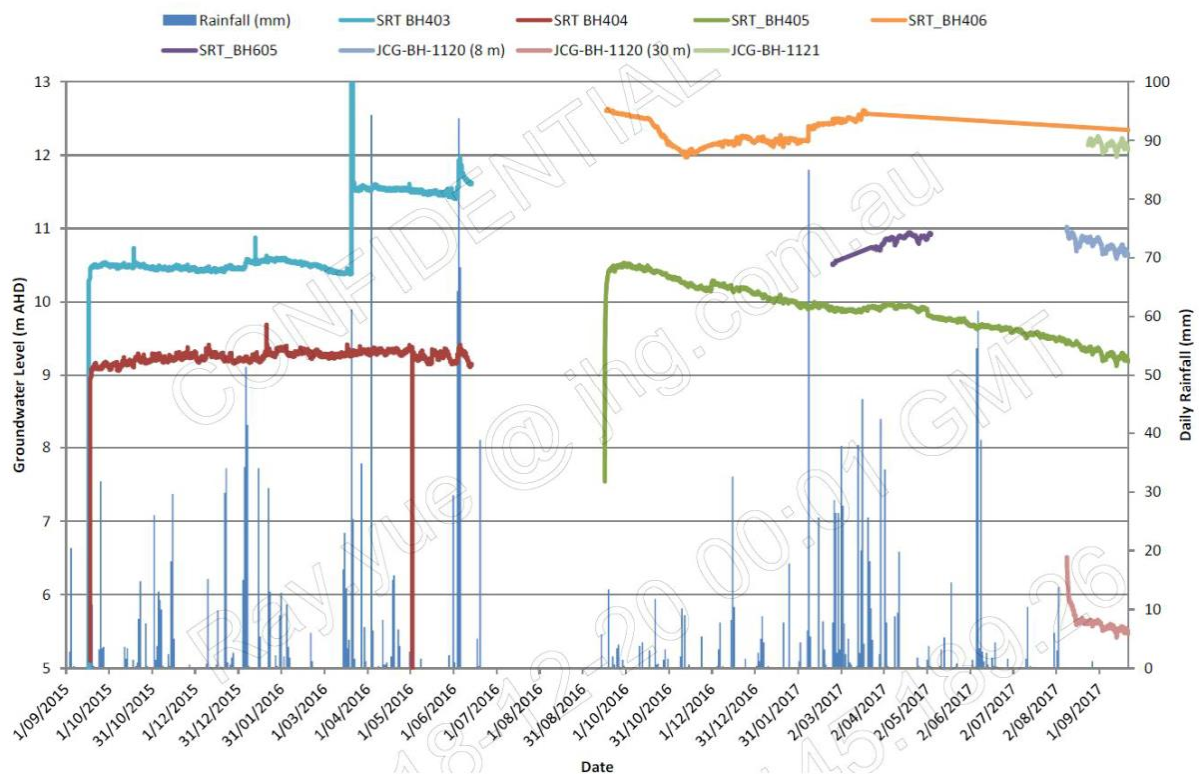


Figure 7.3 Groundwater levels and recorded rainfall (sourced from TSE Hydrogeological Interpretive Report, SMCSWTSE-JPS-TPW-GE-RPT-110003)

7.4 Cone Penetration Test (CPT) Data and Interpretation

Nine cone penetration tests have been conducted on site as shown in Figure 6.1. The CPT logs and the interpretation are provided in Appendix B. Based on established empirical correlations (P. Jacobs, 2004), the interpreted relative density of the sand derived from cone resistance data is as shown as Table 7.3 Figure 6.1. The results indicate that Aeolian Sand across the site generally comprises three distinct layers- medium dense, dense and very dense- with varying thicknesses. Detailed cross sections are presented in Appendix C.

Table 7.3 Correlation between CPS and Relative Density in fine sand

Compaction of Fine Sand	Cone Resistance (qc) (MPa)	Relative Density Dr (%)
Very loose (VL)	<2	<20
Loose (L)	2-4	20-40
Medium Dense (MD)	4-12	40-60
Dense (D)	12-20	60-80
Very Dense (VD)	>20	80-100

8. Geotechnical assessment

The portions of the Waterloo Metro Quarter Development requiring significant geotechnical consideration are the basement structures beneath Buildings 1 and 2 (subject to a separate approval under Basement SSD-10438). The remaining components, including the superstructures of Buildings 1 and 2, interact with the ground only through the basement or the existing station box structure.

The geotechnical aspects of the basement beneath Buildings 1 and 2—such as bulk excavation, site retention, hydrostatic basement slabs, pile foundations, and the impact assessment on the adjacent church—were previously addressed in the Geotechnical Interpretive Report issued for SSD-10438 Basement Car Park (Doc. No. WMQ-SITE-WSP-GT-RPT-001G, dated 21 April 2023). The current applications for the Northern and Central precincts do not alter the geotechnical conditions or design assumptions presented in that report.

While the geotechnical interpretation sections have been refined based on interpretation of recent CPT data (included in Appendix C), all previously stated information, recommendations, and design parameters in the above-mentioned report remain valid for the proposed development.

For completeness and ease of reference, key geotechnical design parameters and selected recommendations that remain applicable to the subject building design and/or civil works associated with these developments are repeated in this report. These include parameters for soil and rock units, typical bearing capacities, stiffness values, and seismic design inputs.

8.1 Geotechnical design parameters

Table 8.1 below presents the recommended geotechnical design parameters based on data from the Sydney Metro (SRT) investigations and our experience on similar projects within the Sydney region. The table presents the design parameters for sand layers with varying densities. These were not included in the Geotechnical Interpretive Report (GIR) issued for the Basement Carpark and are now provided here for completeness and to support the ongoing design development.

Table 8.1 Geotechnical design parameters

Material type	Unit weight (kN/M ³)	Undrained shear strength (C _u) (kPa)	Effective cohesion (c') (kPa)	Effective friction angle (φ') (°)	Young's modulus (E) (MPa)	At Rest Earth Pressure (K _o)	Active Earth Pressure (K _a)	Passive Earth Pressure (K _p)	Poisson Ratio (ν)
Fill (sandy)	16 – 18 (18)	-	0	30 – 35 (33)	10 – 30 (15)	0.45	0.29	3.39	0.3
Sand (Loose)	17	-	0	32	15	0.47	0.31	3.26	0.3
Sand (Medium Dense)	18	-	0	34	25	0.44	0.28	3.54	0.3
Sand (Dense to Very Dense)	19	-	0	36	40	0.41	0.26	3.85	0.3
Residual clay (stiff to very stiff)	20	100 – 200 (150)	10	28	30 – 50 (40)	0.53 ⁽⁵⁾	0.36 ⁽¹⁾	2.77 ⁽¹⁾	0.3
Shale (Class V)	21	100 – 300 (200)	10 – 20 (15)	27 – 30 (28)	60 – 200 (100)	0.53 ⁽⁵⁾	0.36 ⁽¹⁾	2.77 ⁽¹⁾	0.25
Shale (Class IV)	22	-	20 – 40 (30)	28 – 32 (30)	100 – 500 (250)	0.53 ⁽⁵⁾	0.36 ⁽¹⁾	2.77 ⁽¹⁾	0.25

1. Short term (undrained) K_a and K_p = 1.0 for Residual Clay and Class IV/V Shale.
2. All K values assume level ground conditions above the wall. Higher coefficients would apply where the ground surface slopes above the wall. Lower coefficients may apply with assumed wall friction.
3. Appropriate water pressures should be adopted unless effective drainage at the rear of the wall is provided.
4. Surcharge pressures should be added to earth pressure, where appropriate.
5. At rest (K_o) value is based on an expectation that the excavation of the adjacent station box has reduced the lateral pressure which approaches an active (K_a) value.
6. Soil-structure interaction analyses (finite element or other) are more appropriate to quantify lateral earth pressures which would be affected due to the destressing of the temporary anchors associated with the TSE excavation walls

8.2 Seismic design

The Waterloo Metro Quarter Development is located within the Sydney Metropolitan area of the Sydney Basin, which is known to experience infrequent and minor levels of seismicity compared to other regions around the world. The area where the project site is located, in particular, is known to experience lower levels of earthquake activity compared to the southern and western regions of the basin, closer towards the Blue Mountains. This is supported by empirical data, which record that no earthquakes with a magnitude greater than M_L 3.0 have occurred within a 20km radius of the Waterloo project site. Furthermore, a paleo-seismological study by Clark (2010) estimates that earthquake magnitudes in the region of M_L 7.0 along the west and south of Sydney typically have average recurrence period of between 1 to 2 million years. While there are faults located near the project site, there is no known evidence of activity within these faults in recent history.

8.2.1 Site subsoil class

Based on the review of the geotechnical data available, the ground underlying the basement of BLD 1 and BLD 2 can be classified as Class C_e according to AS1170.4. This is based on the layer of residual soil or highly weathered rock overlying competent rock to be greater than 3m thick at the basement of BLD 1 and BLD 2.

8.2.2 Geotechnical seismic loading

Seismic design is typically assessed at two levels of severity:

- **Maximum Design Earthquake (MDE)** – associated with rare, high-intensity events (typically linked to ultimate limit state or collapse prevention).
- **Operating Basis Earthquake (OBE)** – representing more frequent, lower-intensity events (typically aligned with serviceability limit state).

Australia currently does not have a dedicated seismic standard for underground structures. As such, design guidance is typically drawn from AS 1170.4–2007 (Earthquake Actions in Australia) and AS 4678–2002 (Earth-retaining Structures). However, neither standard explicitly defines MDE or OBE for underground applications.

For this preliminary assessment, the definitions by Hashash et al. (2011) and Wang (1993) are adopted:

- **MDE:** An earthquake with a low probability of exceedance (typically 3–5%) over the design life (i.e., ~1:2500-year return period).
- **OBE:** A more frequent event with ~40–50% probability of exceedance, typically equivalent to a 500-year return period for critical infrastructure.

The buttress system beneath Buildings 1 and 2 has been designed and constructed to the same standard as the adjacent Waterloo Station box and in accordance with SMCSW-RBG-SWL-ST-REP-120003, as follows:

- Design life: 100 years
- Importance Level (IL): IL4 (as per clause 2.2.1, Appendix B2 of the SWTC)

All other components of the Waterloo Metro Quarter Development are to be designed for a 50-year design life and IL3.

As per AS 1170.4 Section 2.2, for IL4 structures, the MDE corresponds to a 2500-year return period (i.e., ~4% probability of exceedance in 100 years). IL4 structures must also remain serviceable after an event defined for IL2 structures, which typically aligns with a 500-year return period and is adopted here as the OBE. For IL3 structures, AS 1170.4 specifies a design earthquake with a 1000-year return period. Both IL3 and IL4 structures are to be designed using Earthquake Design Category III (EDC III).

Although AS 1170.4 and AS 4678 do not explicitly define OBE and MDE, the required Peak Ground Accelerations (PGAs) for different return periods can be estimated using:

- The hazard factor (Z),
- The probability factor (kp) (as a proxy for return period), and
- The site sub-soil classification (e.g., Class Ce or De) per AS 1170.4.

Seismic loading for the geotechnical design has been estimated accordingly. Table 8.2 presents the parameters and inputs which can be used to determine geotechnical seismic loads.

Table 8.2 Geotechnical seismic loading inputs

Parameter	Input	
Site subsoil class	C _e	
Importance Level (IL)	4	3
Design life	100 years	50 years
Annual probability of exceedance (OBE)	1/500	1/25
Annual probability of exceedance (MDE)	1/2500	1/1000
Spectral shape factor (C _h (T))	1.3	1.3
Hazard Factor (Z, Sydney)	0.08	0.08
Probability factor (k _p) (OBE)	1.0	0.25
Probability factor (k _p) (MDE)	1.8	1.3
Unweighted design PGA (OBE)	0.10	0.03
Unweighted design PGA (MDE)	0.19	0.14

9. Surface and Groundwater Assessment

According to Item 14 of the SEAR, Surface and Groundwater Impact Assessment is required to be assessed, identifying any potential impacts on the quality and quantity of the surface water resources including related infrastructure, hydrology, dependent ecosystems, drainage lines, downstream assets and watercourses.

The surface and groundwater impact assessment of the associated development were previously assessed and approved under a separate application in the basement SSD (SSD-10438 Basement Car Park, Doc. No. WMQ-SITE-WSP-GT-RPT-001G, dated 21 April 2023). The detailed SSDs addressed in this report will not alter or extend the findings of the previous assessment, as no below-ground works are proposed.

10. Conclusion

This Geotechnical Interpretive Report (GIR) has reviewed and interpreted existing geotechnical data relevant to the Waterloo Metro Quarter Development, with a focus on the Northern and Central Precincts. It provides an updated ground model and geotechnical design parameters to support the structural design of the development and to address Item 14 of the SEARs for Central SSD-79307746 and Northern SSD-79307758.

The assessment is based on existing investigation data and observations from a prior site walkover of the TSE excavation. Relevant geotechnical recommendations for both precincts have been outlined in this report.

From a geotechnical perspective, the site is considered suitable for the proposed development, subject to the adoption of the design parameters and recommendations presented herein and previous GIR for Basement Car Park (Doc. No. WMQ-SITE-WSP-GT-RPT-001G, dated 21 April 2023).

11. Limitations Statement

The geotechnical interpretation presented in this report is based on geotechnical investigation data provided by external third party sources and is at a stage where the specific structural details of the proposed structures are still being confirmed. Once specific development details are confirmed, a geotechnical review should be undertaken and, if necessary, additional investigations commissioned to provide the level of information required for assessing design parameters. The report is provided as a basis to inform design of the structural elements of the proposed structure.

RELIANCE ON DATA

In preparing the report, WSP has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, WSP has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. WSP will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

GEOTECHNICAL INVESTIGATION

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared to meet the specific needs of individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor or even some other consulting civil engineer. This report was prepared expressly for the client and expressly for purposes indicated by the client or his representative. Use by any other persons for any purpose, or by the client for a different purpose, might result in problems. The client should not use this report for other than its intended purpose without seeking additional geotechnical advice.

THIS GEOTECHNICAL REPORT IS BASED ON PROJECT-SPECIFIC FACTORS

This geotechnical engineering report is based on a subsurface investigation which was designed for project-specification factors, including the nature of any development, its size and configuration, the location of any development on the site and its orientation, and the location of access roads and parking areas. Unless further geotechnical advice is obtained this geotechnical engineering report cannot be used:

- when the nature of any proposed development is changed
- when the size, configuration location or orientation of any proposed development is modified. This geotechnical engineering report cannot be applied to an adjacent site.

THE LIMITATIONS OF SITE INVESTIGATION

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between test locations. Site exploration identifies specific subsurface

conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency of test locations; however this often does not result in any overall cost savings for the project. The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The borehole logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and cannot always be definitive. For example, inspection of an excavation or test pit allows a greater area of the subsurface profile to be inspected than borehole investigation, however, such methods are limited by depth and site disturbance restrictions. In borehole investigation, the actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical engineering report is based on conditions which existed at the time of subsurface exploration. Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

AVOID MISINTERPRETATION

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

BORE/PROFILE LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems. For further information on this matter reference should be made to 'Guidelines for the Provision of Geotechnical Information in Construction Contracts' published by the Institution of Engineers Australia, National Headquarters, Canberra 1987.

GEOTECHNICAL INVOLVEMENT DURING CONSTRUCTION

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the client and no other party. WSP assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of WSP or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Bibliography

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Appendices



Appendix A – Borehole logs



SHEET: 1 OF 1

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333570.7 m E 6247708.1 m N MGA94 56
 SURFACE RL: 15.45 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 3.20 m

DRILL RIG: Geoprobe 7822 DT
 CONTRACTOR: Matrix
 LOGGED: RB DATE: 28-10-18
 CHECKED: BH DATE: 14-12-18

Drilling			Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CC			0.0	15.45				CONCRETE				
			0.24	15.21	BH413A_0.25 DS 0.25 m R = 1A PID = 1.5 ppm			FILL: Gravelly SAND fine to coarse grained, poorly sorted, pale brown, fine to coarse grained, angular to subangular gravel	D			Fragments of blue metal, gravel and sandstone cobbles
	H		0.50	14.95	BH413A_0.4 DS 0.40 m R = 1A BH413A_0.5 DS 0.50 m R = 0A PID = 2 ppm			FILL: Silty SAND fine to medium grained, uniform, dark brown	D - M			Trace brick ~20% @ 0.4-0.5mbgl Fragments of glass and brick @ 0.5mbgl Potential reworked natural @ 0.5-0.8mbgl
	M		0.80	14.65				SAND fine to medium grained, uniform, brown				NATURAL
	HA		1.20	14.25	BH413A_1.0 DS 1.00 m QCA110 QCB110 R = 0A PID = 1.2 ppm			: as above pale grey				
	L	GWNE	1.50	13.95	BH413A_1.5 U 1.50 m R = 0A PID = 1.7 ppm			Silty SAND fine to medium grained, dark brown		M		
	PT		2.00		BH413A_2.0 U 2.00 m R = 0A PID = 0.8 ppm							
			2.50	12.95	BH413A_2.5 U 2.50 m R = 0A PID = 0.8 ppm			SAND fine to medium grained, uniform, brown				
			3.00	12.45	BH413A_3.0 U 3.00 m R = 0A PID = 0.9 ppm			: as above becoming paler		M - W		
			12.25					END OF BOREHOLE @ 3.20 m TARGET DEPTH REACHED				

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



SHEET: 1 OF 2

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333559.2 m E 6247720.5 m N MGA94 56
 SURFACE RL: 15.39 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 5.20 m

DRILL RIG: Geoprobe 7822 DT
 CONTRACTOR: Matrix
 LOGGED: RB DATE: 20-10-18
 CHECKED: BH DATE: 14-12-18

Drilling			Sampling			Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CC			0.0	15.39				CONCRETE				
			0.19	15.20	BH415_0.2 0.20 m R = 1A PID = 1 ppm			FILL: Gravelly SAND fine to coarse grained, grey, fine to coarse grained, sub-angular to angular gravel				Road base cobbles ~10cm sandstone
H			0.50	14.89	BH415_0.5 0.50 m QCA106 / QCB106 R = 1A PID = 0.8 ppm			: as above slightly more pale, gravel content decreasing	M	D		
HA			0.80	14.59				SAND fine to medium grained, uniform, brown, with silt				NATURAL
			1.00		BH415_1.0 1.00 m R = 0A PID = 1 ppm							
			1.50		BH415_1.5 1.50 m R = 0A PID = 0.4 ppm							
			1.90	13.49				: as above dark brown	D - M			
			2.00		BH415_2.0 2.00 m R = 0A PID = 0.5 ppm			: as above pale grey brown				
			2.20	13.19								
			2.50									
			2.90	12.49				SAND fine to medium grained, uniform, pale brown				MD - L
L			3.00		BH415_3.0 3.00 m R = 0A PID = 0.3 ppm							
			3.50									
			4.00	11.39				: as above pale grey	W			
PT			4.00		BH415_4.0 4.00 m R = 0A PID = 0.3 ppm							
			4.50									
			5.00									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



SHEET: 2 OF 2

CLIENT: TfNSW

COORDS: 333559.2 m E 6247720.5 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 15.39 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

INCLINATION: -90°

LOGGED: RB DATE: 20-10-18

JOB NO: 1791865

HOLE DEPTH: 5.20 m

CHECKED: BH DATE: 14-12-18

Drilling				Sampling			Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT	L		5.0	BH415_5.0 5.00 m R = 0A				W	MD		NATURAL
			10.29	PID = 0.5 ppm			Silty SAND fine to medium grained, dark brown		L		
			10.19	BH415_5.1 5.10 m R = 0A			END OF BOREHOLE @ 5.20 m Soil Vapour Probe Installed				
			5.5								
			6.0								
			6.5								
			7.0								
			7.5								
			8.0								
			8.5								
			9.0								
			9.5								
			10.0								

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



GOLDER FINAL REPORT OF STANDPIPE INSTALLATION: SRT_BH415

SHEET: 1 OF 2

CLIENT: TfNSW

COORDS: 333559.2 m E 6247720.5 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 15.39 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

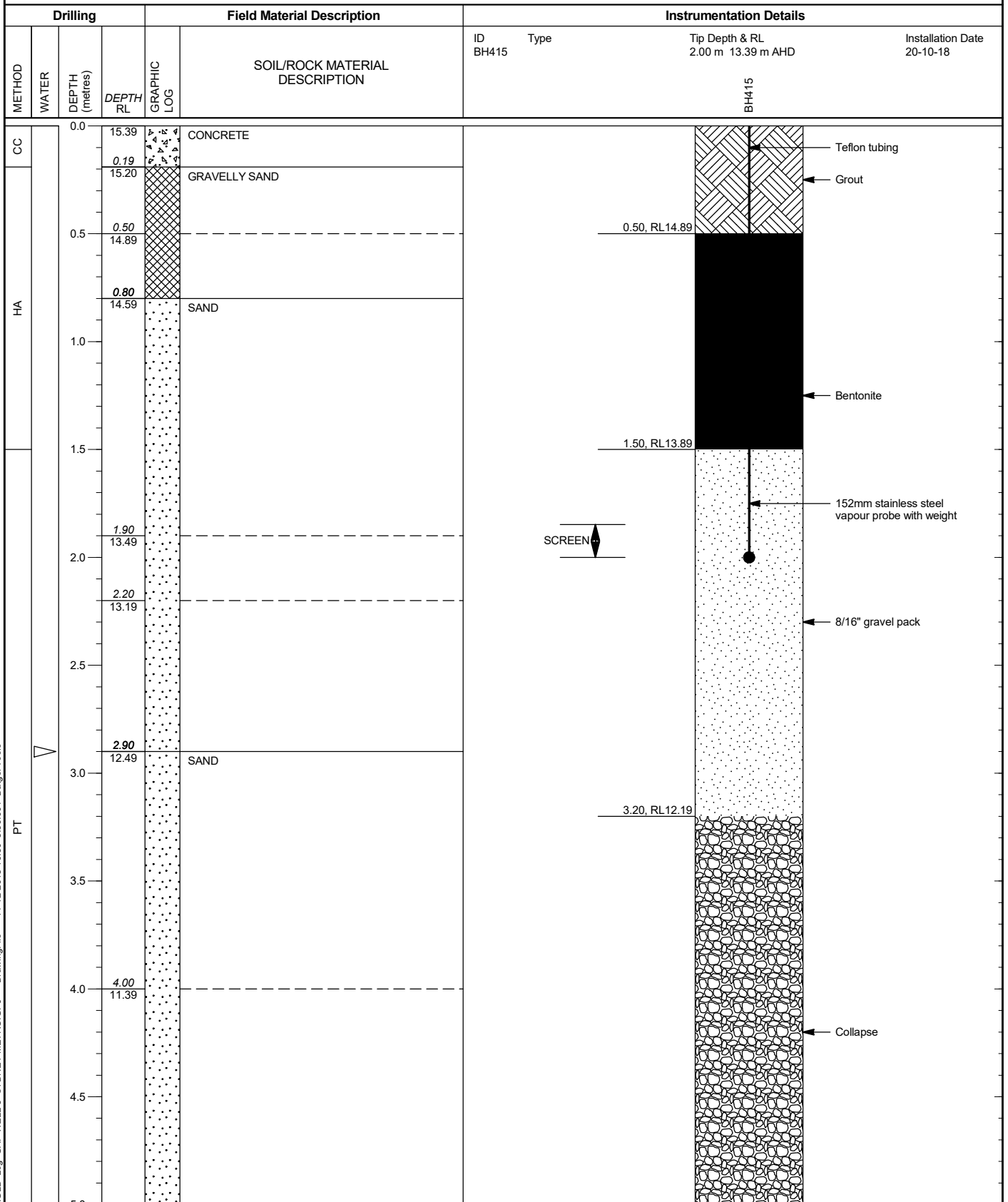
INCLINATION: -90°

LOGGED: RB DATE: 20-10-18

JOB NO: 1791865

HOLE DEPTH: 5.20 m

CHECKED: BH DATE: 14-12-18



This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



GOLDER FINAL REPORT OF STANDPIPE INSTALLATION: SRT_BH415

SHEET: 2 OF 2

CLIENT: TfNSW

COORDS: 333559.2 m E 6247720.5 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 15.39 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

INCLINATION: -90°

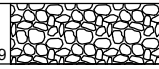
LOGGED: RB DATE: 20-10-18

JOB NO: 1791865

HOLE DEPTH: 5.20 m

CHECKED: BH DATE: 14-12-18

Drilling			Field Material Description		Instrumentation Details				
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	ID	Type	Tip Depth & RL	Installation Date
PT		5.0	5.10		SAND	BH415		2.00 m 13.39 m AHD	20-10-18
			10.29		SILTY SAND				
			5.20						
			10.19		END OF BOREHOLE @ 5.20 m Soil Vapour Probe Installed				
		5.5							
		6.0							
		6.5							
		7.0							
		7.5							
		8.0							
		8.5							
		9.0							
		9.5							
		10.0							



5.20, RL 10.19

GAP 8_16.6 LIB\GIB Log GAP WELL 3 SYDNEY METRO.GPJ <<DrawingFile>> 14-12-2018 16:30 8.30.004 Datgel Tools

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



SHEET: 1 OF 1

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333572.6 m E 6247728.1 m N MGA94 56
 SURFACE RL: 15.56 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 3.20 m

DRILL RIG: Geoprobe 7822 DT
 CONTRACTOR: Matrix
 LOGGED: PK DATE: 7-10-18
 CHECKED: BH DATE: 14-12-18

Drilling			Sampling			Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CC	H		0.0	15.56				CONCRETE				
			0.25	15.30	SRT_BH416_0.25 0.23 m R = 0A PID = 0.4 ppm				FILL: Gravelly SAND fine to coarse grained, brown, trace silt : as above colour change to grey and pale grey/yellow			
HA			0.5	15.16	SRT_BH416_0.5 0.50 m R = 0A PID = 0.7 ppm			Silty SAND fine to medium grained, dark brown, trace gravel FILL: Silty SAND fine to medium grained, dark brown, with gravel				
			0.90	14.66			SAND fine to medium grained, pale grey/brown : as above with bands of silty sand, dark/red/brown					NATURAL
M-L	GWNE		1.5	14.36	SRT_BH416_1.5 1.50 m R = 0A PID = 0.7 ppm							
			2.0	13.56	SRT_BH416_2.0 2.00 m R = 0A PID = 0.8 ppm				: as above pale grey/white			
PT			2.5	13.06				: as above brown				
			2.65	12.91			: as above pale grey					
			3.0	12.36	SRT_BH416_3.0 3.00 m R = 0A PID = 0.8 ppm			END OF BOREHOLE @ 3.20 m TARGET DEPTH REACHED Soil Vapour Probe Installed				
			3.5									
			4.0									
			4.5									
			5.0									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



GOLDER FINAL REPORT OF STANDPIPE INSTALLATION: SRT_BH416

SHEET: 1 OF 1

CLIENT: TfNSW

COORDS: 333572.6 m E 6247728.1 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 15.56 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

INCLINATION: -90°

LOGGED: PK

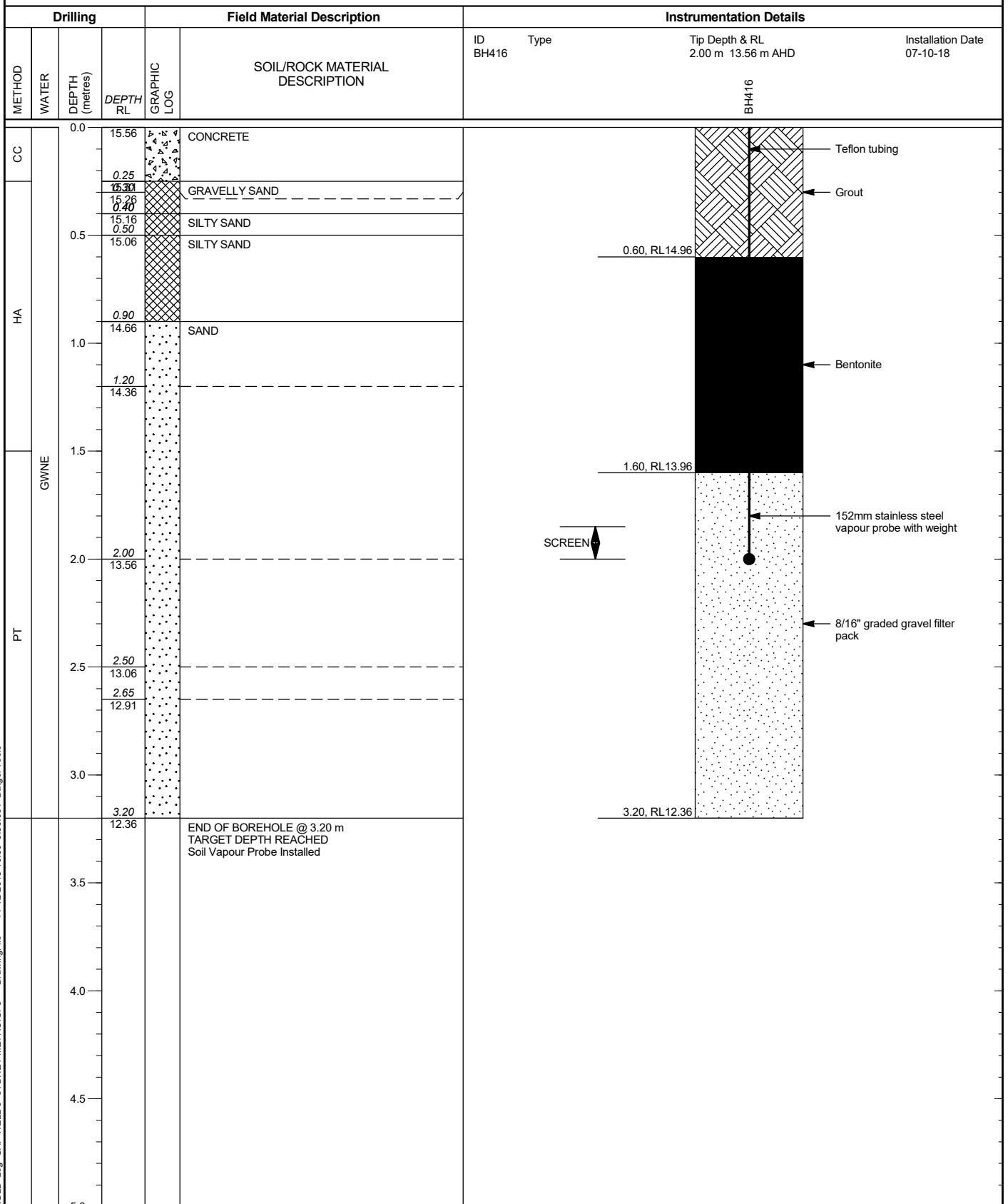
DATE: 7-10-18

JOB NO: 1791865

HOLE DEPTH: 3.20 m

CHECKED: BH

DATE: 14-12-18



GAP-8-16.6 LIB\GLOB Log GAP WELL 3 SYDNEY METRO.GPJ <<DrawingFile>> 14-12-2018 16:30 8.30.004 Datgcl Tools

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F17
RL1



SHEET: 1 OF 1

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333567.6 m E 6247753.1 m N MGA94 56
 SURFACE RL: 16.20 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 3.20 m

DRILL RIG: Geoprobe 7822 DT
 CONTRACTOR: Matrix
 LOGGED: RB DATE: 27-10-18
 CHECKED: BH DATE: 14-12-18

Drilling				Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CC			0.0	16.20				CONCRETE			
			0.15	16.05	BH418_0.2 DS 0.20 m R = 1A PID = 0.4 ppm			FILL: Sandy GRAVEL fine to coarse grained, sub-angular to angular, poorly sorted, brown, fine to coarse sand	D - M		Fragments of sandstone, bricks and concrete ~50-60%
			0.40	15.80				FILL: Gravelly SAND fine to coarse grained, well sorted, brown, fine gravel		D	Fragments of brick ~20%
			0.70	15.50	BH418_0.5 DS 0.50 m R = 1A PID = 1.5 ppm			: as above orange brown			
			0.90	15.30				SAND fine to medium grained, uniform, brown grey		M	NATURA
			1.20	15.00	BH418_1.0 DS 1.00 m QCA109 / QCB109 R = 0A PID = 2 ppm			Silty SAND fine to medium grained, uniform, dark brown			
			1.70	14.50	BH418_1.5 DS 1.50 m R = 0A PID = 0.3 ppm			SAND fine to medium grained, uniform, pale grey brown			
			2.0		BH418_2.0 U 2.00 m R = 0A PID = 0.3 ppm					MD - L	
			2.5							M - W	
			3.0		BH418_3.0 U 3.00 m R = 0A PID = 0 ppm						
				13.00				END OF BOREHOLE @ 3.20 m TARGET DEPTH REACHED			
				3.5							
				4.0							
				4.5							
				5.0							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



SHEET: 1 OF 1

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333539.2 m E 6247744.8 m N MGA94 56
 SURFACE RL: 15.96 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 1.20 m

DRILL RIG: Dando Terrier
 CONTRACTOR: BG Drilling
 LOGGED: RB DATE: 13-10-18
 CHECKED: BH DATE: 14-12-18

Drilling				Sampling			Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0				CONCRETE				
			15.96								
			0.25	BH419_0.25 0.25 m R = 0A PID = 6.1 ppm			FILL: Gravelly SAND fine to coarse grained, brown, fine to medium grained, angular to sub-angular gravel	M			roadbase
			15.71								
			0.35								
			15.61	BH419_0.5 0.50 m R = 1A PID = 0.8 ppm			FILL: Sandy GRAVEL fine to coarse grained, angular, brown, fine to coarse grained sand	D - M			Fragments of brick, blue metal gravel, ceramic and metal. Large concrete boulder ~20x20cm
			0.5								
			1.0	BH419_1.0 1.00 m QCA104/QCB104 R = 1A PID = 1 ppm			END OF BOREHOLE @ 1.20 m REFUSAL ON CONCRETE				
			14.76								
			1.5								
			2.0								
			2.5								
			3.0								
			3.5								
			4.0								
			4.5								
			5.0								

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 1 OF 5

PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS

DRILLING				MATERIAL			
PROGRESS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY	RELATIVE DENSITY
DRILLING & CASING WATER LOSS DRILLING PENETRATION GROUND WATER LEVELS SAMPLES & FIELD TESTS	DT ADV HW Casing F 0.50m D 1.00m D 2.00m D 3.00m D 5.50m D 7.00m D 8.0		CONCRETE 0.35m SP CI CI	ROAD SURFACE CONCRETE FILL:: brown and dark grey, sand Clayey SAND: grey, fine to medium grained sand Black and brown, fine to medium Yellow and grey, fine to medium Sandy CLAY: yellow, grey and brown CLAY: grey, red and orange mottled, trace organics RESIDUAL SOIL	M M W	D D VSt St	STRUCTURE & Other Observations

RMS.LIB.40.3.8.GLB.Log.RTA.NON-CORE.DRILL.HOLE.2.SMW.WATERLOO.GPJ <-DrawingFile> 18/Jan/2019 14:15 8.30.004 Datggl Tools

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180


SHEET : 2 OF 5

PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS

DRILLING					MATERIAL							
PROGRESS		DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY	RELATIVE DENSITY	STRUCTURE & Other Observations
DRILLING & CASING	WATER LOSS											
WB — HW Casing — ↓		F			8.0 8.3		Cl	CLAY: grey, red and orange mottled, trace organics (<i>continued</i>)	W	St		RESIDUAL SOIL
					8.45m			Continued as Cored Drill Hole				
					9.0 7.3							
					10.0 6.3							
					11.0 5.3							
					12.0 4.3							
					13.0 3.3							
					14.0 2.3							
					15.0 1.3							
					16.0 0.3							

RMS LIB 40.3.8.GLB Log RTA NON-CORE DRILL HOLE 2 SMW WATERLOO.GPJ <-DrawingFile>> 18/Jan/2019 14:15 8.30.004 Datgel Tools

See Explanatory Notes for details of abbreviations & basis of descriptions.

CORED DRILL HOLE LOG

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 3 OF 5

PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 6 Step face BIT CONDITION : Good

DRILLING				MATERIAL				FRACTURES							
DRILLING & CASING	WATER LOSS	CORE LOSS DRILL RUN (%)	ROD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50)				NATURAL FRACTURE (mm)	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, dip, [dip direction], infilling or coating, shape, roughness, thickness, other
									VL	L	M	H			
					8.0										
					8.3										
		40% LOSS	0	Is(50) d=0.02 a=0.01 MPa	8.45m		START CORING AT 8.45m								
					8.53m		CORE LOSS 0.08m (8.45-8.53)								
					9.0		CLAY (CI-CH): medium to high plasticity, pale grey, trace silt; moist and w<PL, stiff to very stiff	XW							
					9.3										
					9.60m		CORE LOSS 1.17m (9.60-10.77)								9.50: HP =175 kPa
		10.20 24% LOSS	0	Is(50) d=0.02 a=0.01 MPa	10.0										
					10.3										
					10.77m										
					10.88m		CLAY (CI-CH): medium to high plasticity, pale grey, trace clay; moist and w<PL, very stiff	XW							10.80: HP =350 kPa
					11.0		SILTSTONE: dark grey, <5% fine grained sandstone laminations	SW							BPx5 0 - 10° CN IR S
					11.3										BP 0 - 10° CN UN S
					11.6										BP 0 - 10° Fe SN UN S
					11.9										BP 0° CN PR S
					12.0										BPx4 0 - 15° Fe SN PR S
					12.3										JT 40° CN PR S
					12.48		CORE LOSS 0.36m (12.48-12.84)								JT 60° Clay VNR UN S
		20% LOSS	-2	Is(50) d=0.02 a=0.02 MPa	12.0										JT 80° CN PR S
					12.48										JT 70° CN PR S
					12.84m		SANDSTONE: fine to medium grained, dark grey to grey, massive	F							JT 50 - 55° CN PR S
					13.0										JT 45° CN PR S
					13.3										BPx2 0 - 10° CN IR S
					14.0										JT 45° CN PR S
					14.3										JT 50 - 55° CN PR S
					14.18										BPx4 0 - 10° Clay VNR UN S
		0% LOSS	35	Is(50) d=0.41 a=0.34 MPa	14.0										BP 0 - 10° CN PR RF
					14.3										BP 0 - 10° CN PR RF
					15.0		INTERBEDDED SANDSTONE AND SILTSTONE: fine to medium grained, grey to pale grey, 30-40% indistinct and irregular interbedded and interlaminated siltstone								BP 0 - 10° Clay VNR UN RF
		15.28 -94% LOSS	189	Is(50) d=0.32 a=0.43 MPa	15.0										
					15.3										
					16.0										
					16.0										

RMS LIB 40.3.8.GLB Log RTA CORED DRILL HOLE 4.SMW WATERLOG.GPJ <<DrawingFiles>> 18/Jan/2019 14:17 8.30.004 Daigal Tools

CORED DRILL HOLE LOG

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 4 OF 5

PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 6 Step face BIT CONDITION : Good

DRILLING				MATERIAL				FRACTURES				
PROGRESS		CORE LOSS (% DRILL DEPTH)	ROD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● Axial ○ Diametral	NATURAL FRACTURE (mm)	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, dip, [dip direction], infilling or coating, shape, roughness, thickness, other
DRILLING & CASING	WATER LOSS											
		-94%	189		16.0 0.3		INTERBEDDED SANDSTONE AND SILTSTONE: fine to medium grained, grey to pale grey, 30-40% indistinct and irregular interbedded and interlaminated siltstone (<i>continued</i>)					BP 0 - 10° CN UN RF BP 0 - 10° CN UN RF
				Is(50) d=0.26 a=0.57 MPa	17.0 -0.7		SANDSTONE: medium with coarse grained, pale grey, <10% irregular siltstone laminations					XS 50 mm BP 0 - 10° CN UN RF
		18.28		Is(50) d=1.03 a=1.37 MPa	18.0 -1.7							BP 0 - 10° CN PR RF
		29%	71		19.0 -2.7							
				Is(50) d=1.32 a=1.19 MPa	20.0 -3.7							
		21.10		Is(50) d=1.38 a=1.45 MPa	21.0 -4.7							BP 0 - 10° CN PR RF
		0%	100		22.0 -5.7							BP 10° Clay CT UN RF
				Is(50) d=1.5 a=1.58 MPa	23.0 -6.7							
		23.00		Is(50) d=1.44 a=1.31 MPa	24.0 -7.7							
		0%	100									
				Is(50) d=1.38 a=1.19 MPa								

RMS LIB 40.3.8.GLB Log RTA CORED DRILL HOLE 4.SMW WATERLOO.GPJ <<DrawingFiles>> 18/Jan/2019 14:17 8.30.004 Daigel Tools

CORED DRILL HOLE LOG

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 5 OF 5

PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 6 Step face BIT CONDITION : Good

DRILLING				MATERIAL				FRACTURES				
PROGRESS		CORE LOSS DRILL RUN (%)	ROD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● Axial ○ Diametral	NATURAL FRACTURE (mm)	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, dip, [dip direction], infilling or coating, shape, roughness, thickness, other
DRILLING & CASING	WATER LOSS											
HQ3	0%	0%	100		24.0 -7.7	25.00m	T	VL L L M H H VH EH	20 40 100 300 1000			
		0% LOSS		Is(50) d=1.59 a=1.37 MPa	25.0 -8.7		BOREHOLE SRT-BH420 TERMINATED AT 25.00 m Target depth Groundwater well installed					
					26.0 -9.7							
					27.0 -10.7							
					28.0 -11.7							
					29.0 -12.7							
					30.0 -13.7							
					31.0 -14.7							
					32.0 -15.7							

RMS LIB 40.3.8.GLB Log RTA CORED DRILL HOLE 4.SMW WATERLOO.GPJ <<DrawingFiles>> 18/Jan/2019 14:17 8:30:004 Daigel Tools

CORE PHOTOGRAPHS

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 1 OF 5

PROJECT : Sydney Metro West
LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32(mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS



CORE PHOTOGRAPHS

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 2 OF 5

PROJECT : Sydney Metro West
LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32(mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS



CORE PHOTOGRAPHS

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 3 OF 5

PROJECT : Sydney Metro West
LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32(mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS



CORE PHOTOGRAPHS

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 4 OF 5

PROJECT : Sydney Metro West
LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32(mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS



CORE PHOTOGRAPHS

HOLE NO : SRT-BH420

FILE / JOB NO : 00013/11180

SHEET : 5 OF 5

PROJECT : Sydney Metro West
LOCATION : Waterloo - Mid-eastern boundary

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32(mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test DRILLER : LC / Matrix

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS





SHEET: 1 OF 2

CLIENT: TfNSW

COORDS: 333563.7 m E 6247771.9 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 16.32 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

INCLINATION: -90°

LOGGED: RB

DATE: 6-10-18

JOB NO: 1791865

HOLE DEPTH: 7.50 m

CHECKED: BH

DATE: 14-12-18

Drilling				Sampling			Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0				CONCRETE				
			0.35								
			15.97								
			0.5	SRT_BH420_0.5 0.50 m			FILL: Silty Gravelly SAND brown and dark grey, with clay				fragments of igneous gravel, brick concrete, sandstone and tiles
			1.0	SRT_BH420_1.0 1.00 m						MD	
			1.35								
			14.97				SAND fine to medium grained, grey				NATURAL
			2.0	SRT_BH420_2.0 2.00 m			SAND fine to medium grained, black and brown, coffee rock			M D	
			2.60								
			13.72				SAND fine to medium grained, yellow and grey				
			3.0	SRT_BH420_3.0 3.00 m							
			3.5								
			4.0	SRT_BH420_4.0-4.45 4.00 m							
			4.5								
			5.0								

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SHEET: 2 OF 2

CLIENT: TfNSW
 PROJECT: Sydney Metro
 LOCATION: Botany Road, Waterloo, NSW
 JOB NO: 1791865

COORDS: 333563.7 m E 6247771.9 m N MGA94 56
 SURFACE RL: 16.32 m DATUM: AHD
 INCLINATION: -90°
 HOLE DEPTH: 7.50 m

DRILL RIG: Geoprobe 7822 DT
 CONTRACTOR: Matrix
 LOGGED: RB DATE: 6-10-18
 CHECKED: BH DATE: 14-12-18

Drilling				Sampling			Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			5.0				SAND fine to medium grained, yellow and grey				NATURAL
ADV			5.5	SRT_BH420_5.5-5.95 5.50 m							MD
			5.80 10.52				Sandy CLAY yellow, grey and brown				F
			6.0								W
ADV			6.30 10.02				CLAY grey, red and orange mottled, trace organics				St
			7.0	SRT_BH420_7.0-7.45 7.00 m							
SPT			7.5				END OF BOREHOLE @ 7.50 m TARGET DEPTH REACHED Groundwater Well Installed				
			8.0								
			8.5								
			9.0								
			9.5								
			10.0								

GAP 8_16.6 LIB\GLB Log GAP NON-CORED FULL PAGE SYDNEY METRO.GPJ <<DrawingFile>> 14-12-2018 16:28 8.30.004 Datgel Tools

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



GOLDER FINAL REPORT OF STANDPIPE INSTALLATION: SRT_BH420

SHEET: 1 OF 2

CLIENT: TfNSW

COORDS: 333563.7 m E 6247771.9 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 16.32 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

INCLINATION: -90°

LOGGED: RB

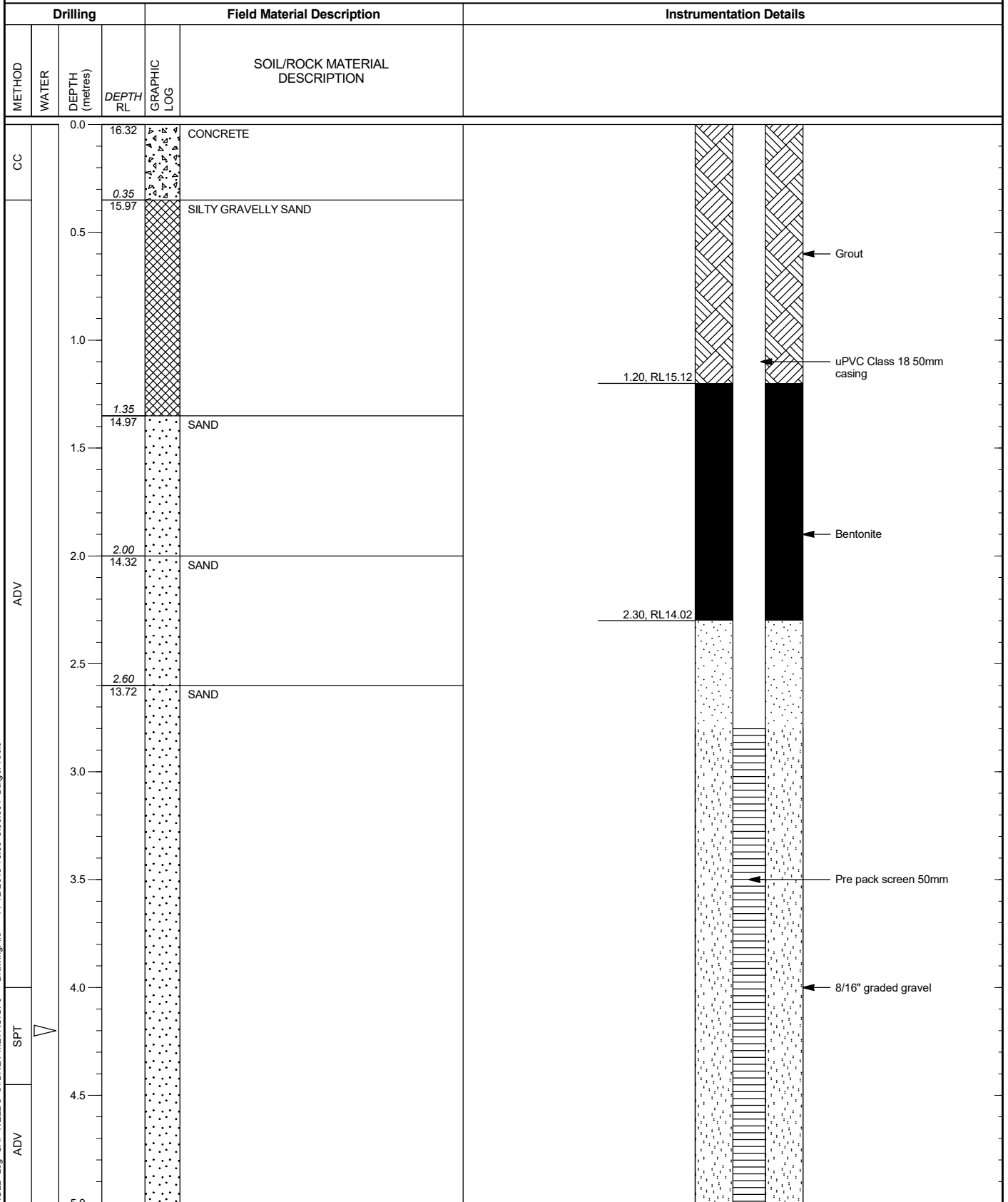
DATE: 6-10-18

JOB NO: 1791865

HOLE DEPTH: 7.50 m

CHECKED: BH

DATE: 14-12-18



This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.



GOLDER FINAL REPORT OF STANDPIPE INSTALLATION: SRT_BH420

SHEET: 2 OF 2

CLIENT: TfNSW

COORDS: 333563.7 m E 6247771.9 m N MGA94 56

DRILL RIG: Geoprobe 7822 DT

PROJECT: Sydney Metro

SURFACE RL: 16.32 m DATUM: AHD

CONTRACTOR: Matrix

LOCATION: Botany Road, Waterloo, NSW

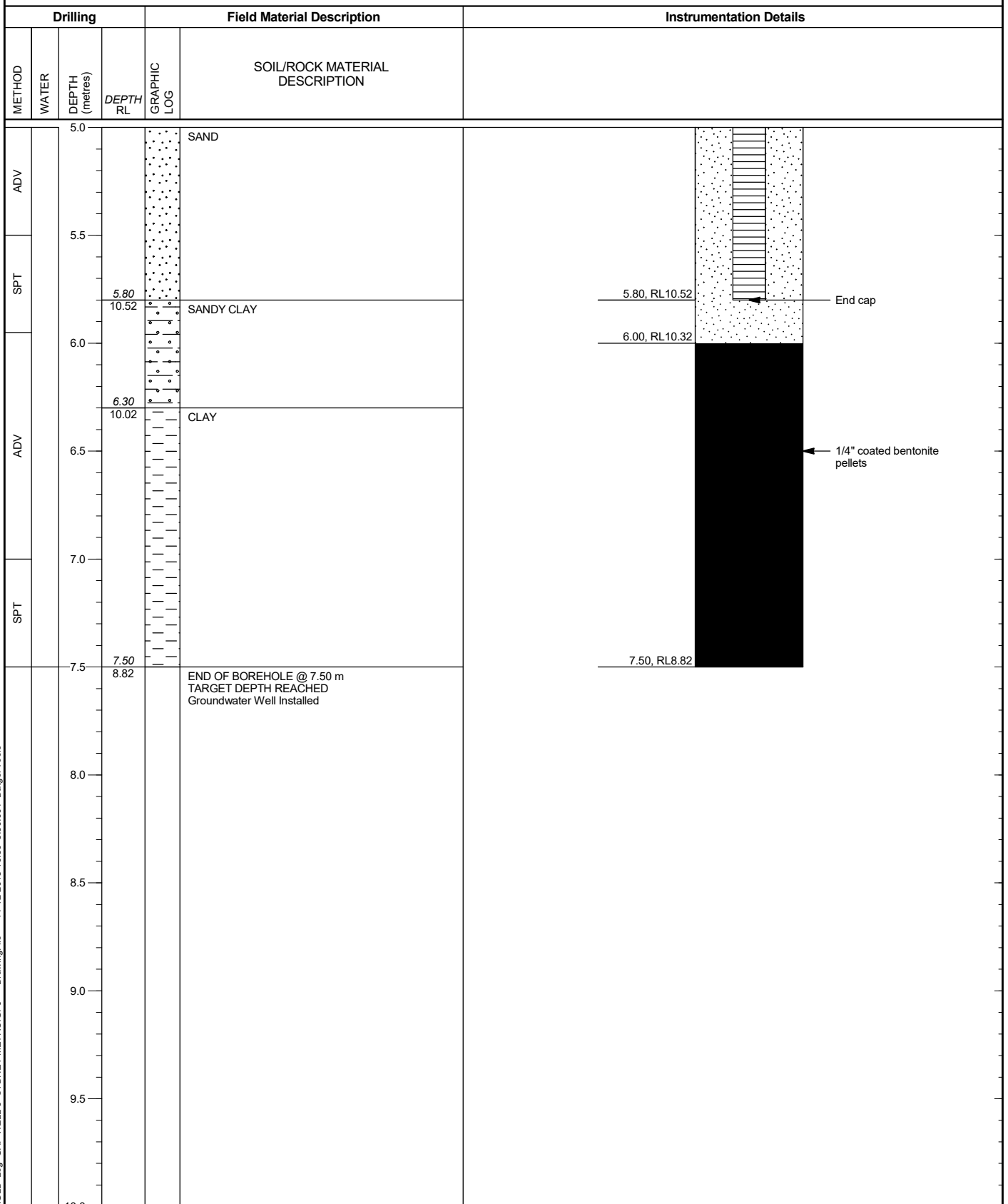
INCLINATION: -90°

LOGGED: RB DATE: 6-10-18

JOB NO: 1791865

HOLE DEPTH: 7.50 m

CHECKED: BH DATE: 14-12-18



GAP 8_1616 LIB\GIB Log GAP WELL 3 SYDNEY METRO.GPJ <<DrawingFile>> 14-12-2018 16:30 8.30.004 Datgel Tools

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

PIEZOMETER CONSTRUCTION

HOLE NO : SRT-BH420_w

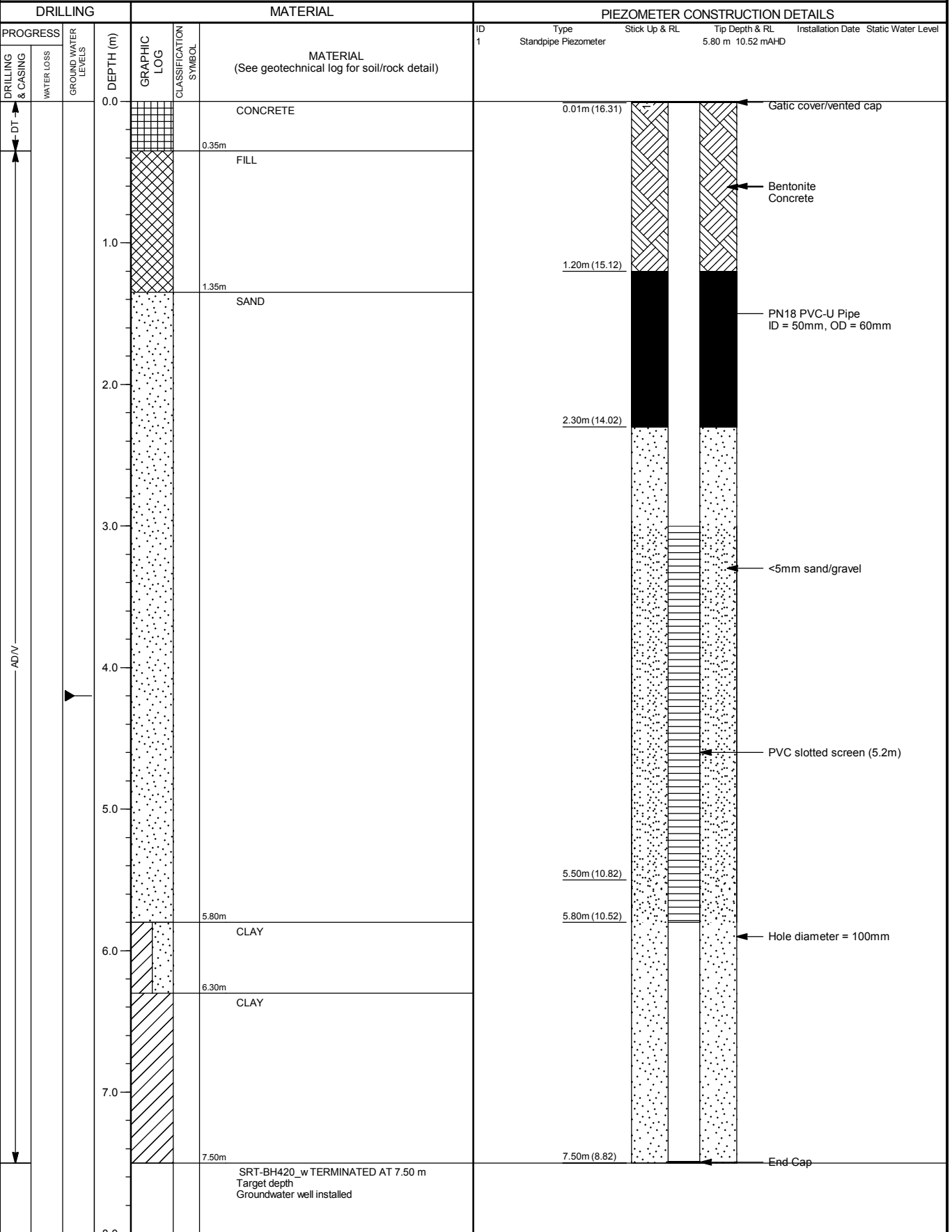
PROJECT : Sydney Metro West
 LOCATION : Waterloo - Mid-eastern boundary

FILE / JOB NO : 00013/11180
 SHEET : 1 OF 1

POSITION : E: 333563.7, N: 6247771.9 (56 MGA94) SURFACE ELEVATION : 16.32 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : GEO 305 MOUNTING : Track / Geoprobe 7822DT CONTRACTOR : Ground Test

DATE STARTED : 6/10/18 DATE COMPLETED : 7/10/18 DATE LOGGED : 10/10/18 LOGGED BY : AT CHECKED BY : GS



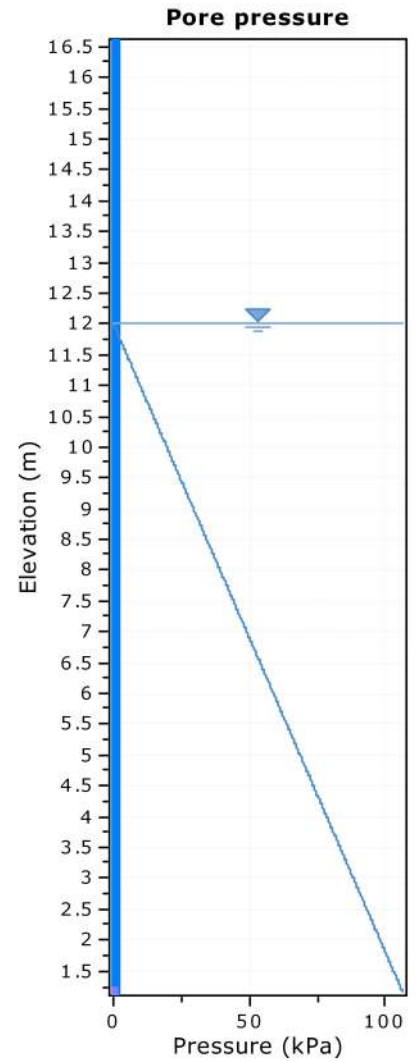
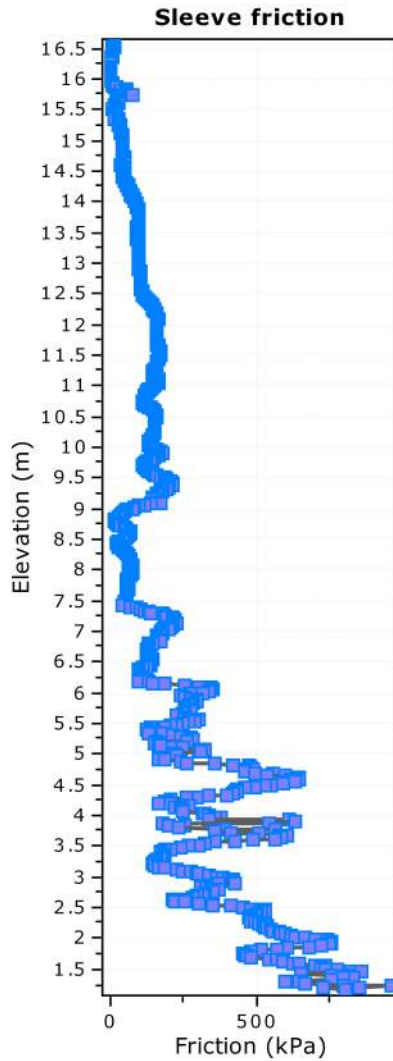
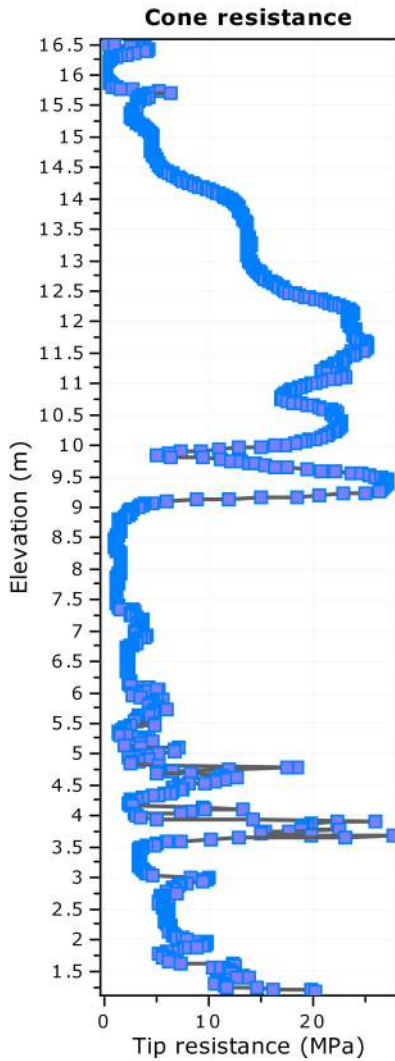
RMS.LIB.40.3.8.GLB.Log.RTA.PIEZOMETER.INSTALLATION.LOG.1.SMW.WATERLOO.GPJ <<DrawingFile>> 18/Jan/2019 14:13.8.30.004.Datagel.T.coils

This report of well/VWP installation must be read in conjunction with accompanying notes and abbreviations. The geotechnical log is a summary only and the detailed log should be referred to for strata details and any core loss zones.

Appendix B – CPT Logs and Interpretation

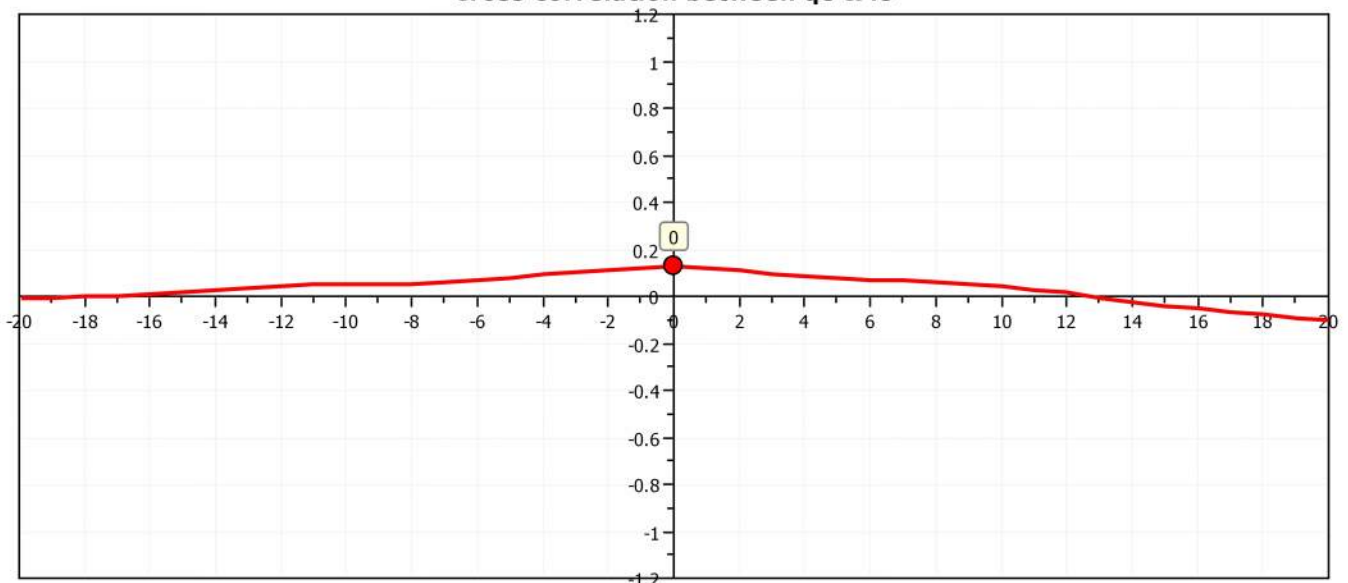
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

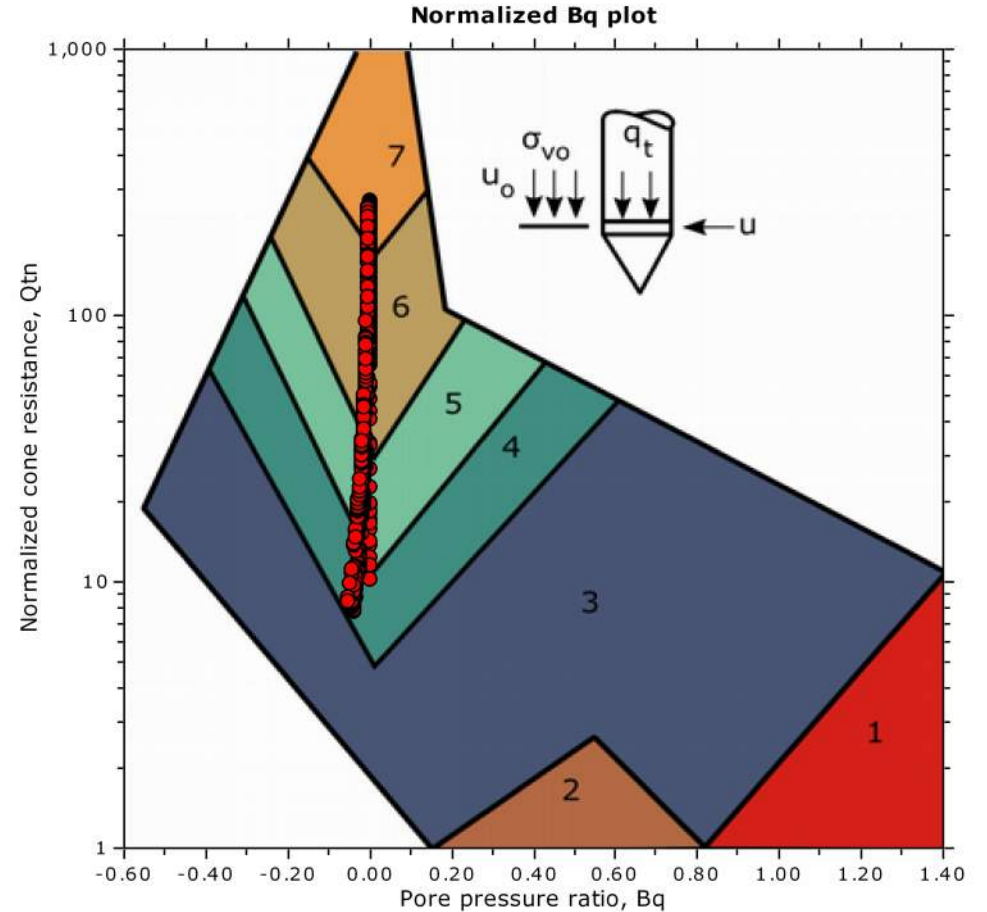
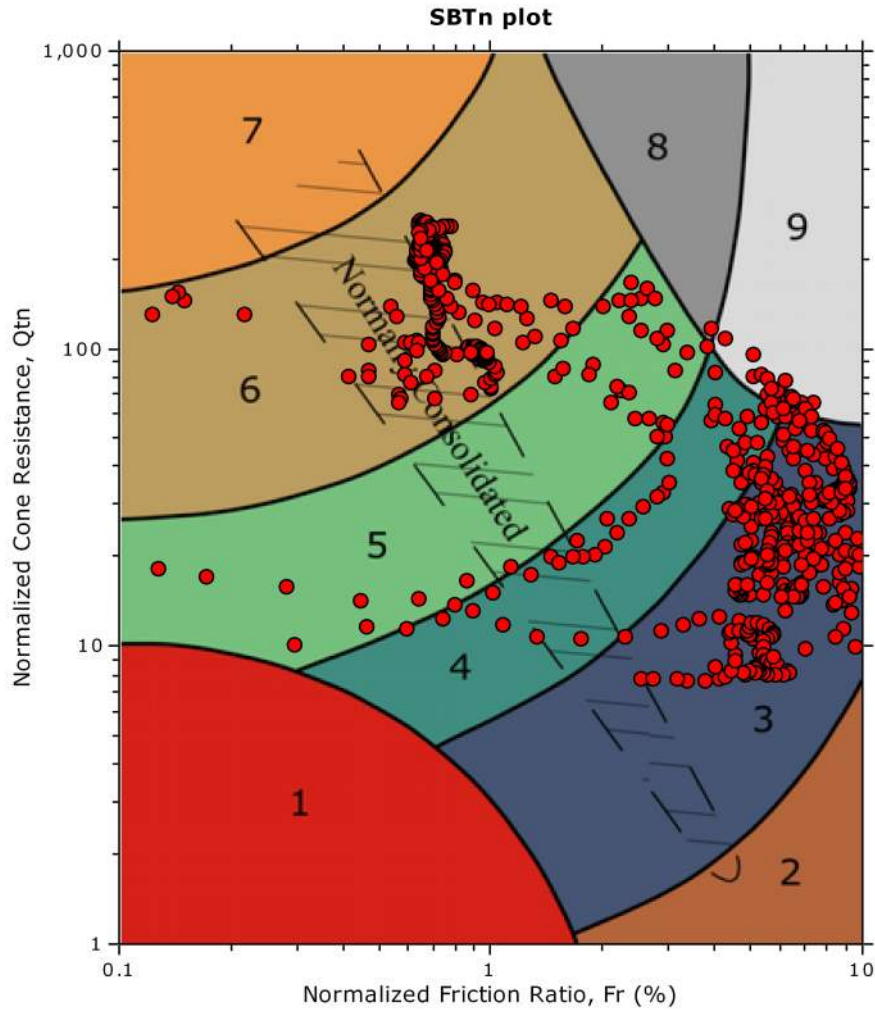




Project:

Location:

SBT - Bq plots (normalized)



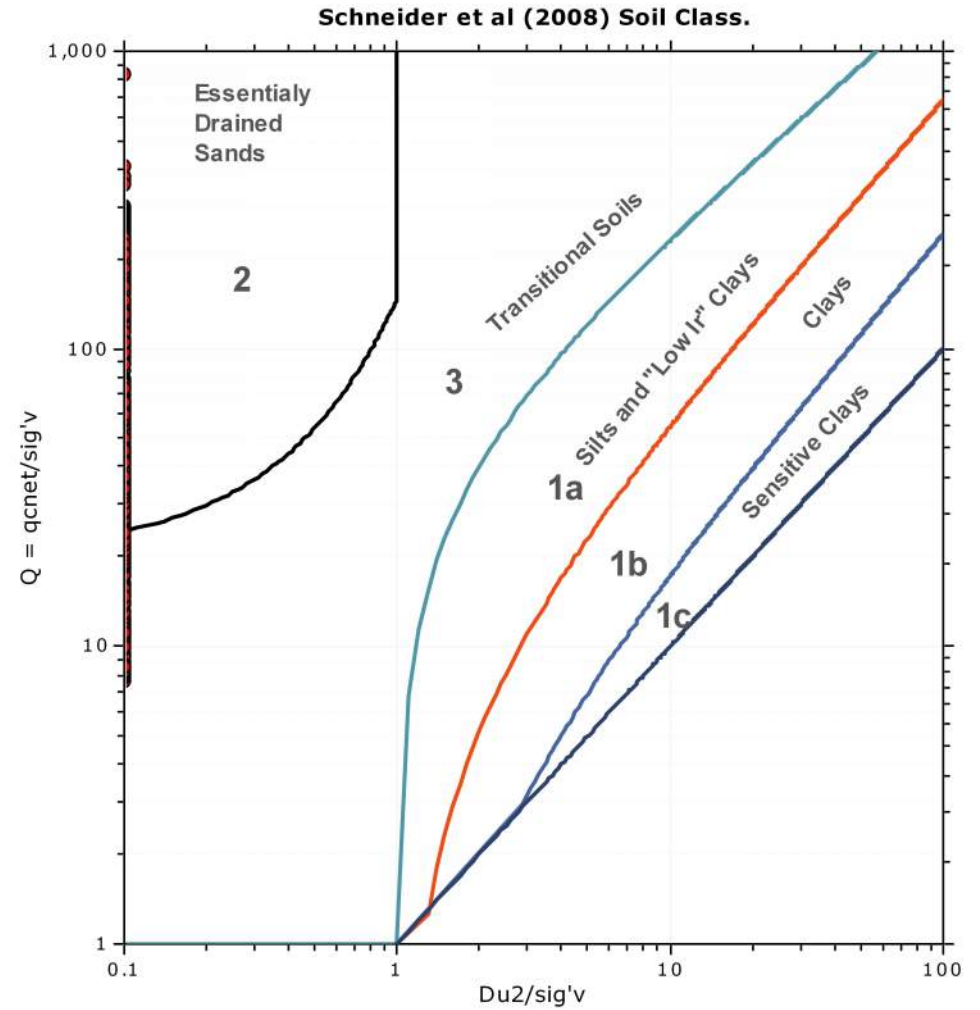
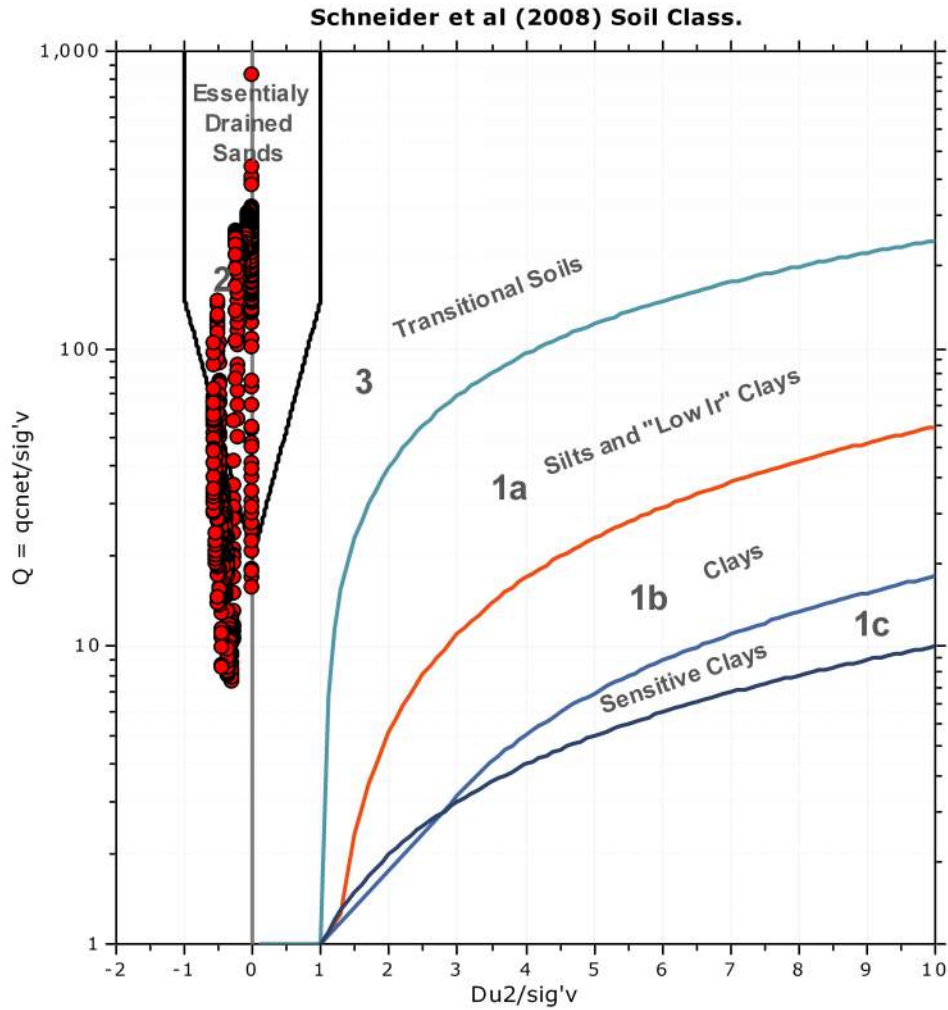
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

Project:

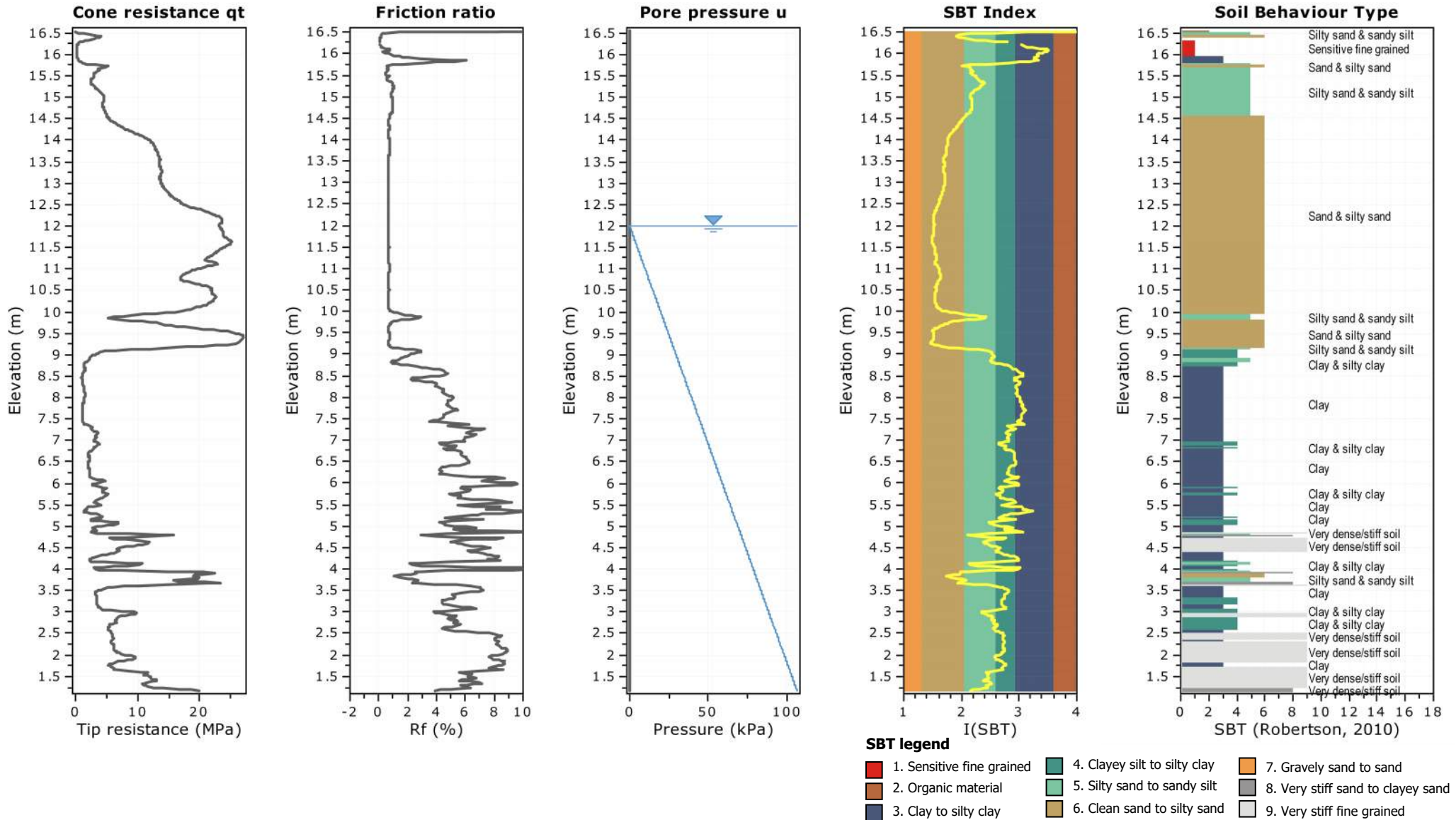
Location:

Bq plots (Schneider)

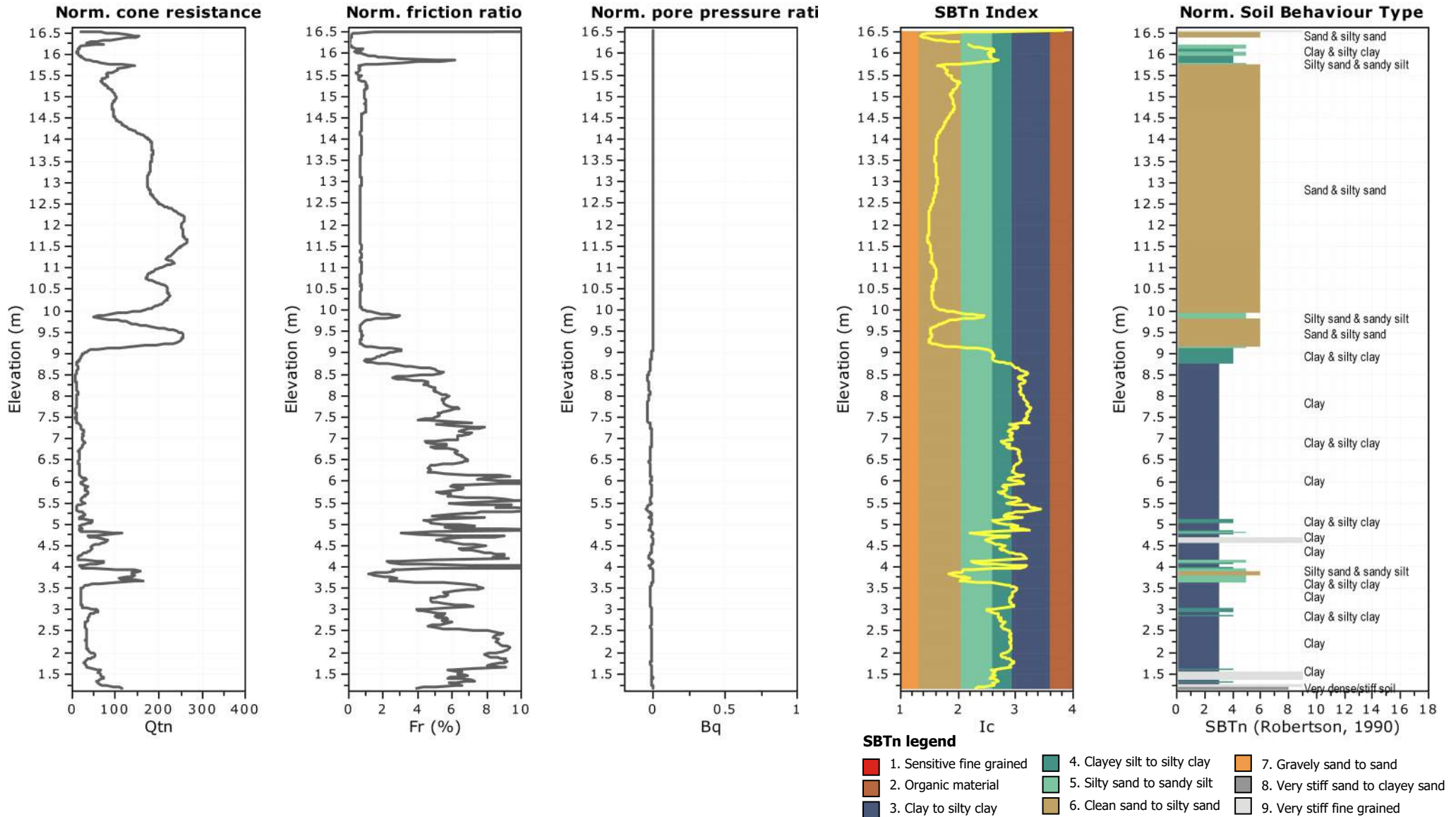


Project:

Location:

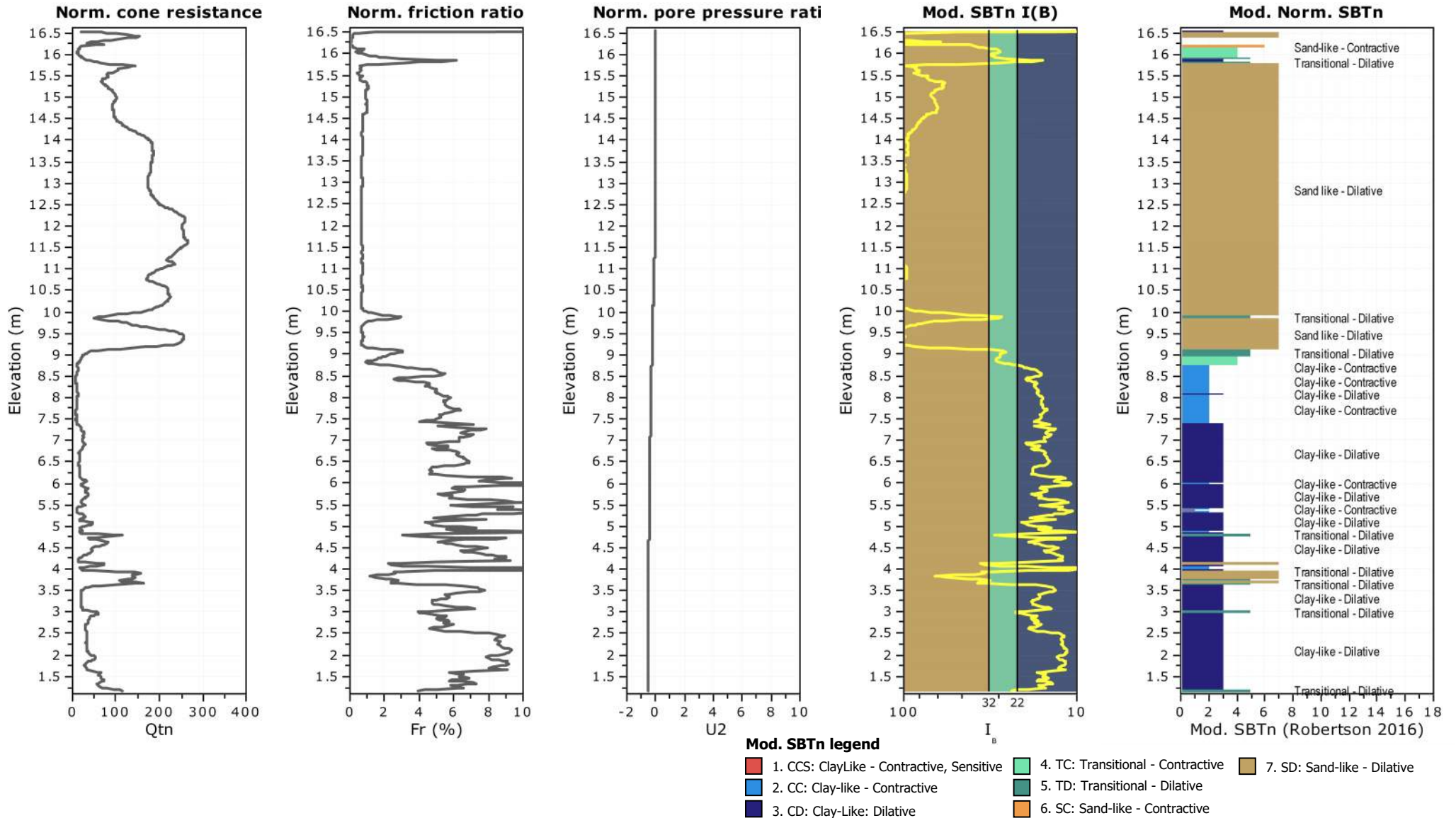


Project:
Location:



Project:

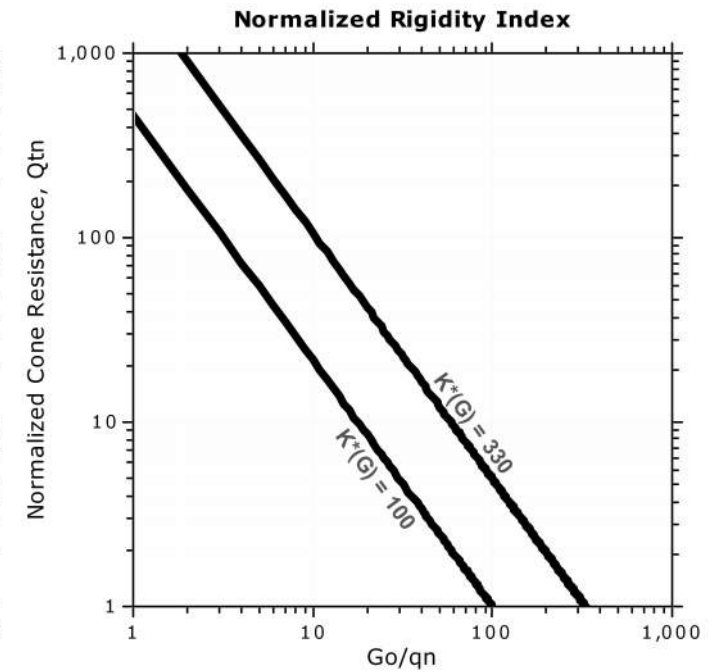
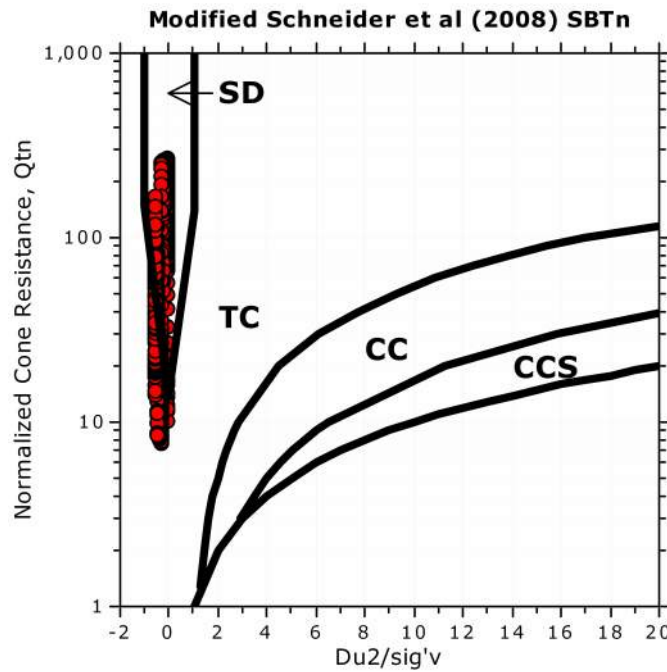
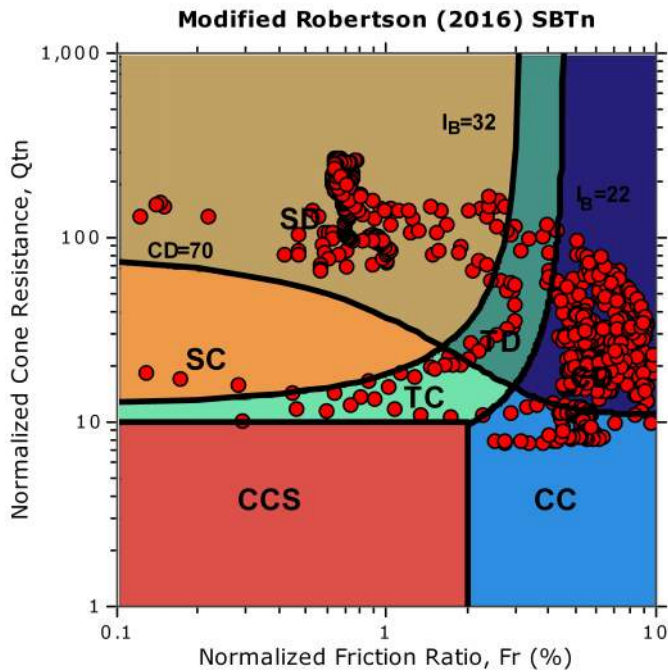
Location:



Project:

Location:

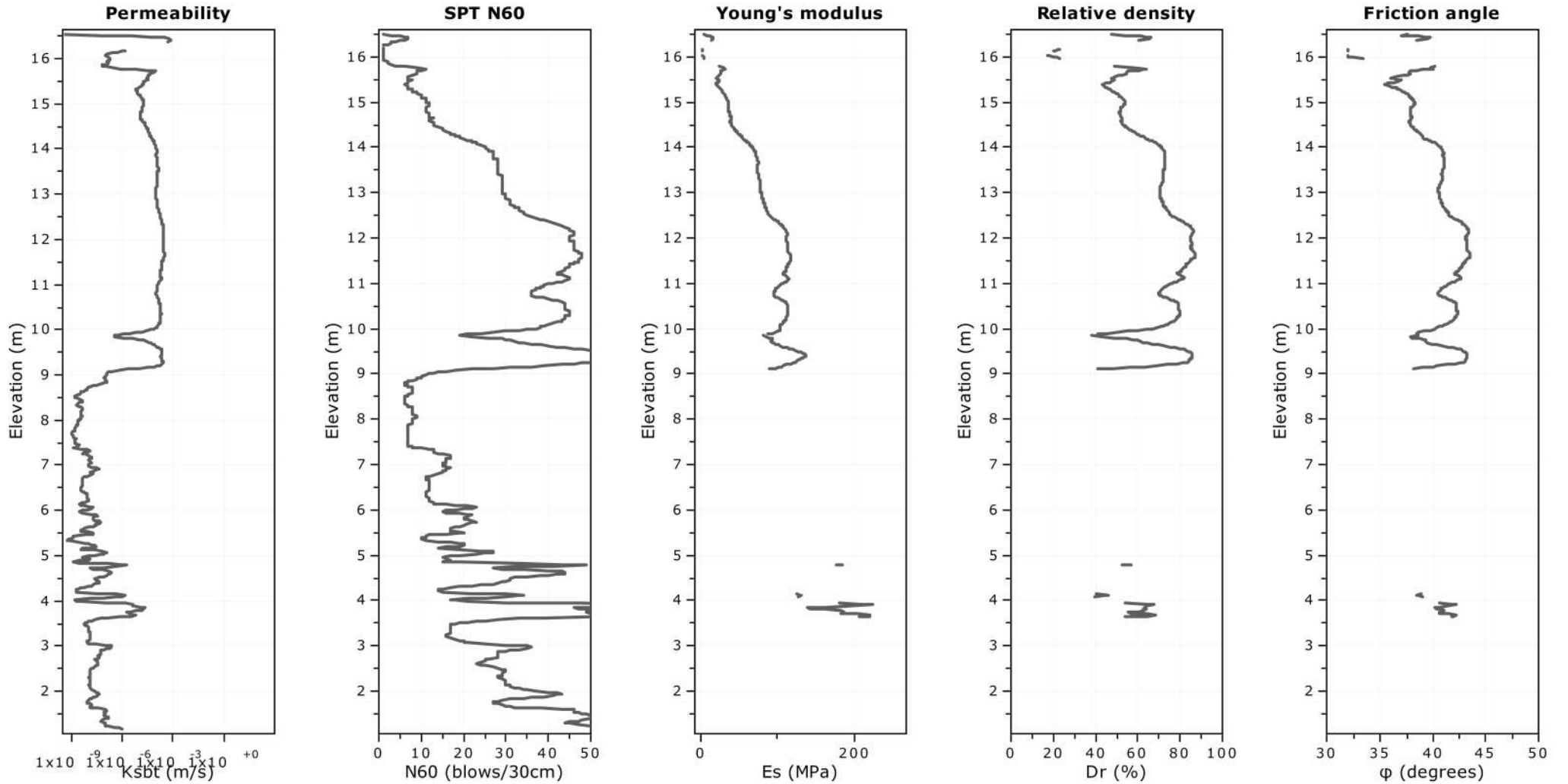
Updated SBTn plots



- 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)

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

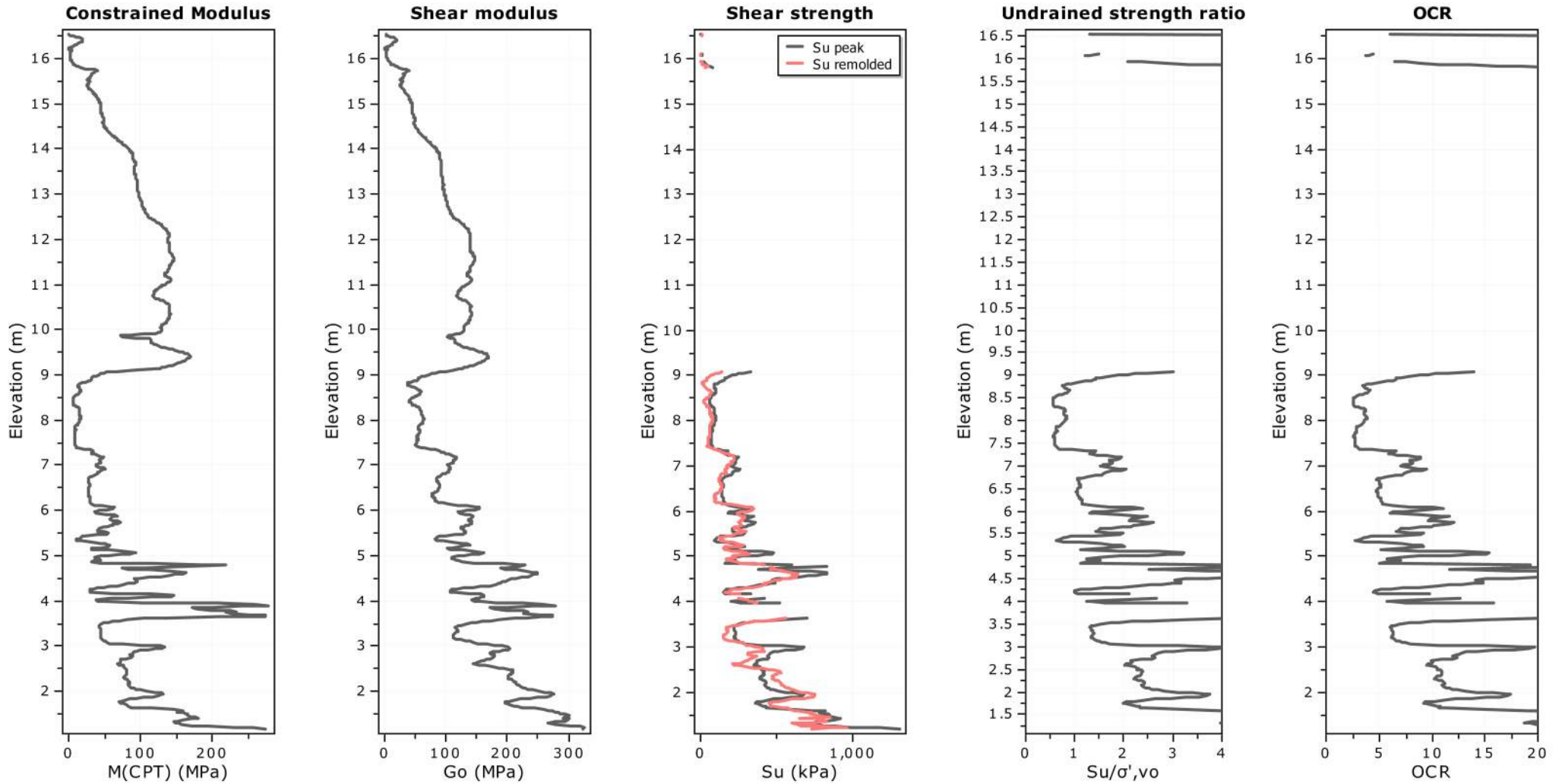
Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

● — User defined estimation data

Project:

Location:



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

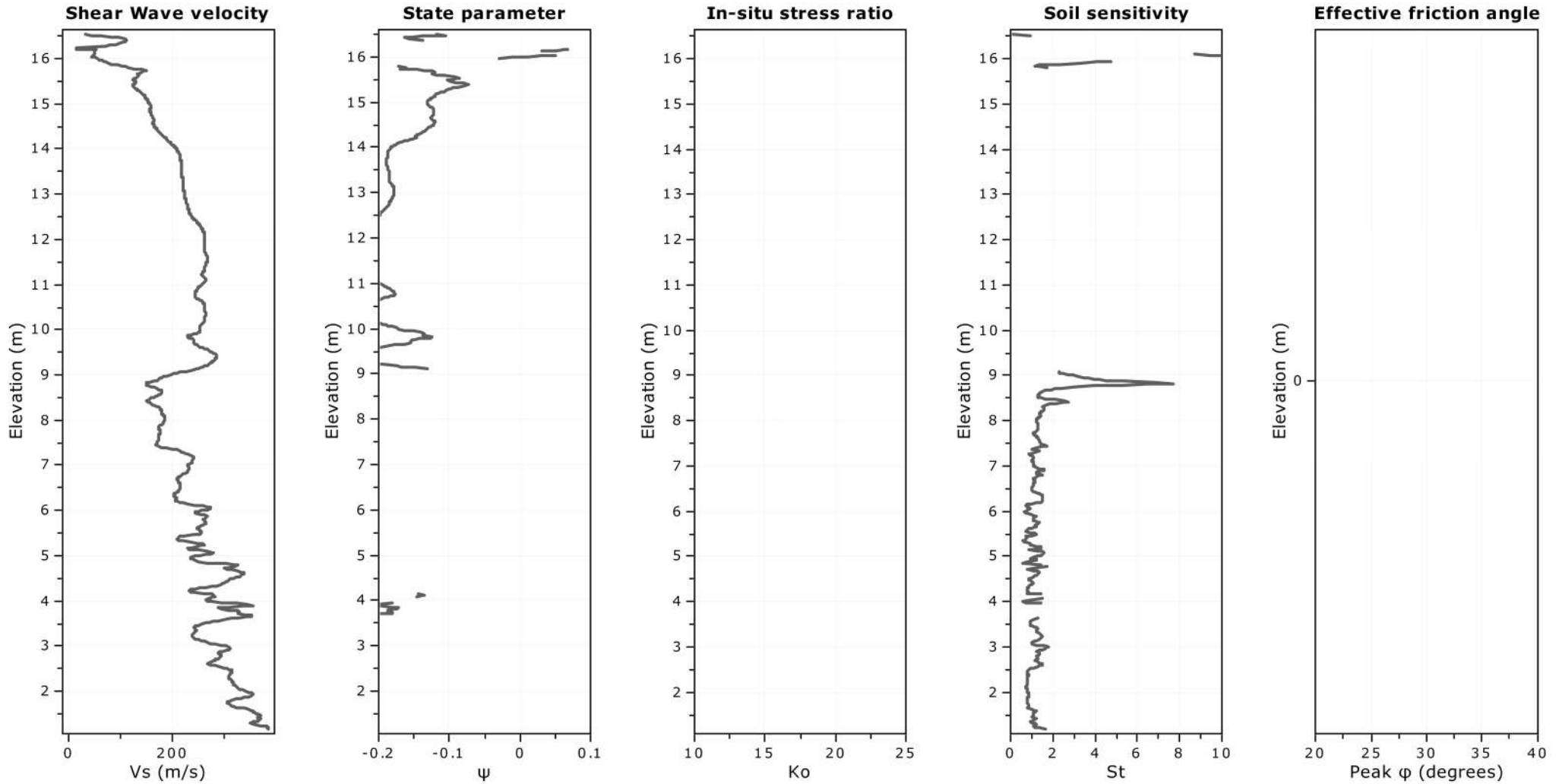
OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:

Location:



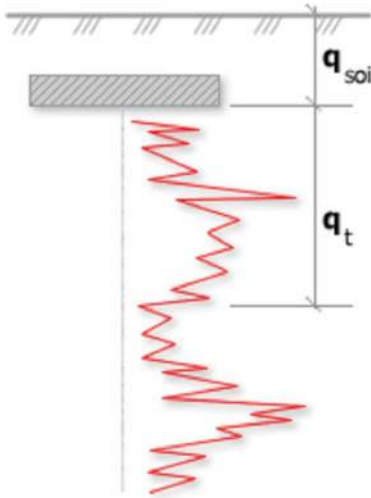
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

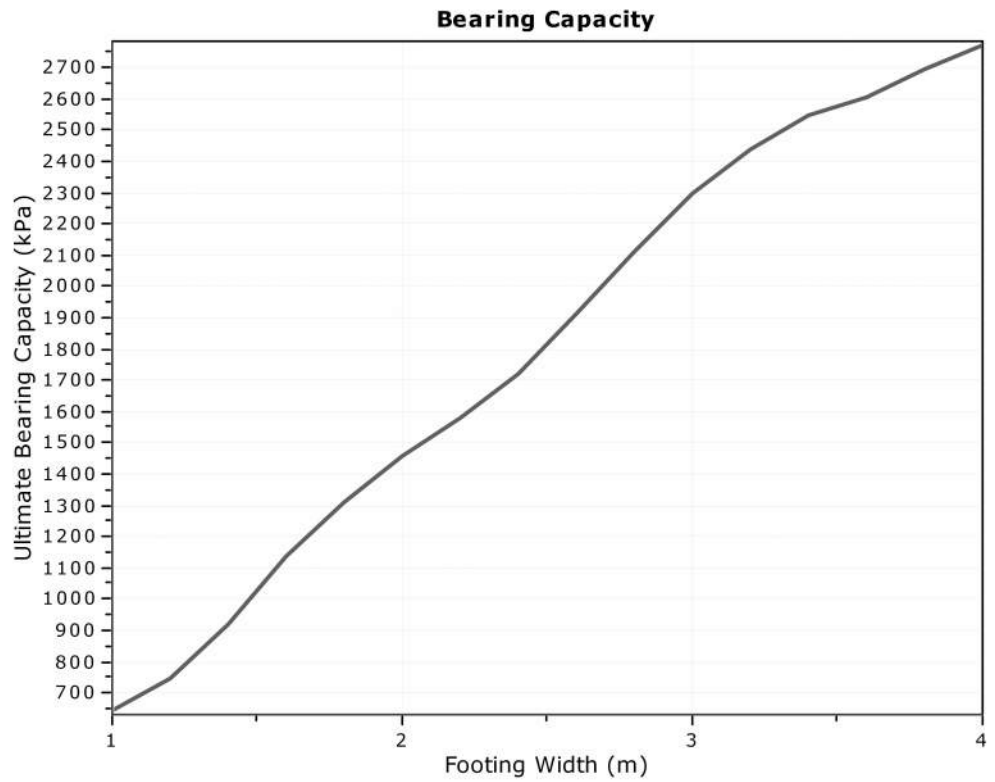
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

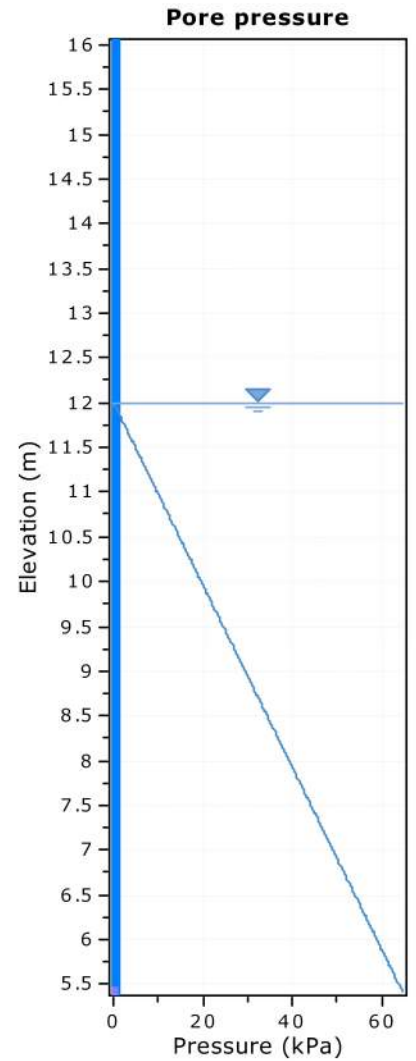
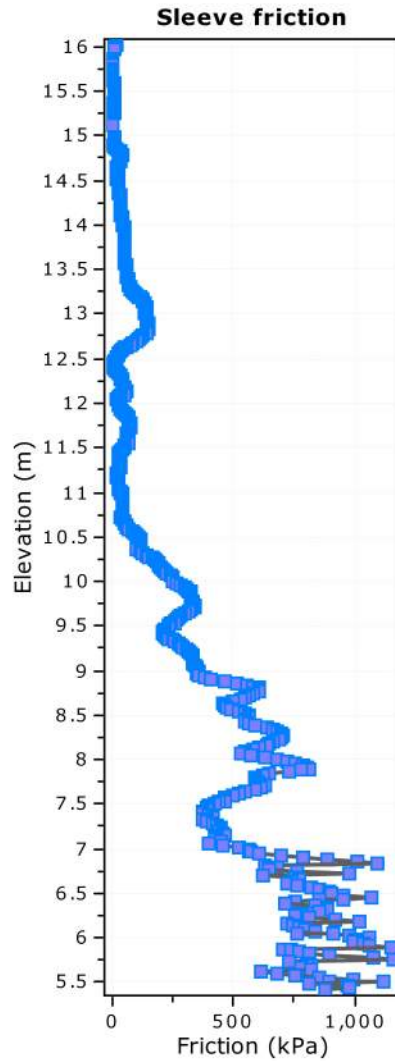
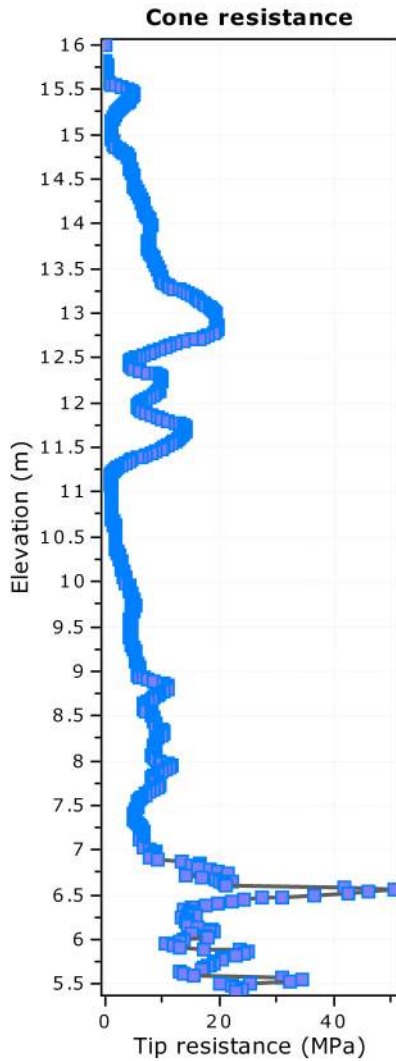


:: Tabular results ::

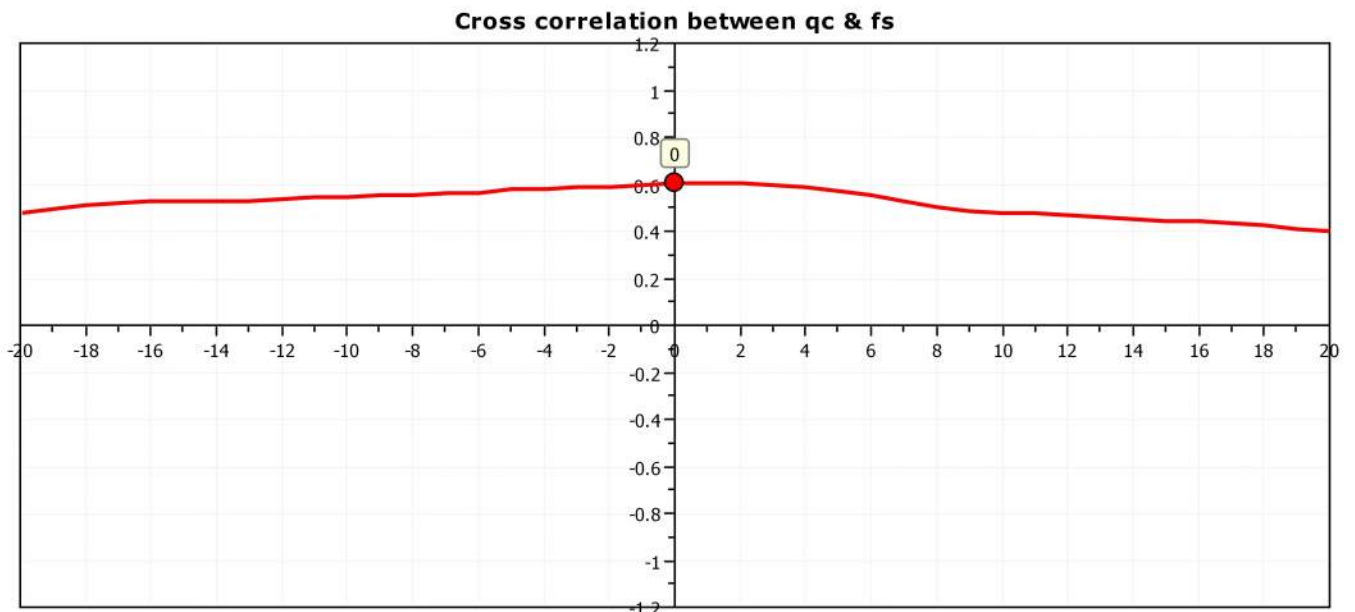
No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	3.17	0.20	9.50	643.97
2	1.20	0.50	2.30	3.69	0.20	9.50	746.60
3	1.40	0.50	2.60	4.54	0.20	9.50	917.69
4	1.60	0.50	2.90	5.63	0.20	9.50	1135.91
5	1.80	0.50	3.20	6.50	0.20	9.50	1310.41
6	2.00	0.50	3.50	7.23	0.20	9.50	1454.62
7	2.20	0.50	3.80	7.86	0.20	9.50	1580.71
8	2.40	0.50	4.10	8.55	0.20	9.50	1719.78
9	2.60	0.50	4.40	9.52	0.20	9.50	1913.11
10	2.80	0.50	4.70	10.51	0.20	9.50	2111.56
11	3.00	0.50	5.00	11.43	0.20	9.50	2295.40
12	3.20	0.50	5.30	12.15	0.20	9.50	2440.22
13	3.40	0.50	5.60	12.69	0.20	9.50	2547.17
14	3.60	0.50	5.90	12.96	0.20	9.50	2602.04
15	3.80	0.50	6.20	13.41	0.20	9.50	2691.56
16	4.00	0.50	6.50	13.81	0.20	9.50	2771.44

Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

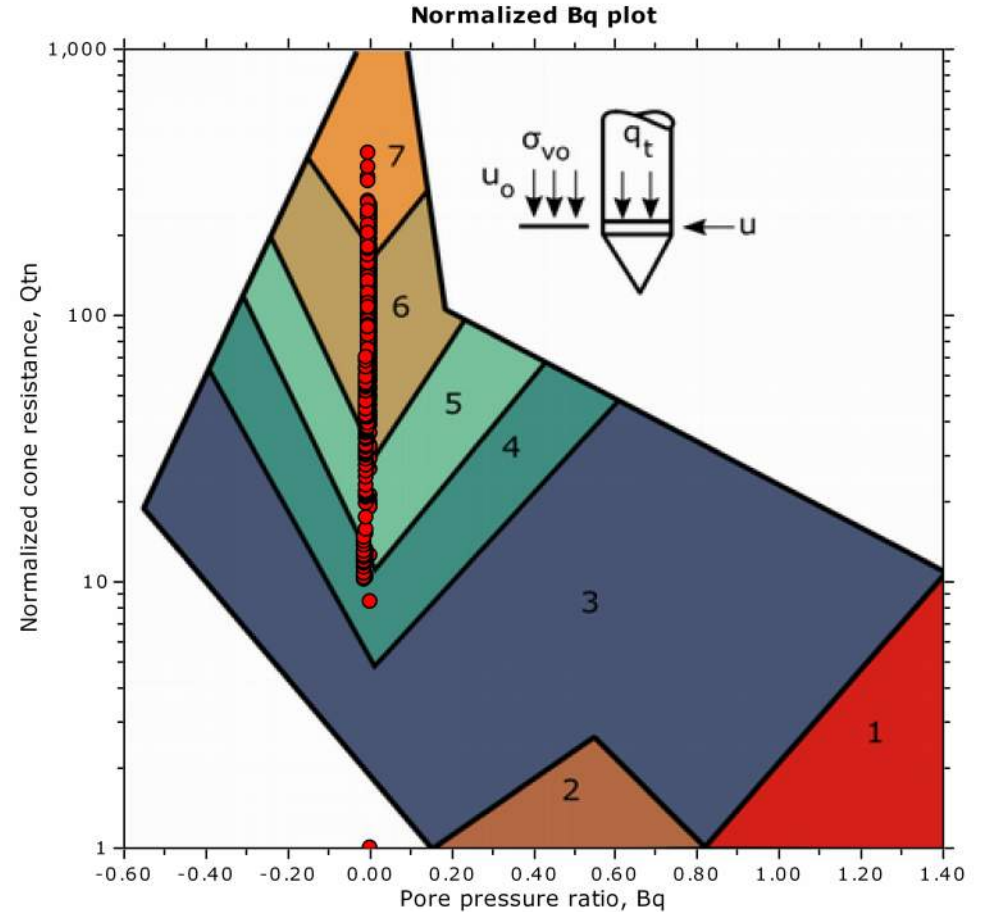
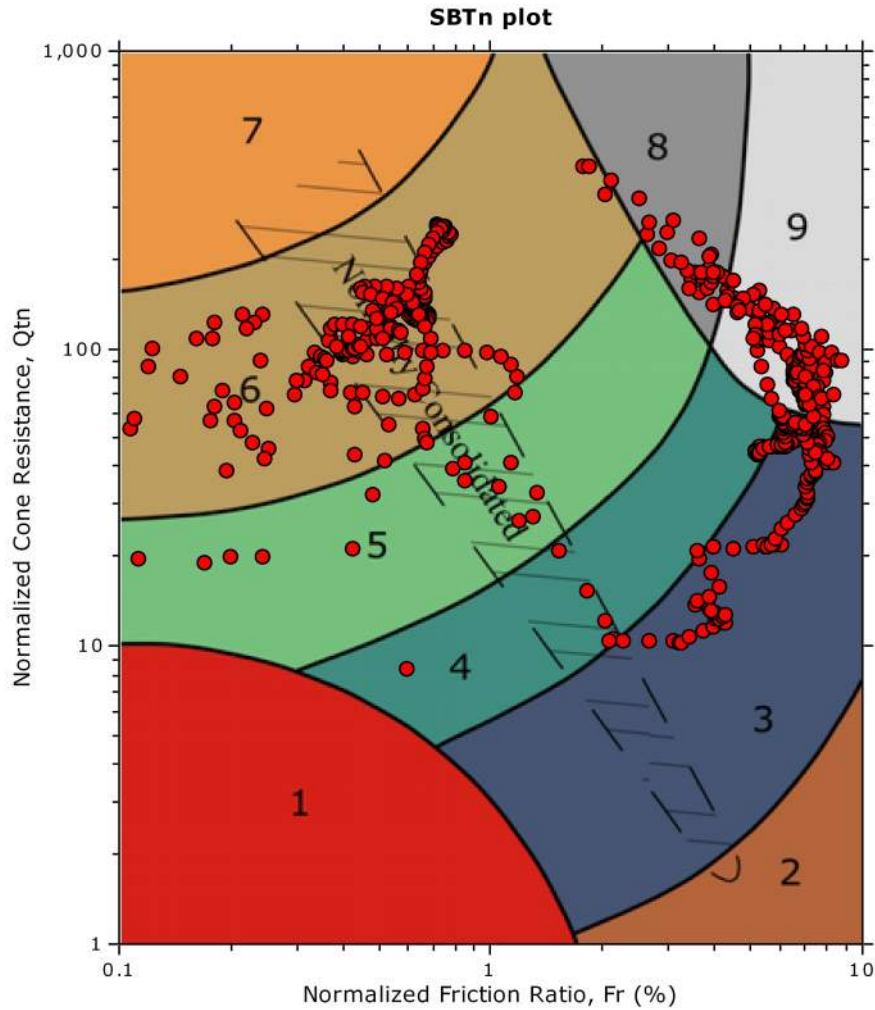




Project:

Location:

SBT - Bq plots (normalized)



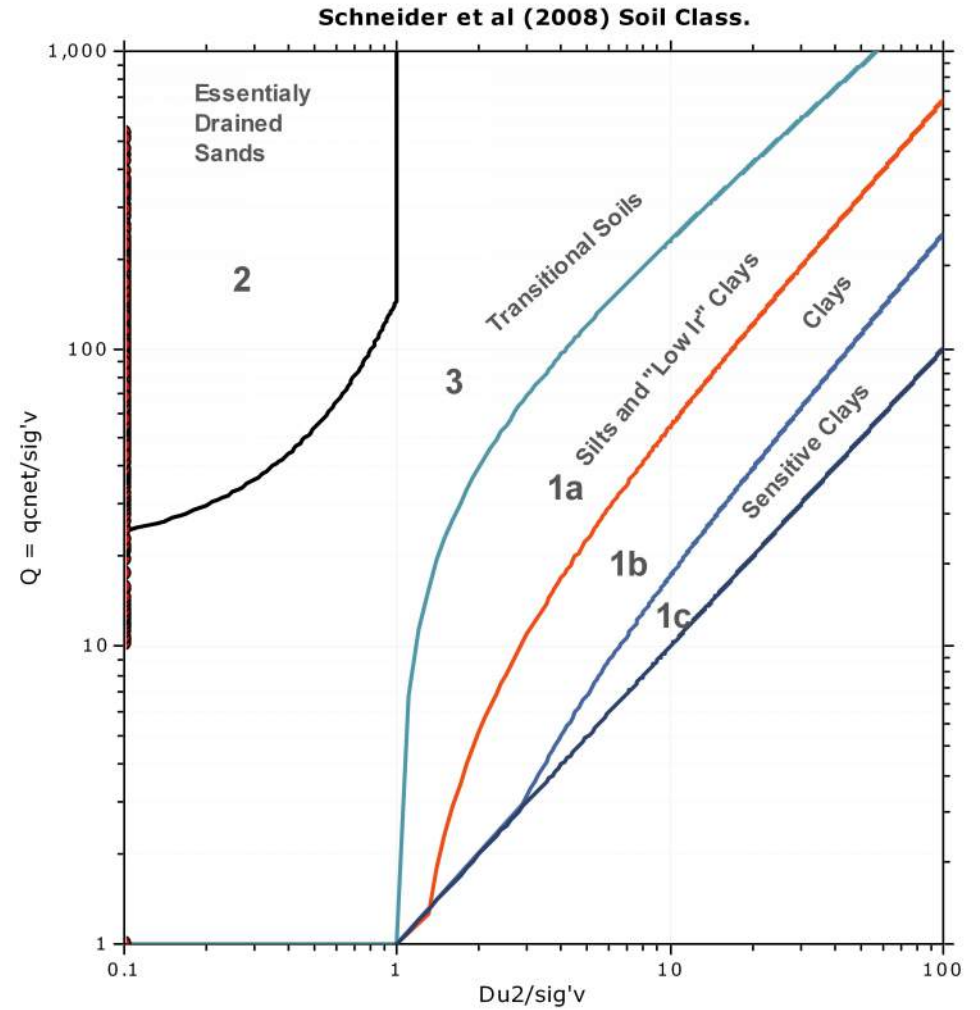
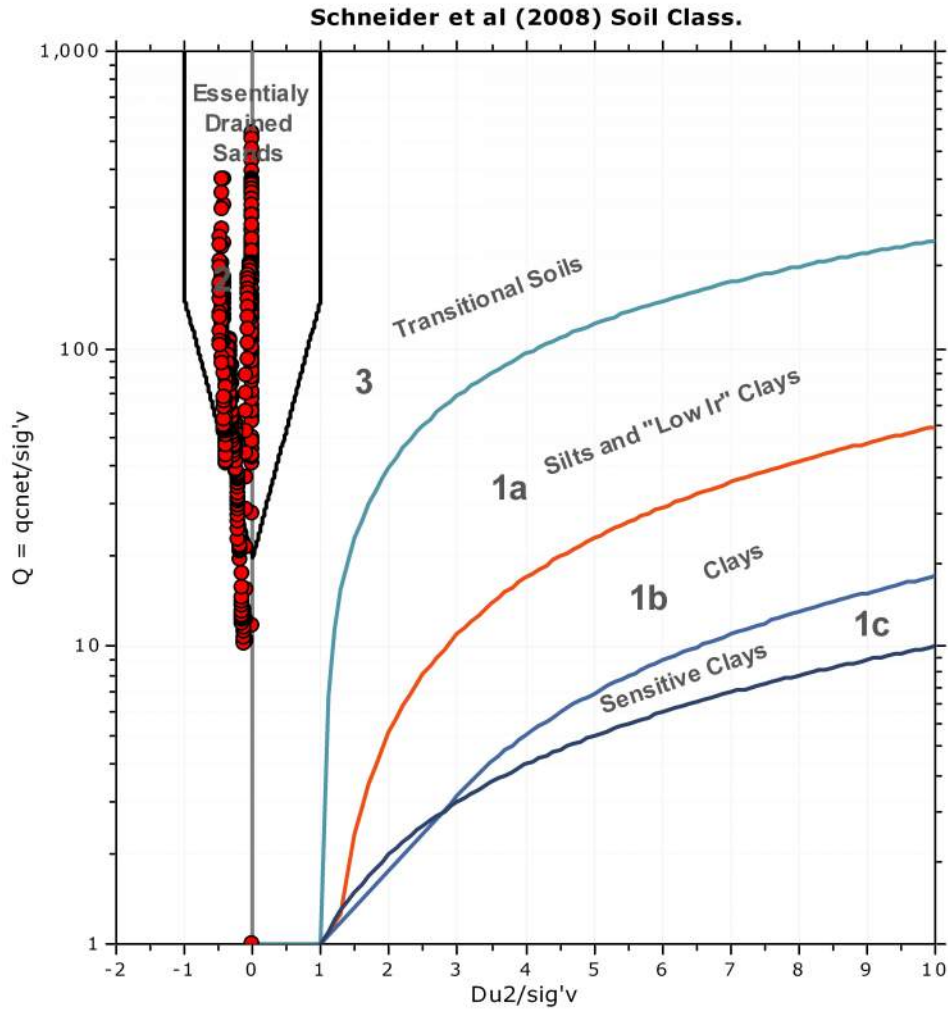
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

Project:

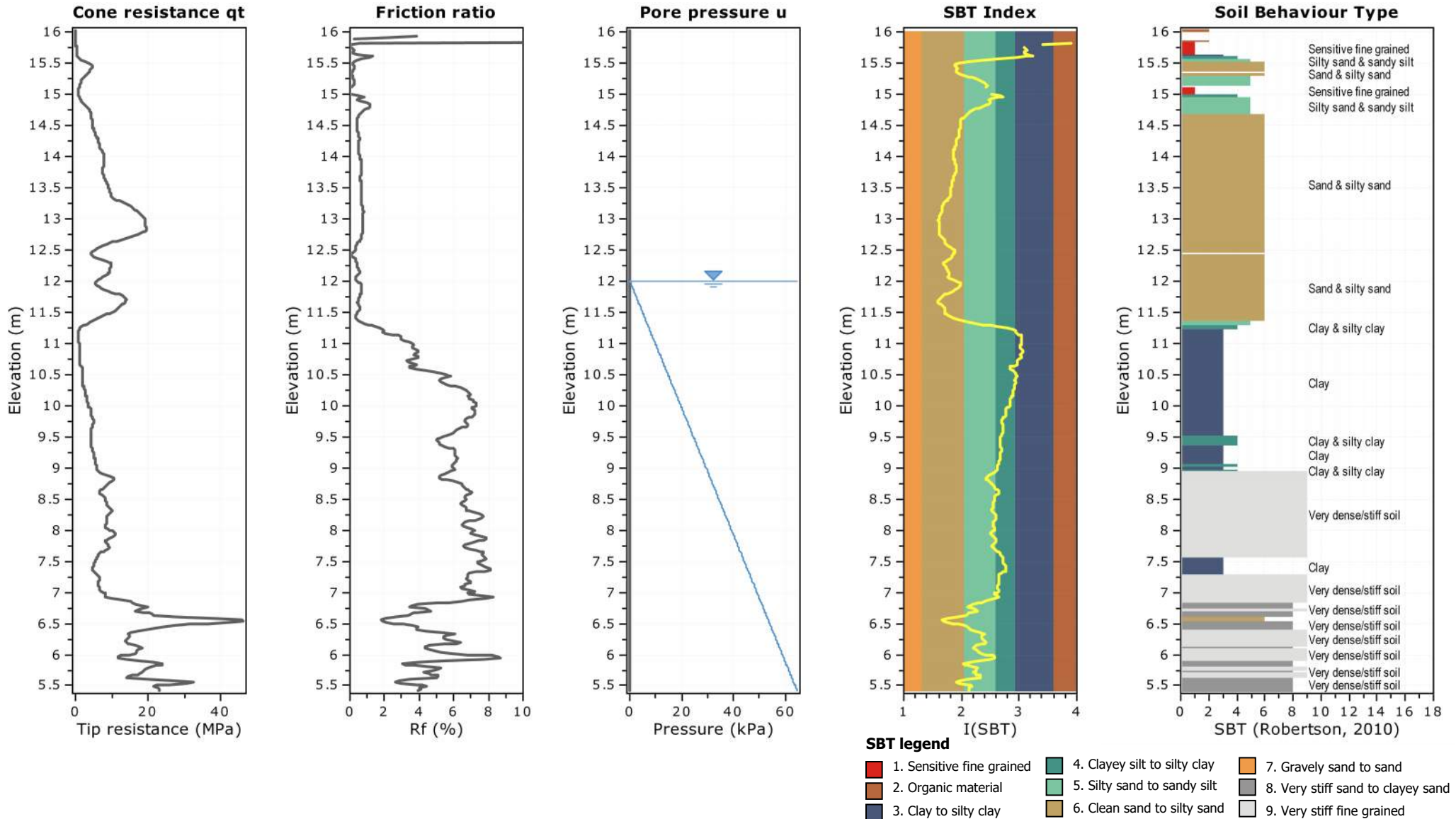
Location:

Bq plots (Schneider)

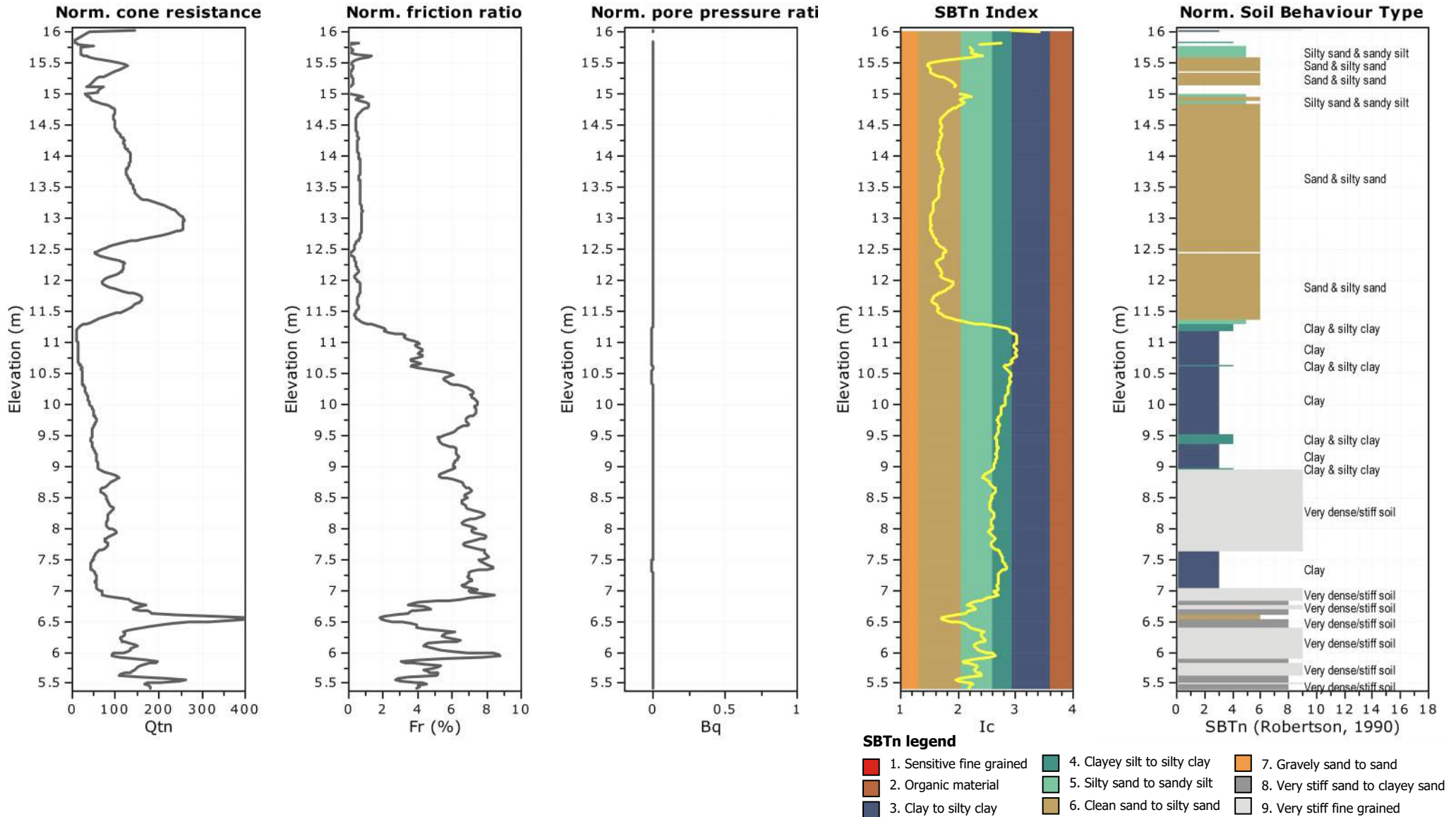


Project:

Location:

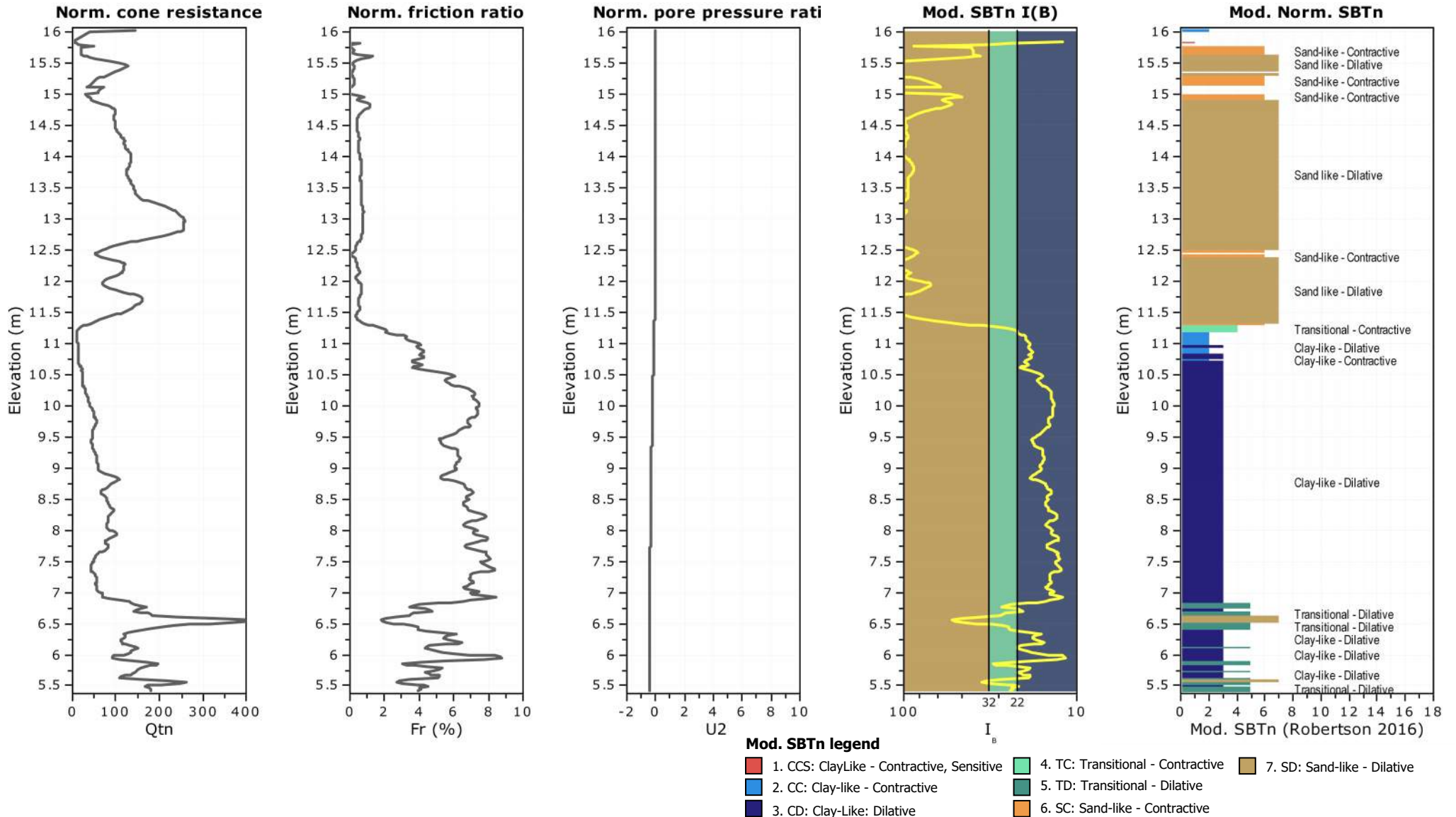


Project:
Location:



Project:

Location:

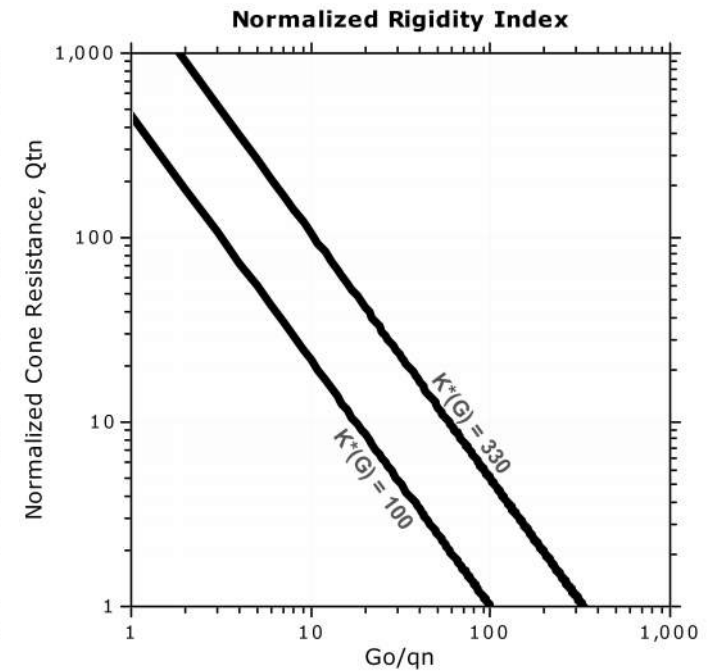
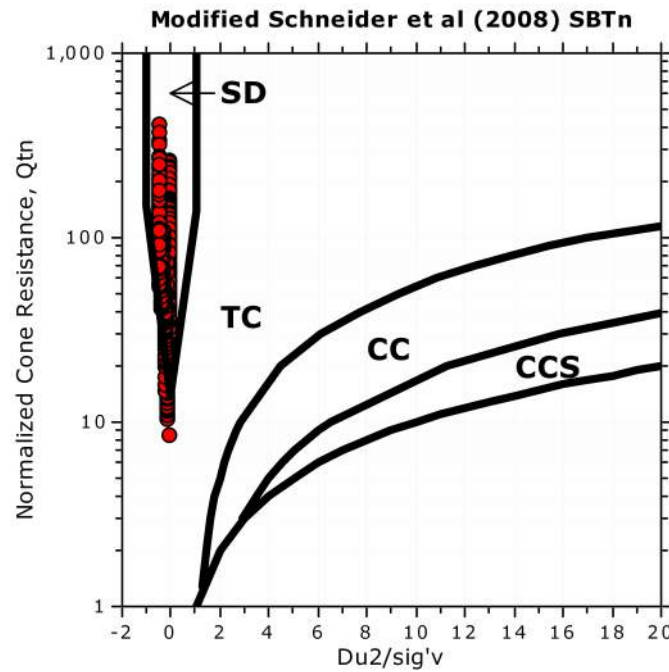
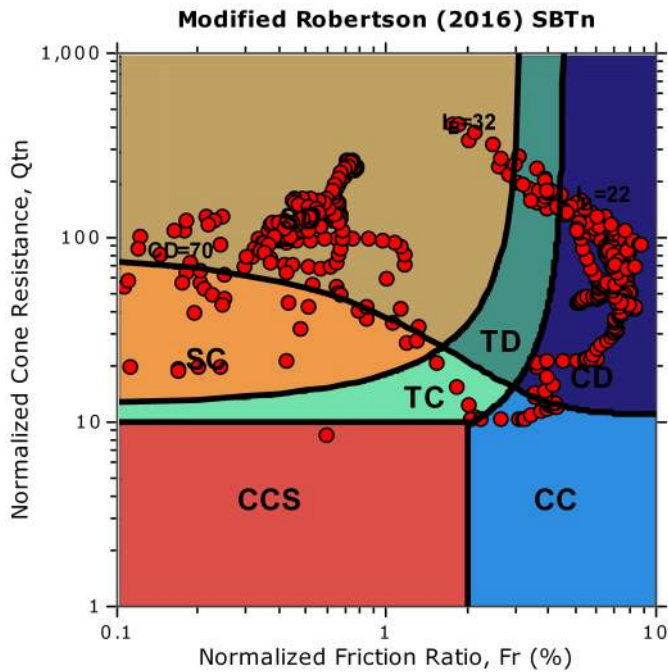




Project:

Location:

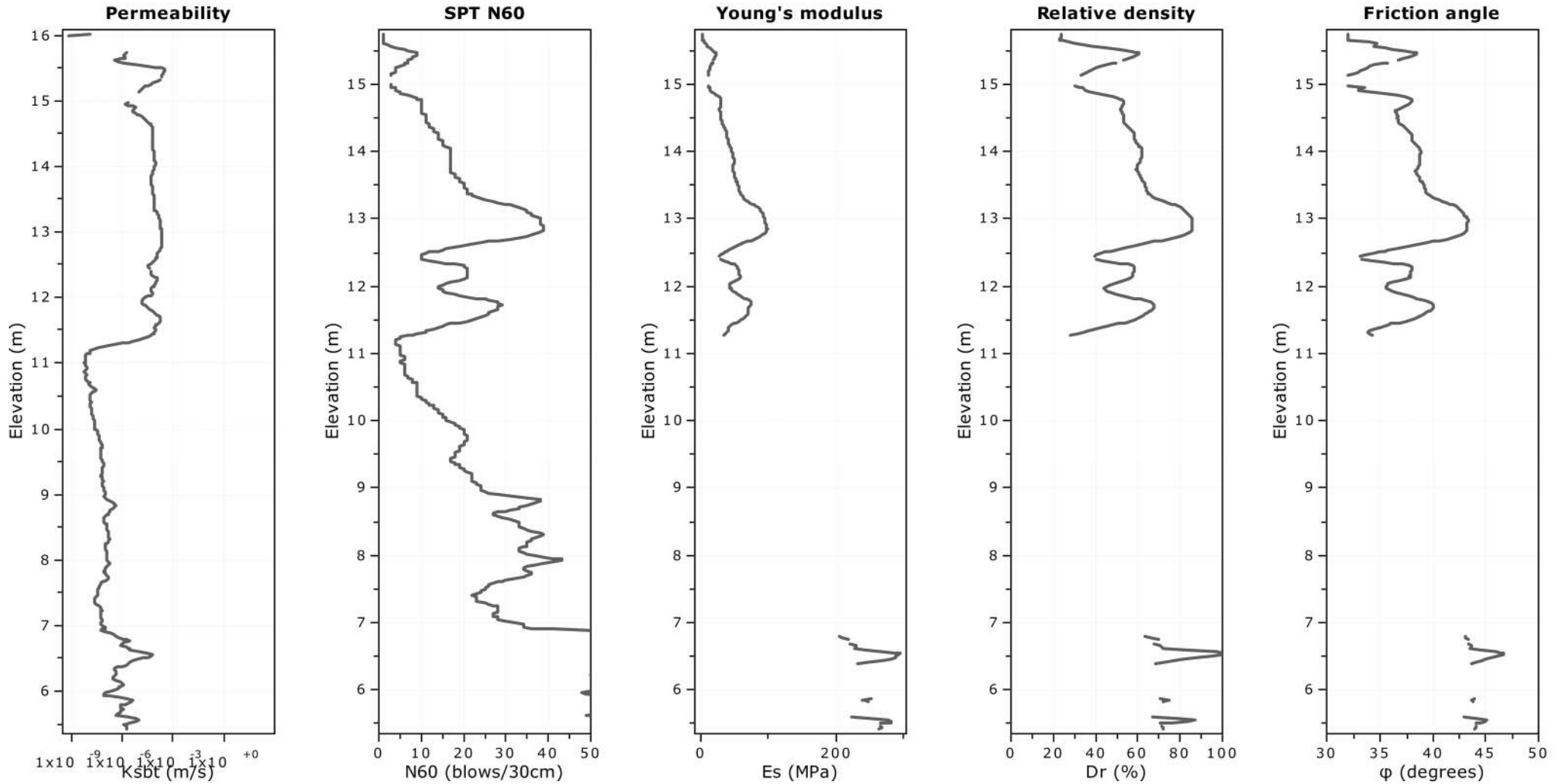
Updated SBTn plots



- 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)

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

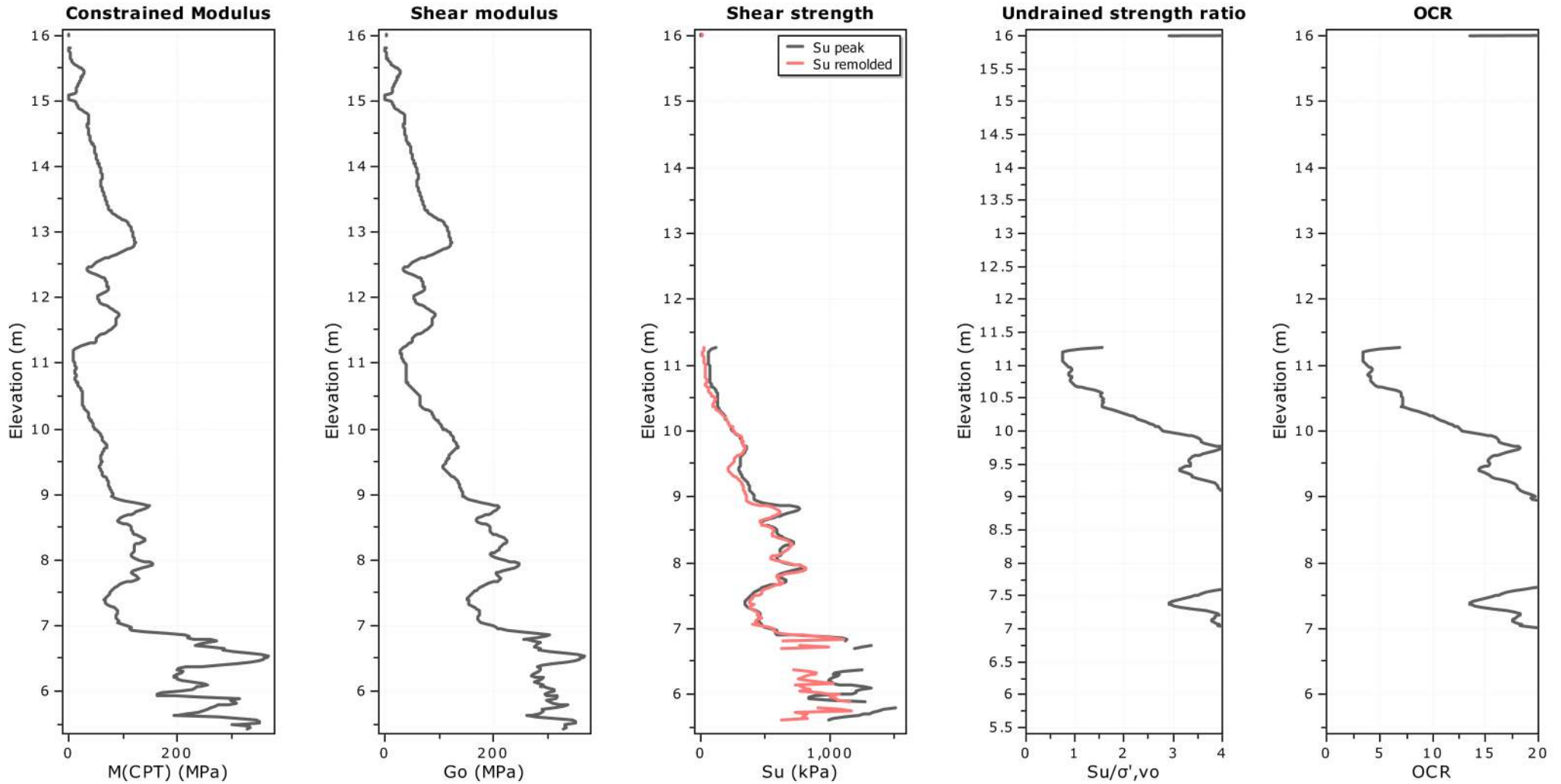
Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

● User defined estimation data

Project:

Location:



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)

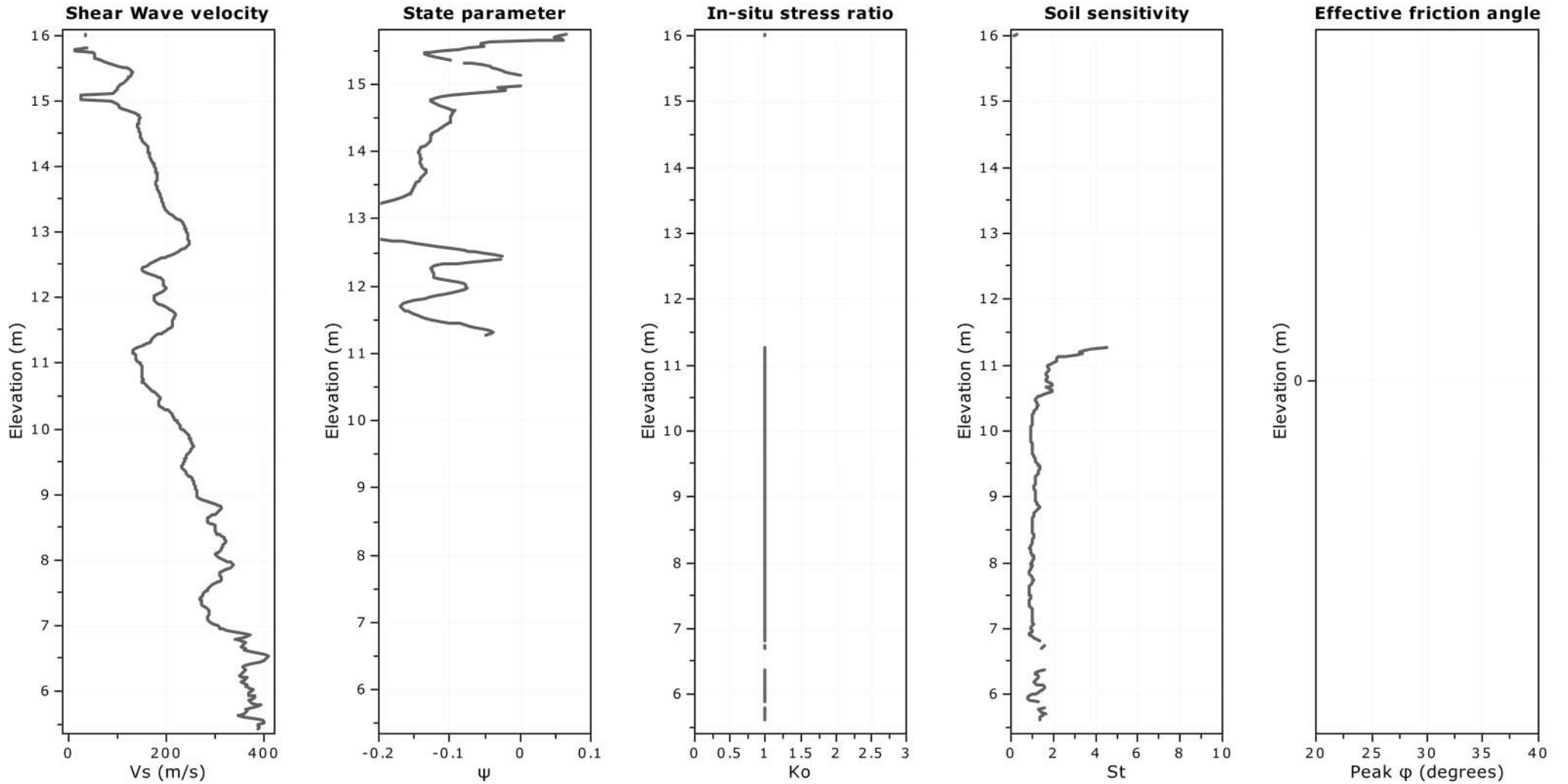
Undrained shear strength cone factor for clays, N_{kt} : 14

OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:
Location:



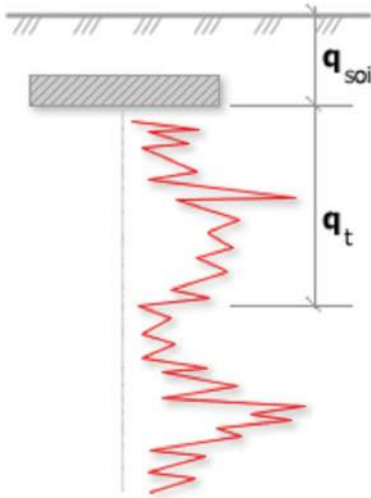
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

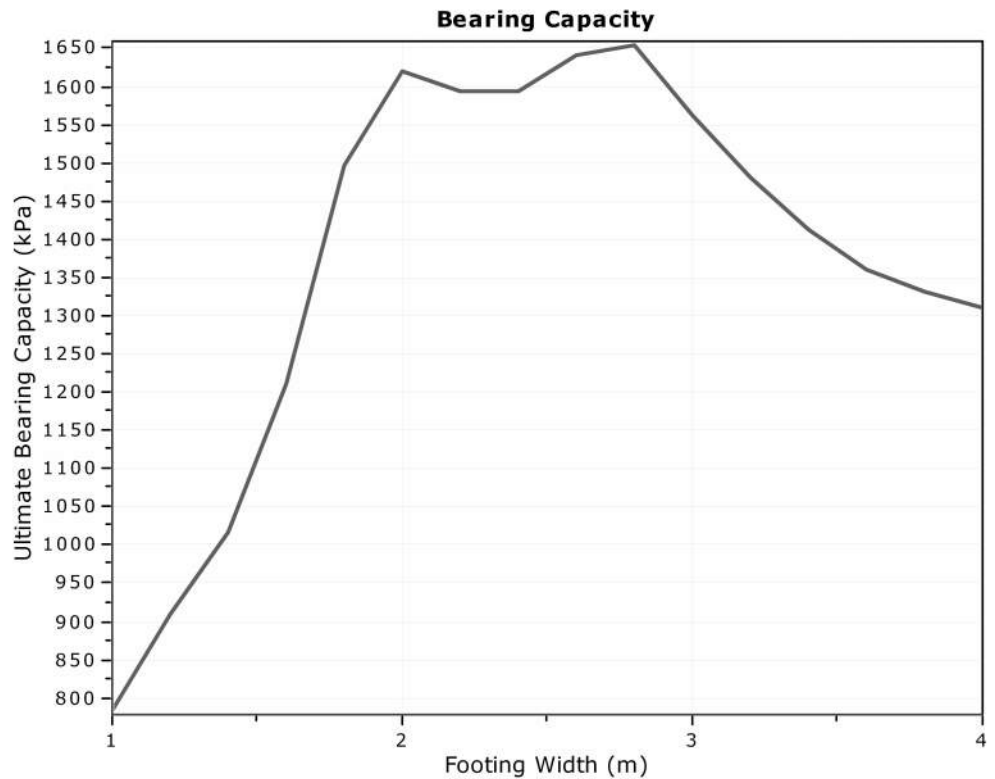
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

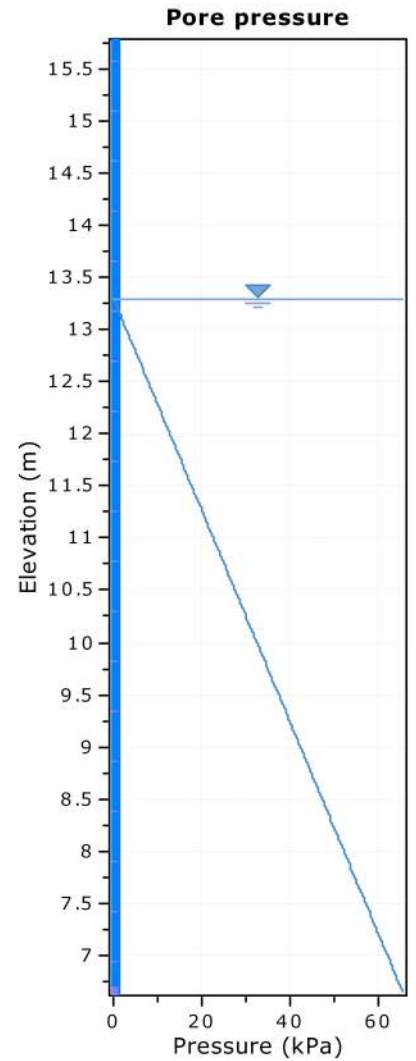
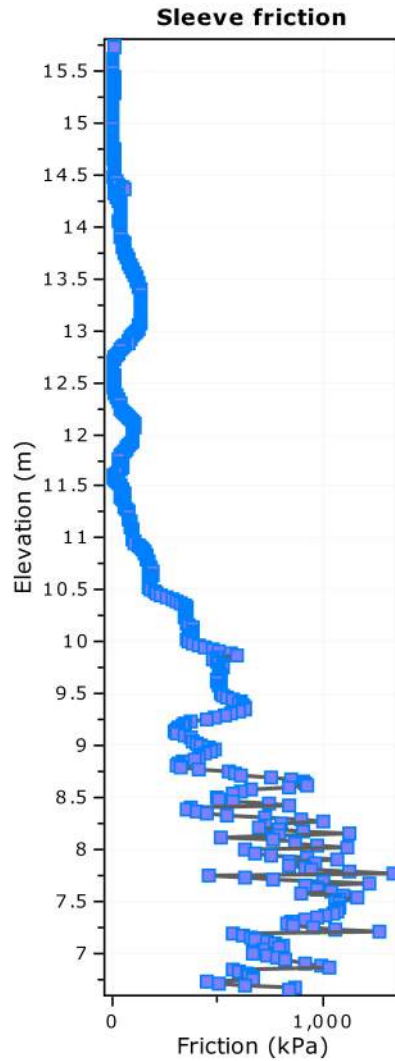
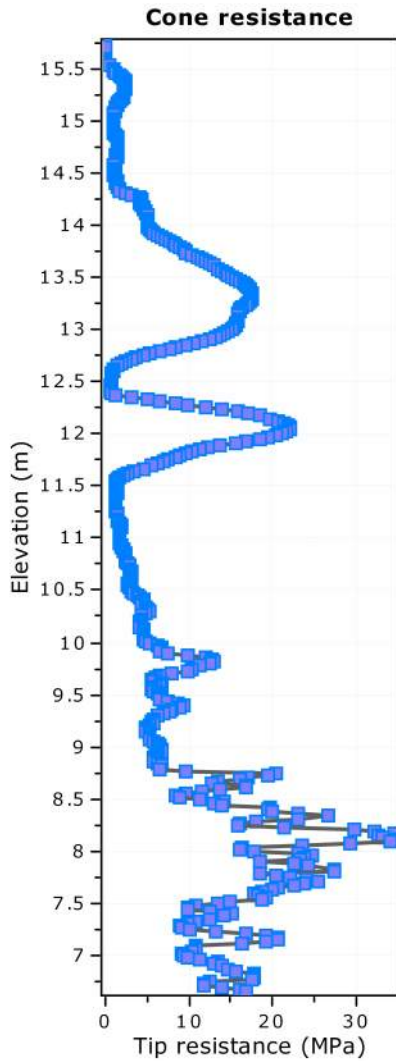


:: Tabular results ::

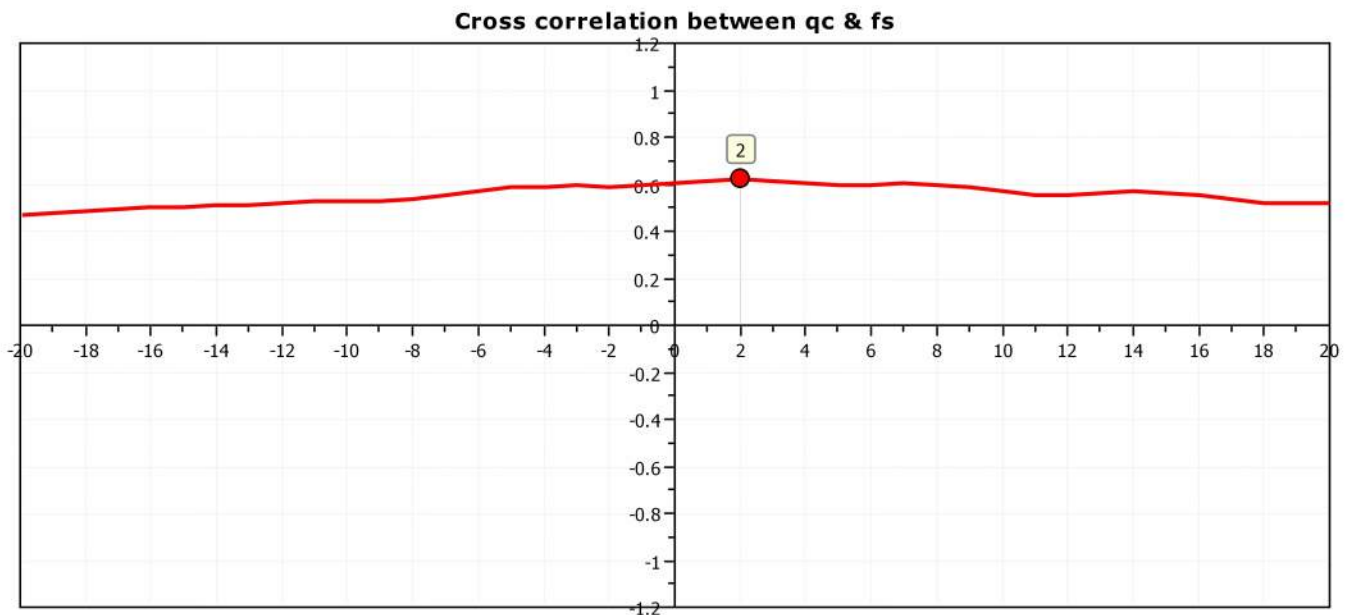
No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	3.87	0.20	9.50	783.52
2	1.20	0.50	2.30	4.50	0.20	9.50	909.81
3	1.40	0.50	2.60	5.04	0.20	9.50	1017.21
4	1.60	0.50	2.90	6.01	0.20	9.50	1212.04
5	1.80	0.50	3.20	7.43	0.20	9.50	1495.99
6	2.00	0.50	3.50	8.05	0.20	9.50	1619.36
7	2.20	0.50	3.80	7.92	0.20	9.50	1594.31
8	2.40	0.50	4.10	7.92	0.20	9.50	1593.18
9	2.60	0.50	4.40	8.16	0.20	9.50	1640.89
10	2.80	0.50	4.70	8.22	0.20	9.50	1653.80
11	3.00	0.50	5.00	7.77	0.20	9.50	1562.87
12	3.20	0.50	5.30	7.35	0.20	9.50	1479.50
13	3.40	0.50	5.60	7.02	0.20	9.50	1412.86
14	3.60	0.50	5.90	6.76	0.20	9.50	1361.48
15	3.80	0.50	6.20	6.60	0.20	9.50	1330.46
16	4.00	0.50	6.50	6.51	0.20	9.50	1311.40

Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

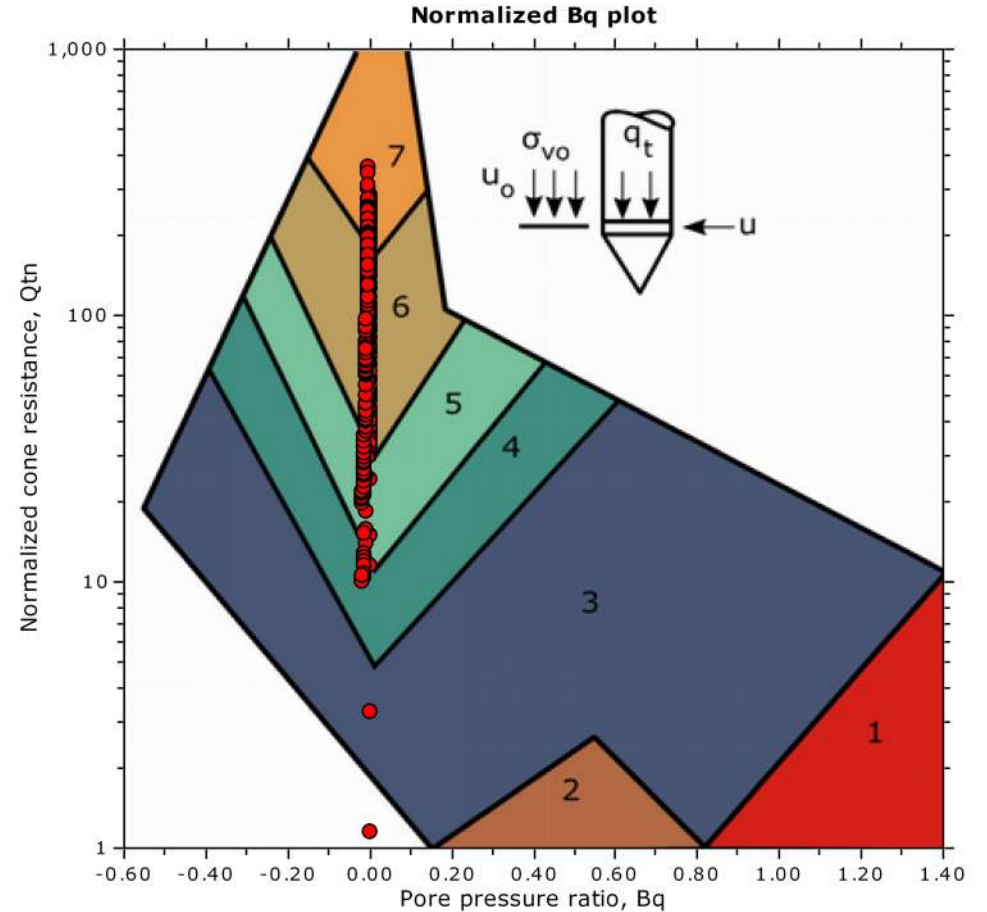
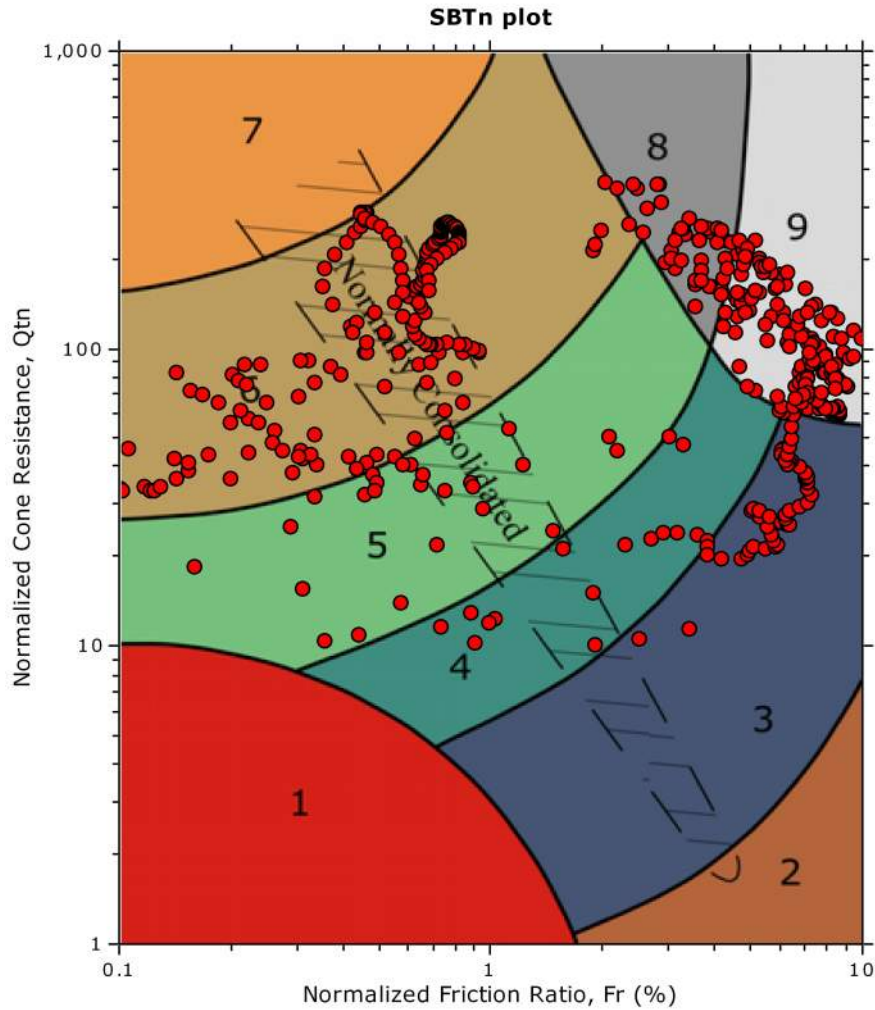




Project:

Location:

SBT - Bq plots (normalized)



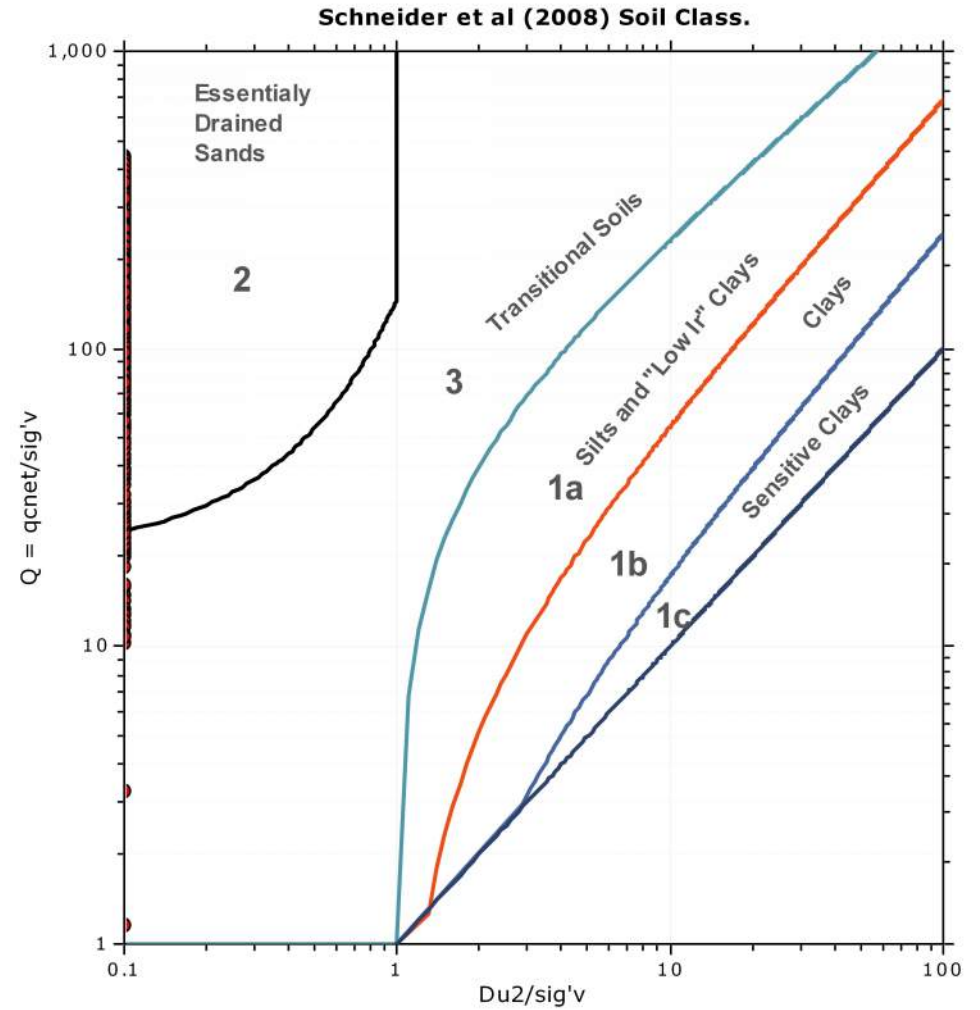
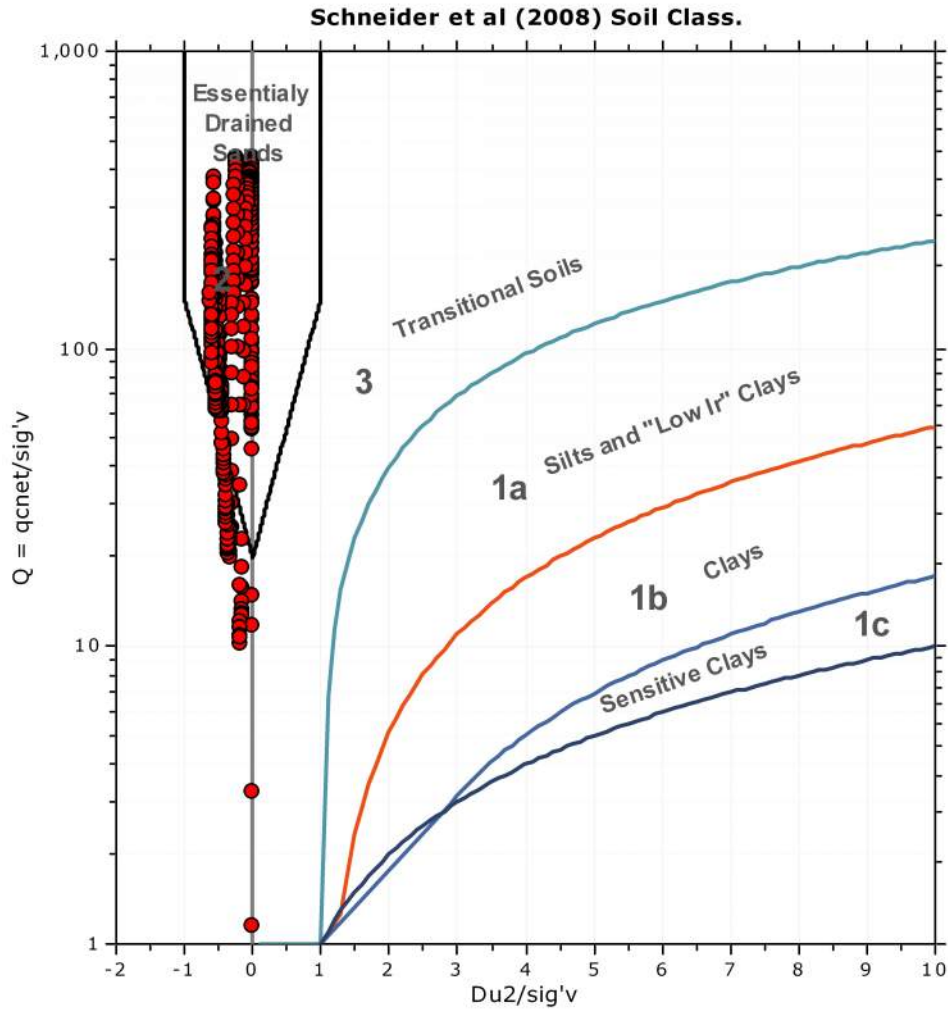
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

Project:

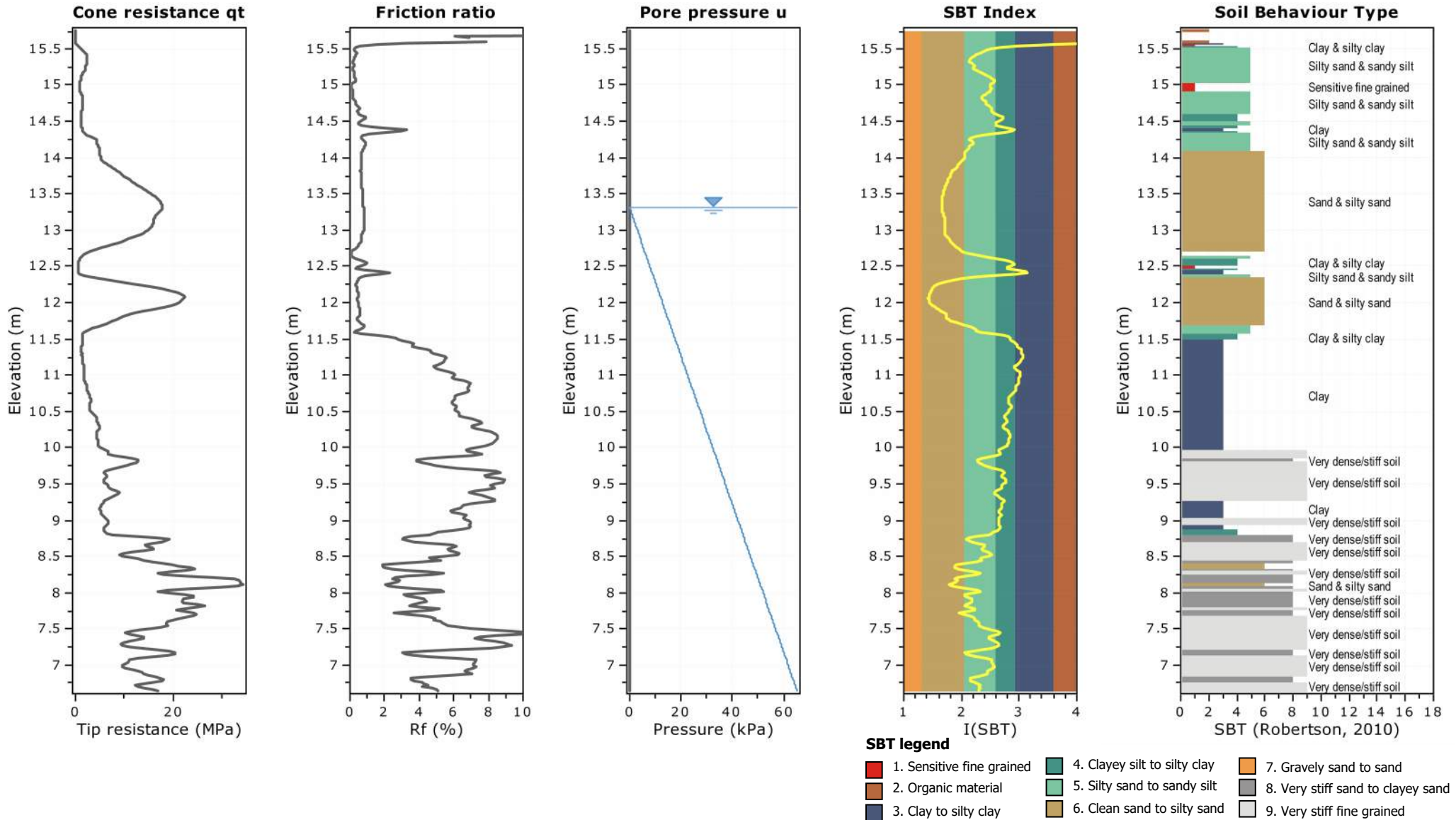
Location:

Bq plots (Schneider)



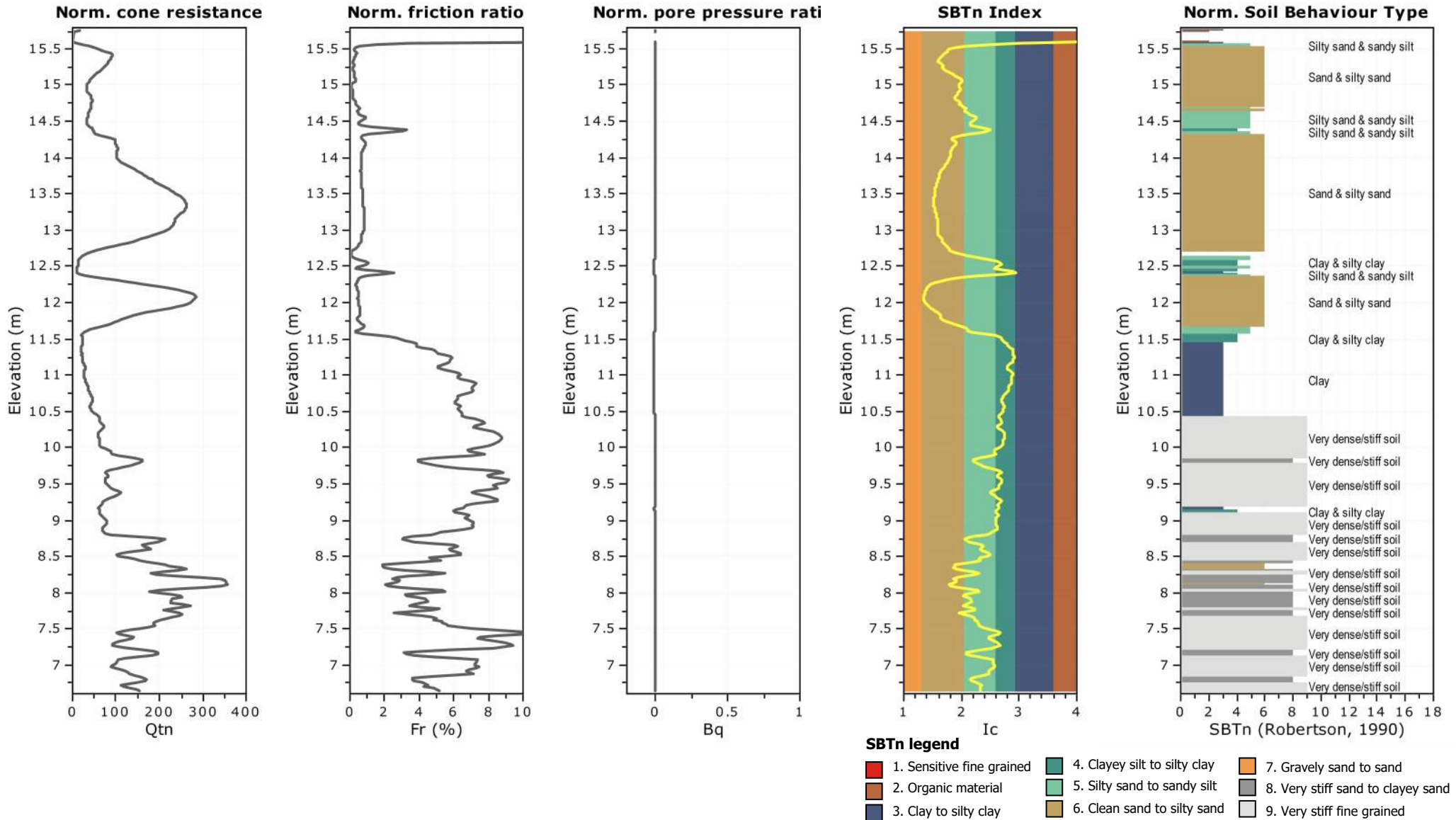
Project:

Location:



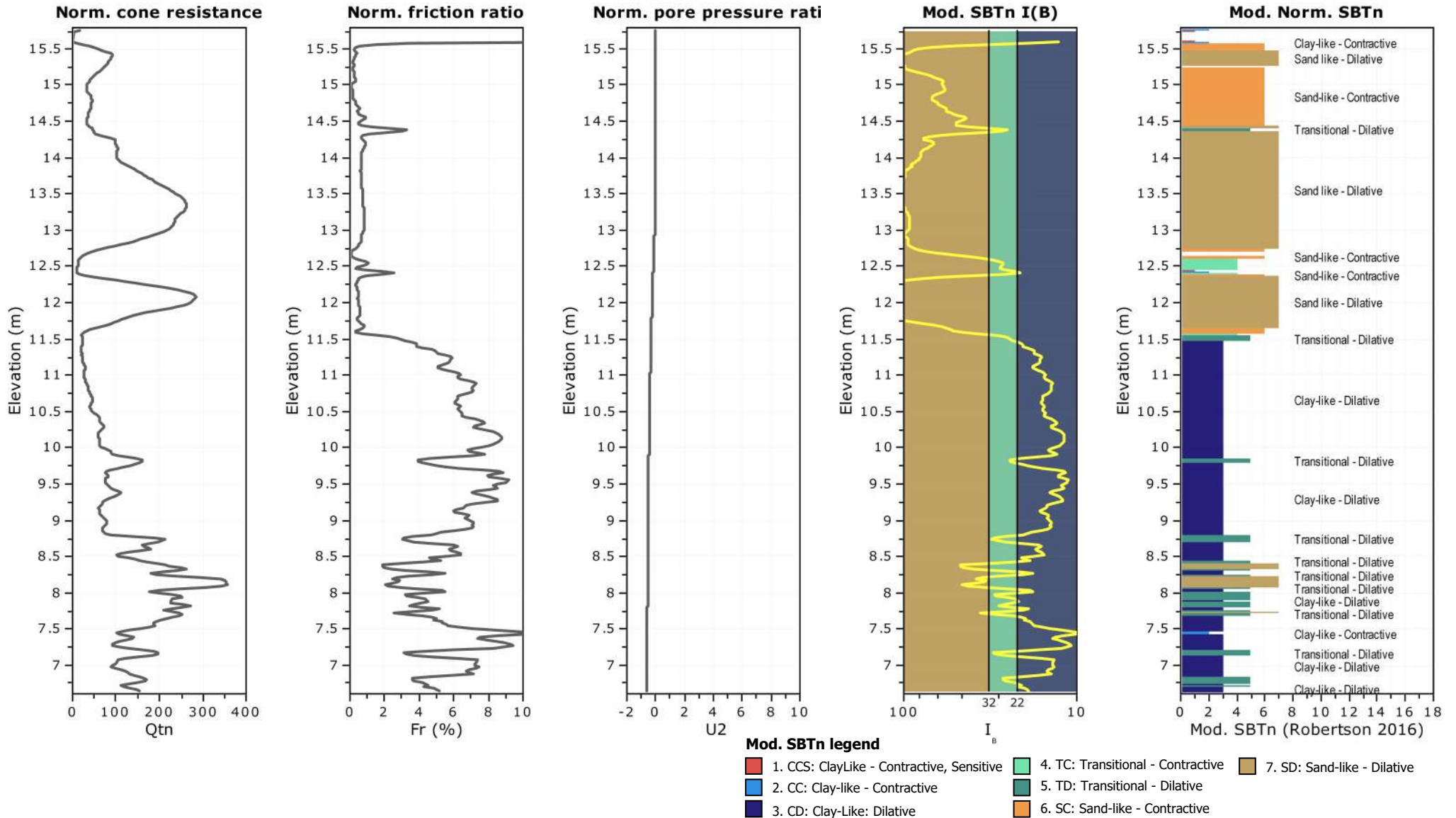
Project:

Location:



Project:

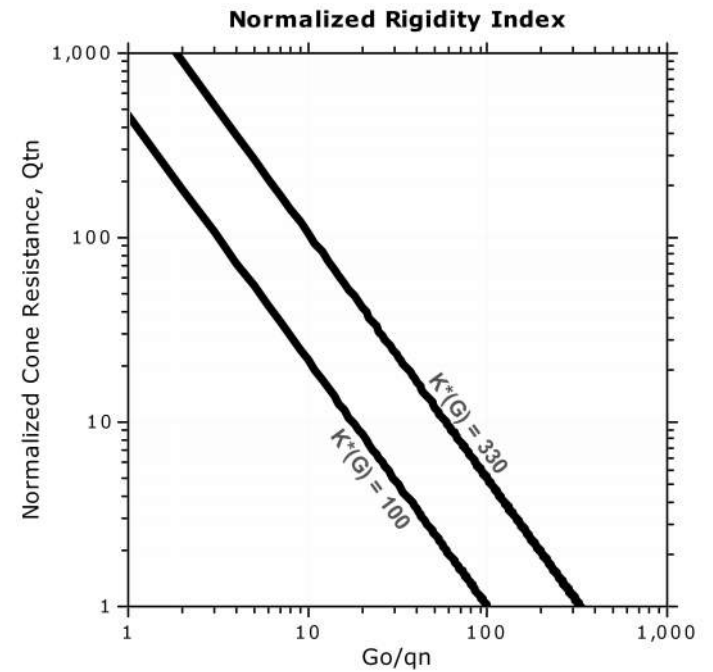
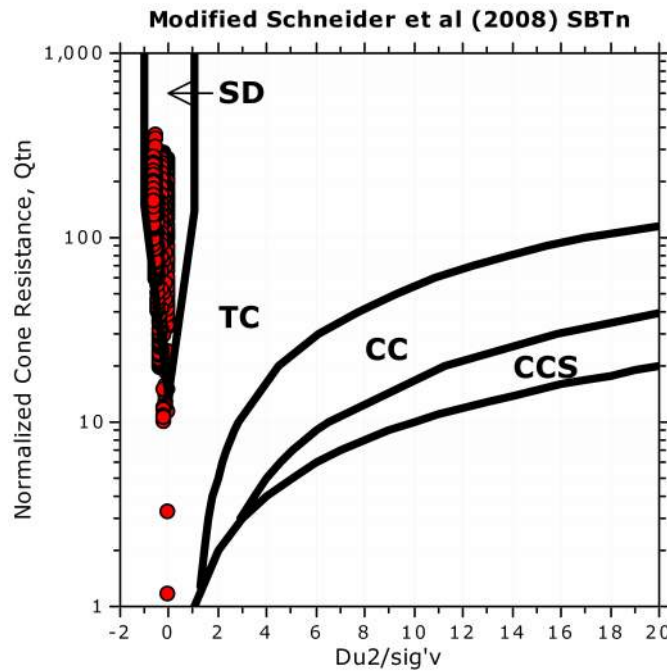
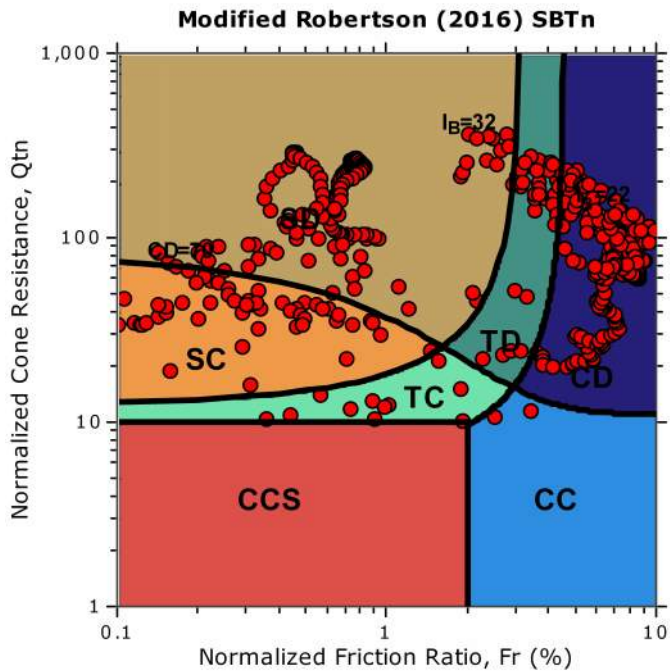
Location:



Project:

Location:

Updated SBTn plots

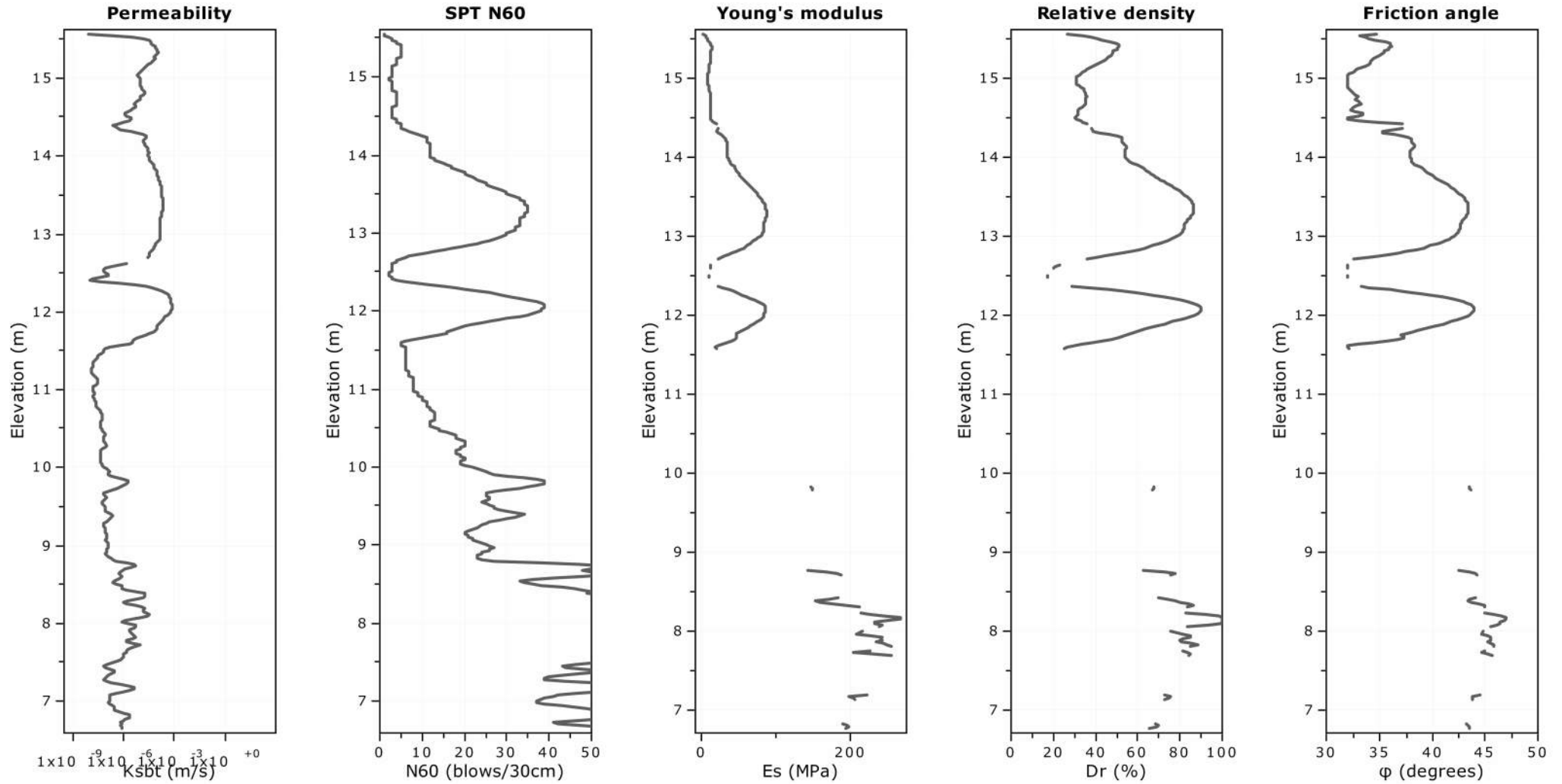


- CCS: Clay-like - Contractive - Sensitive
- CC: Clay-like - Contractive
- CD: Clay-like - Dilative
- TC: Transitional - Contractive
- TD: Transitional - Dilative
- SC: Sand-like - Contractive
- SD: Sand-like - Dilative

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

Project:

Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

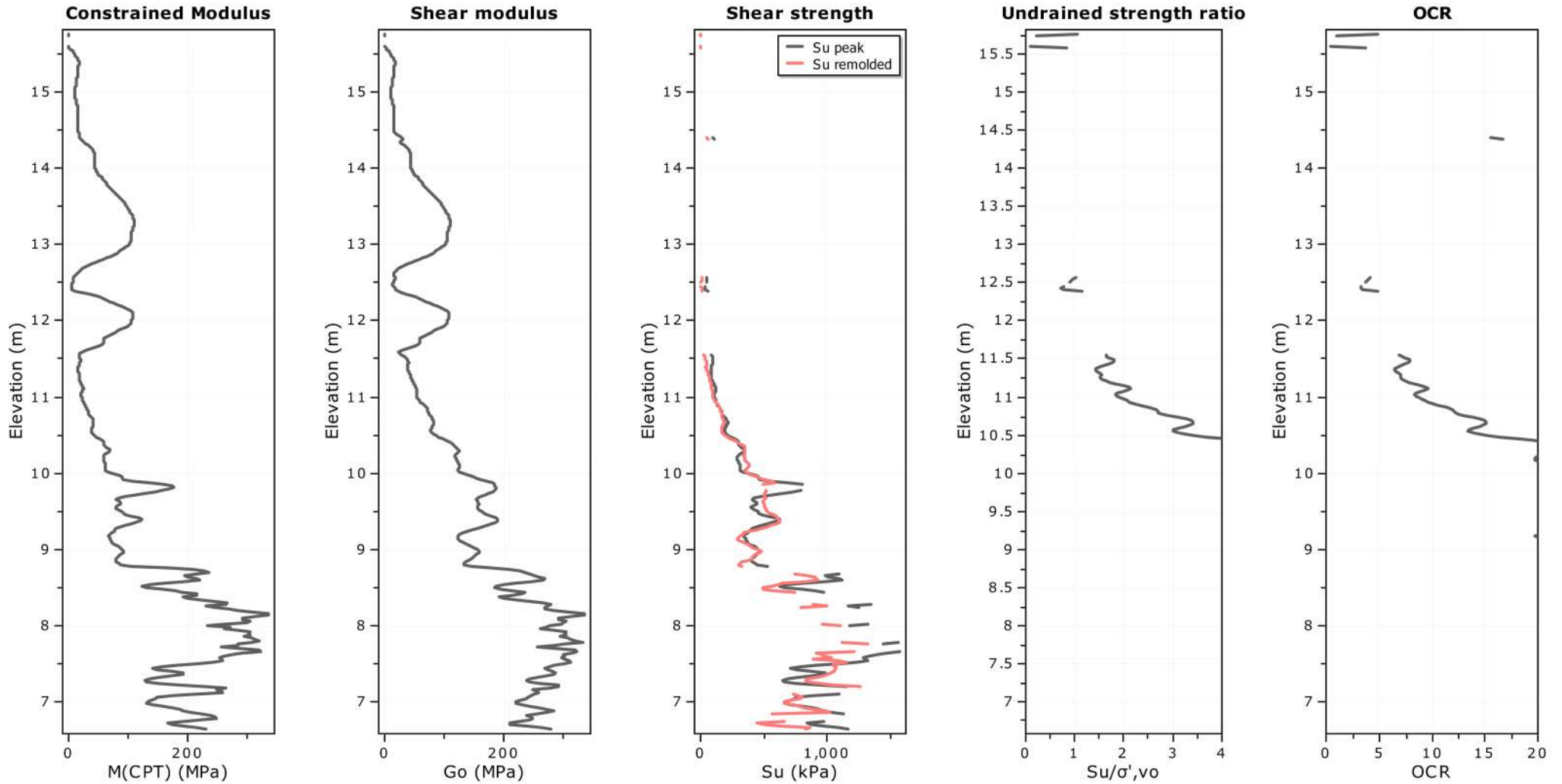
Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

● — User defined estimation data

Project:

Location:



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

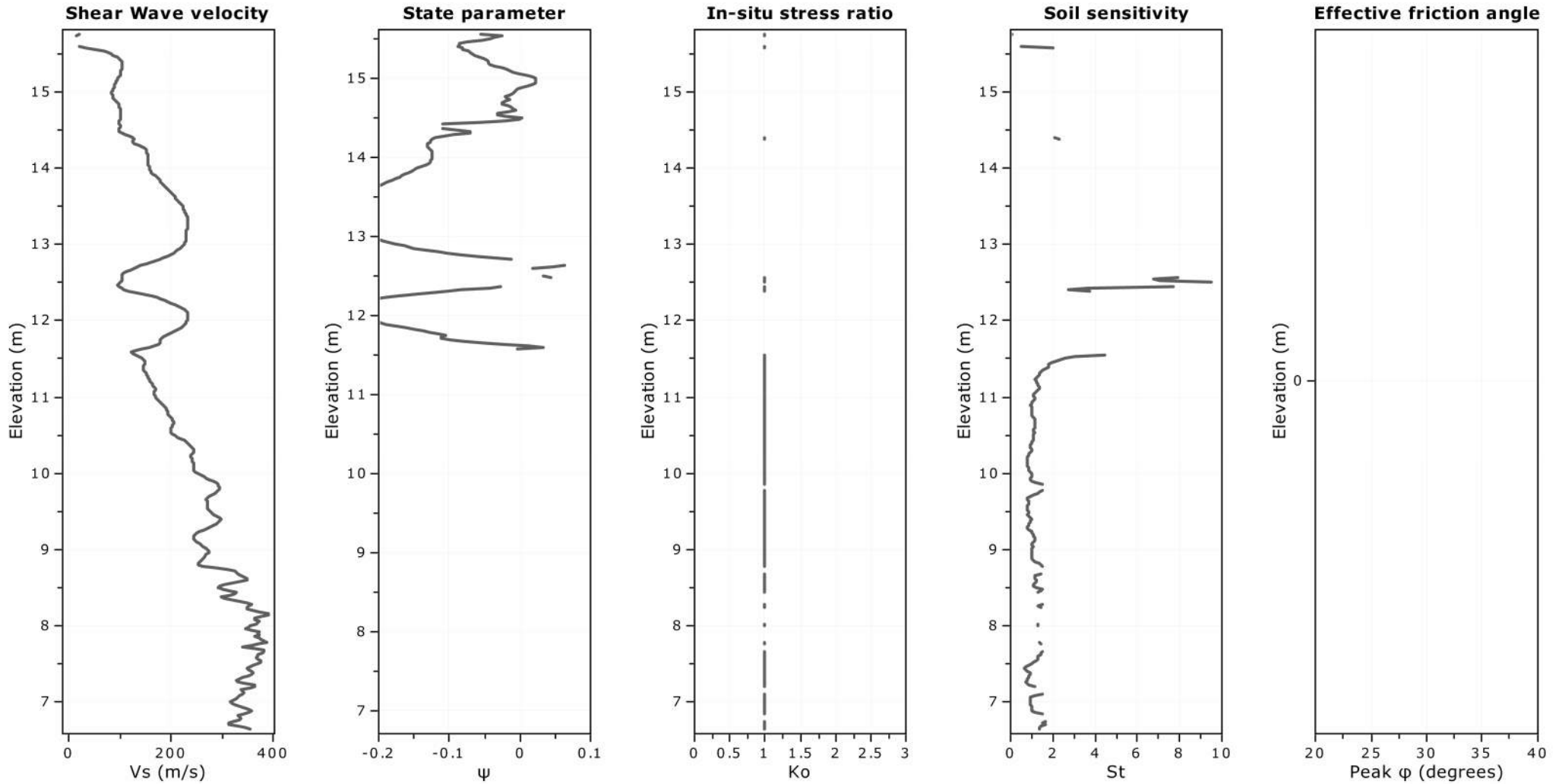
OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:

Location:



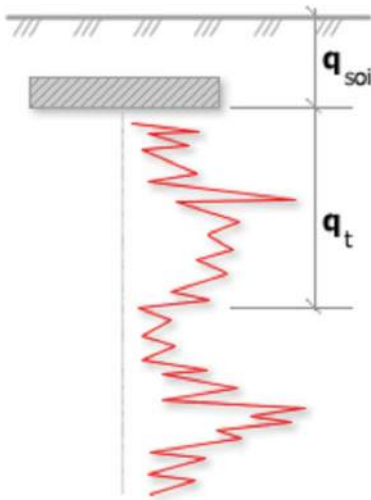
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

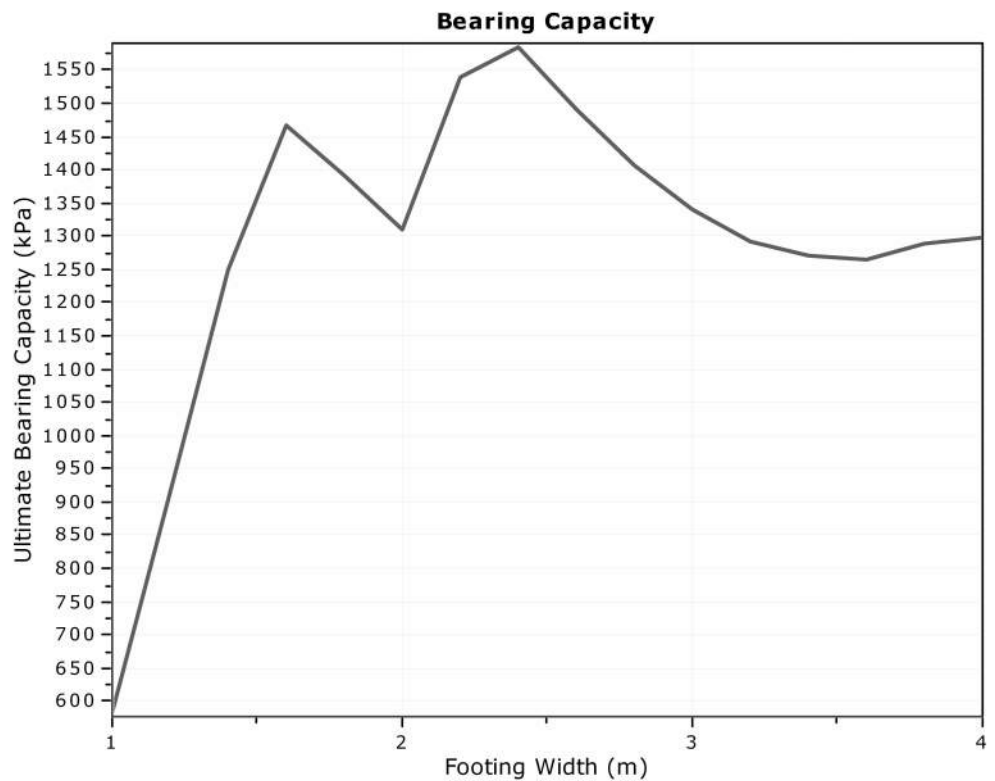
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

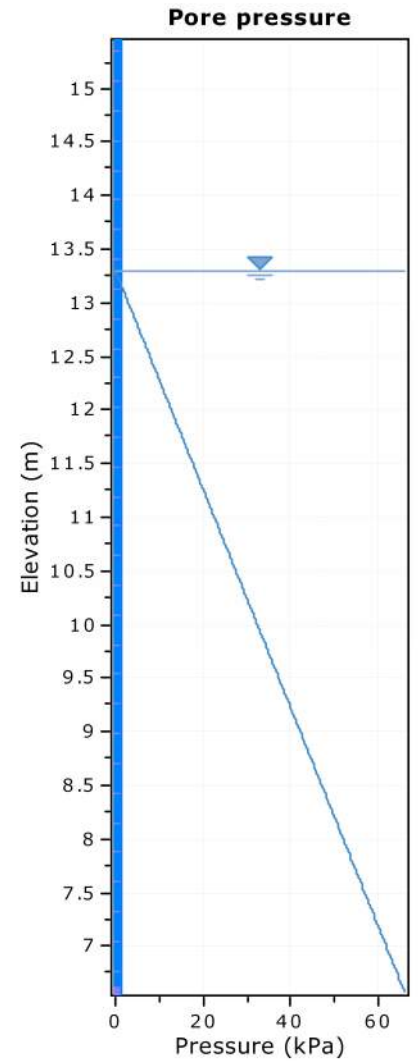
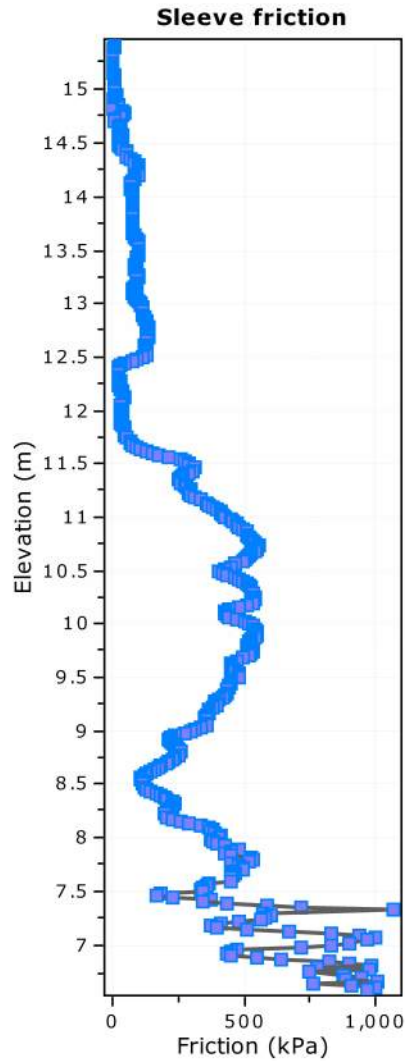
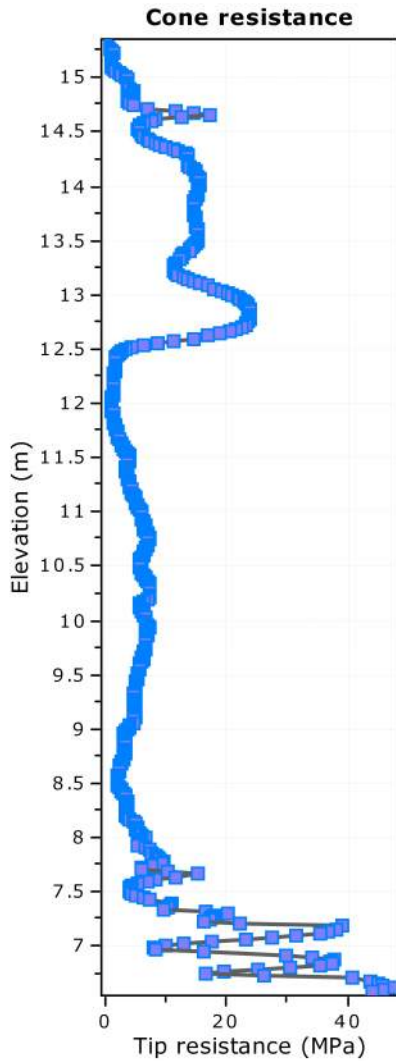


:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	2.87	0.20	9.50	582.77
2	1.20	0.50	2.30	4.52	0.20	9.50	913.21
3	1.40	0.50	2.60	6.19	0.20	9.50	1248.12
4	1.60	0.50	2.90	7.29	0.20	9.50	1467.26
5	1.80	0.50	3.20	6.91	0.20	9.50	1391.88
6	2.00	0.50	3.50	6.49	0.20	9.50	1308.44
7	2.20	0.50	3.80	7.64	0.20	9.50	1537.71
8	2.40	0.50	4.10	7.87	0.20	9.50	1584.26
9	2.60	0.50	4.40	7.40	0.20	9.50	1489.48
10	2.80	0.50	4.70	6.98	0.20	9.50	1405.23
11	3.00	0.50	5.00	6.65	0.20	9.50	1339.08
12	3.20	0.50	5.30	6.42	0.20	9.50	1293.11
13	3.40	0.50	5.60	6.30	0.20	9.50	1269.92
14	3.60	0.50	5.90	6.27	0.20	9.50	1263.16
15	3.80	0.50	6.20	6.40	0.20	9.50	1289.72
16	4.00	0.50	6.50	6.44	0.20	9.50	1296.60

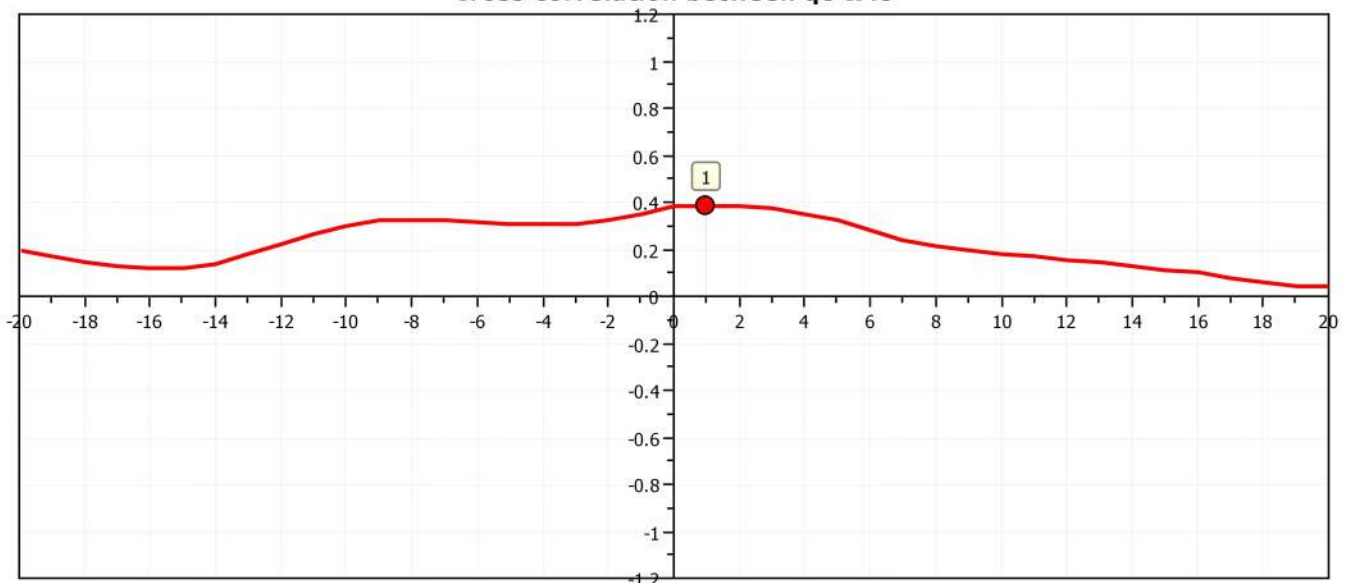
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

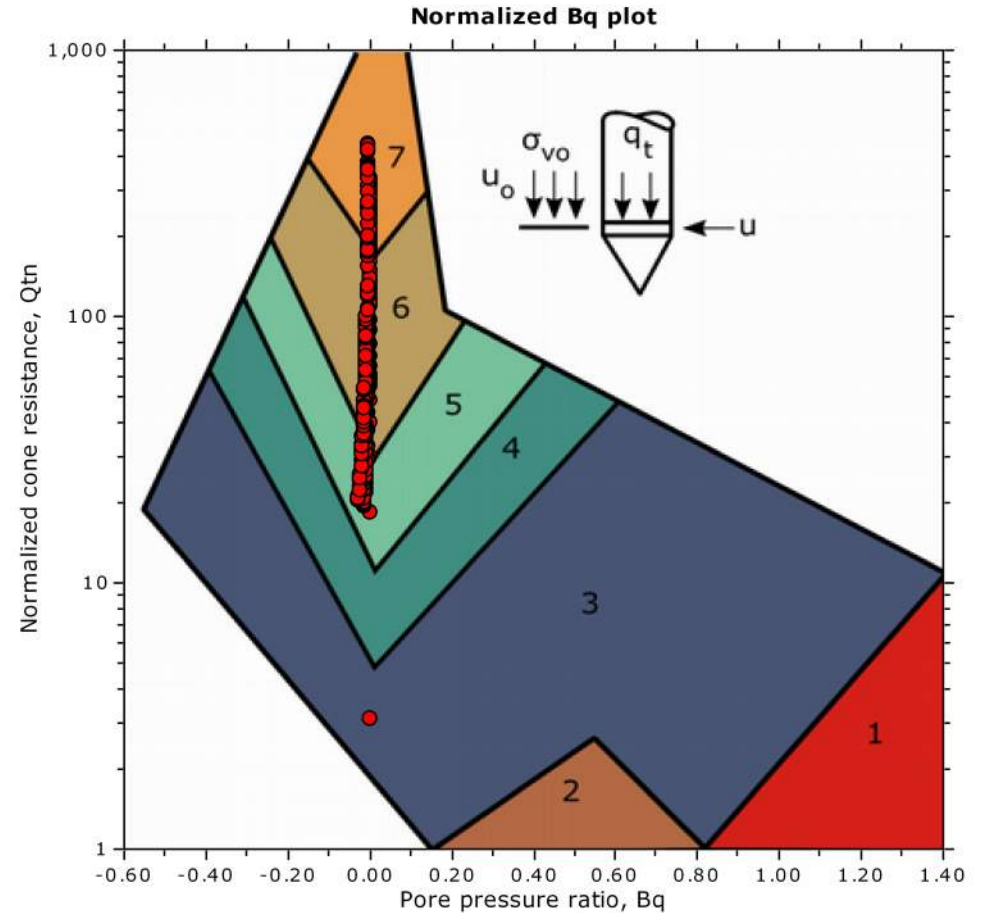
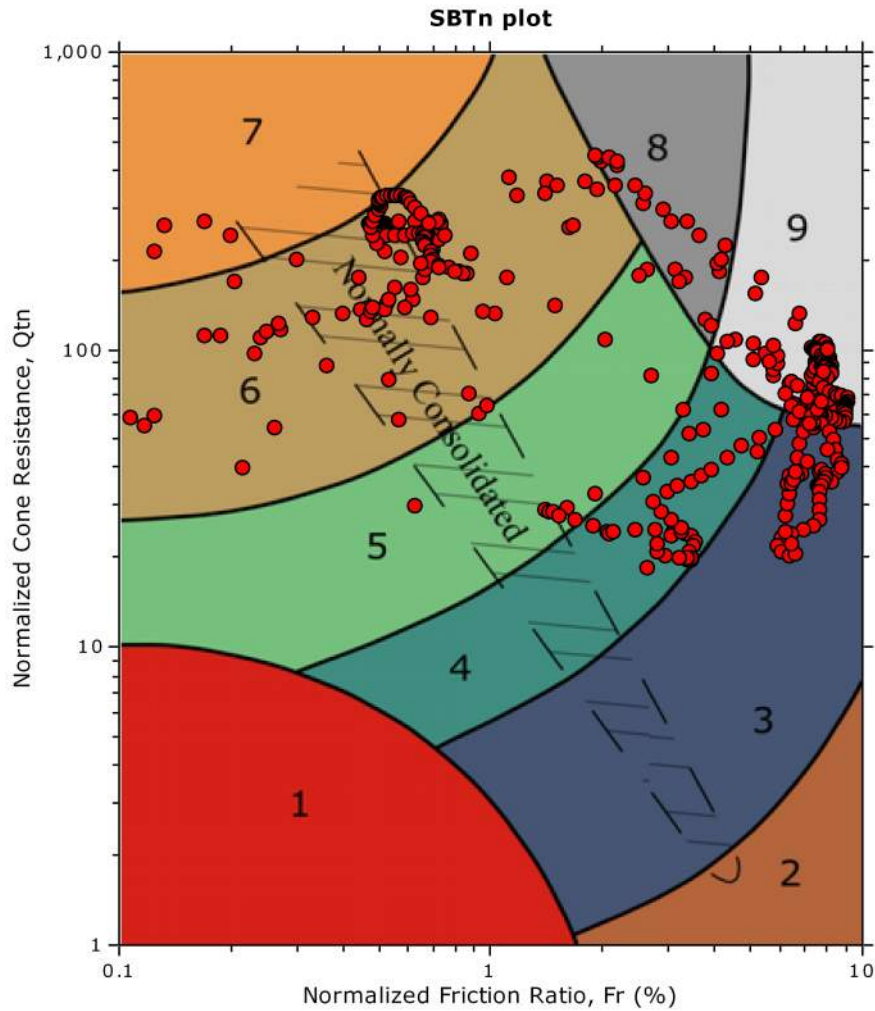




Project:

Location:

SBT - Bq plots (normalized)

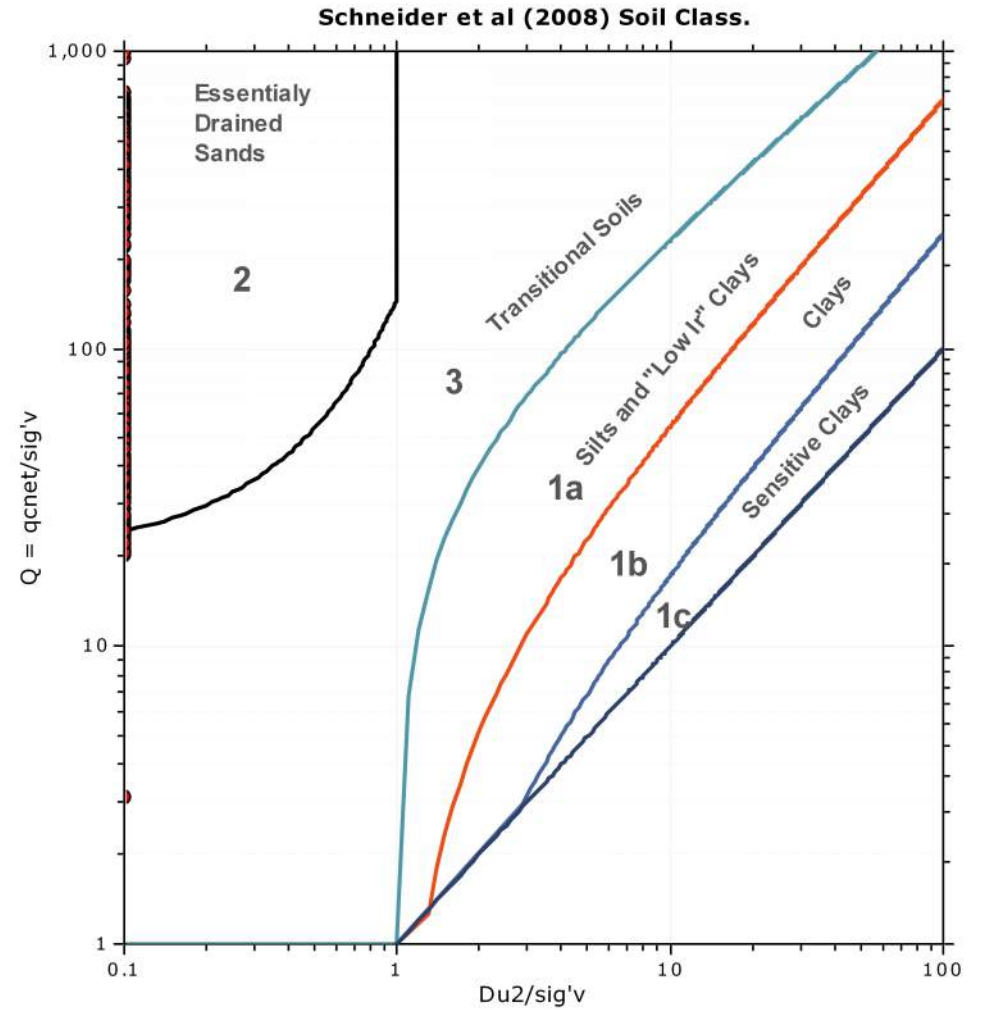
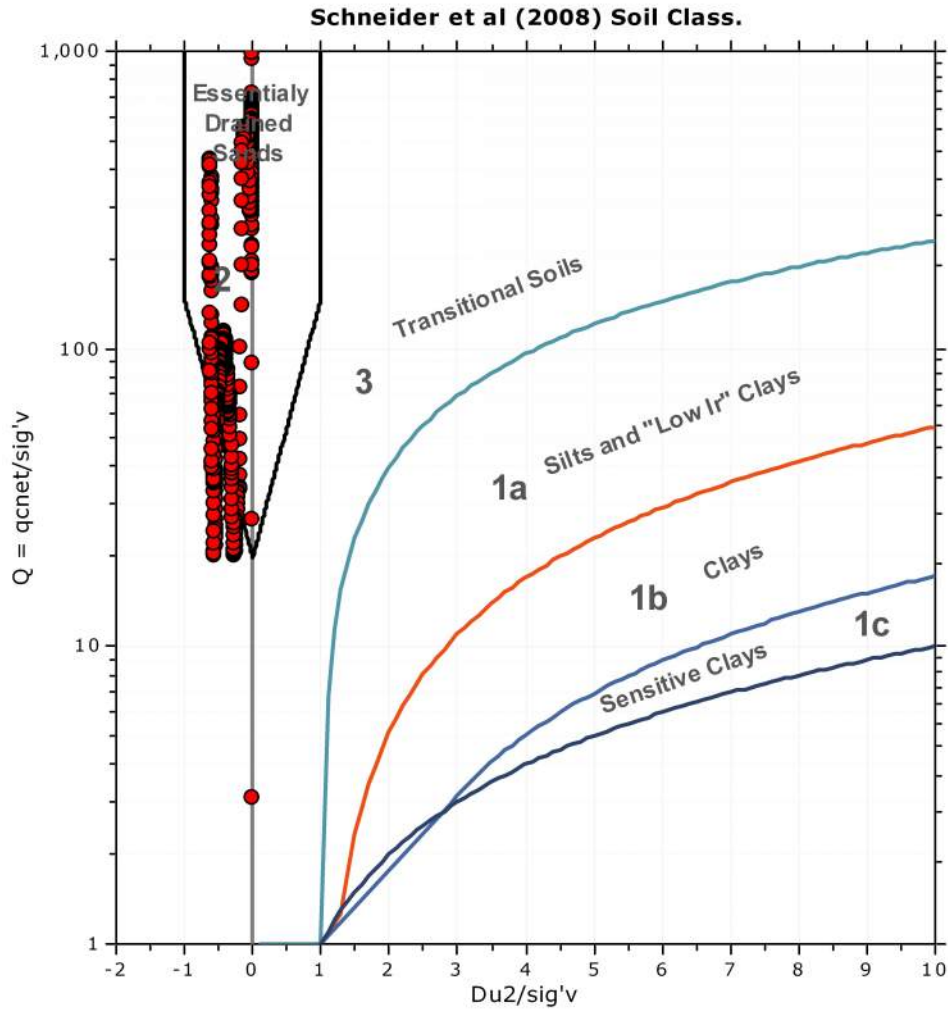


SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

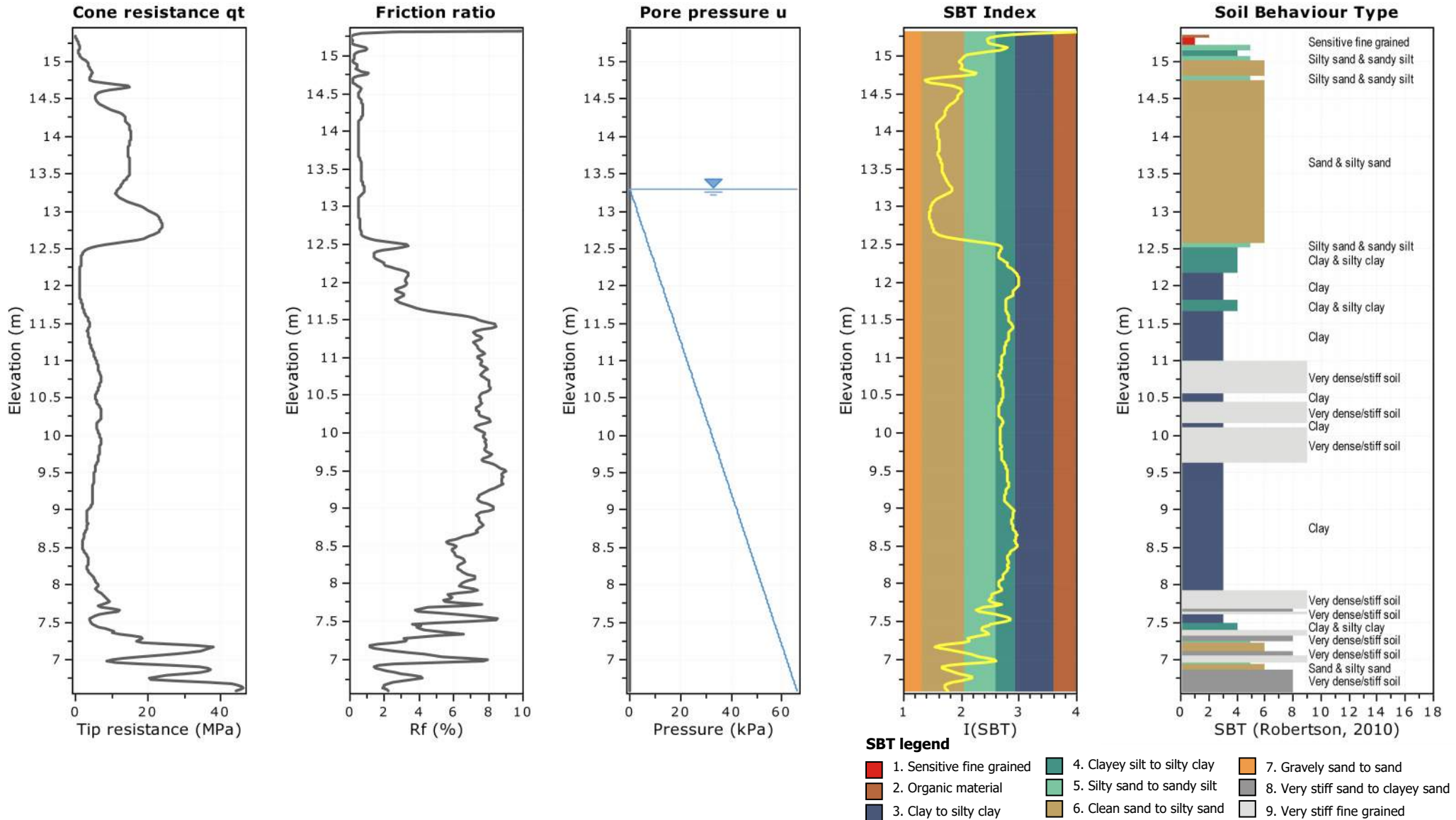
Project:
Location:

Bq plots (Schneider)



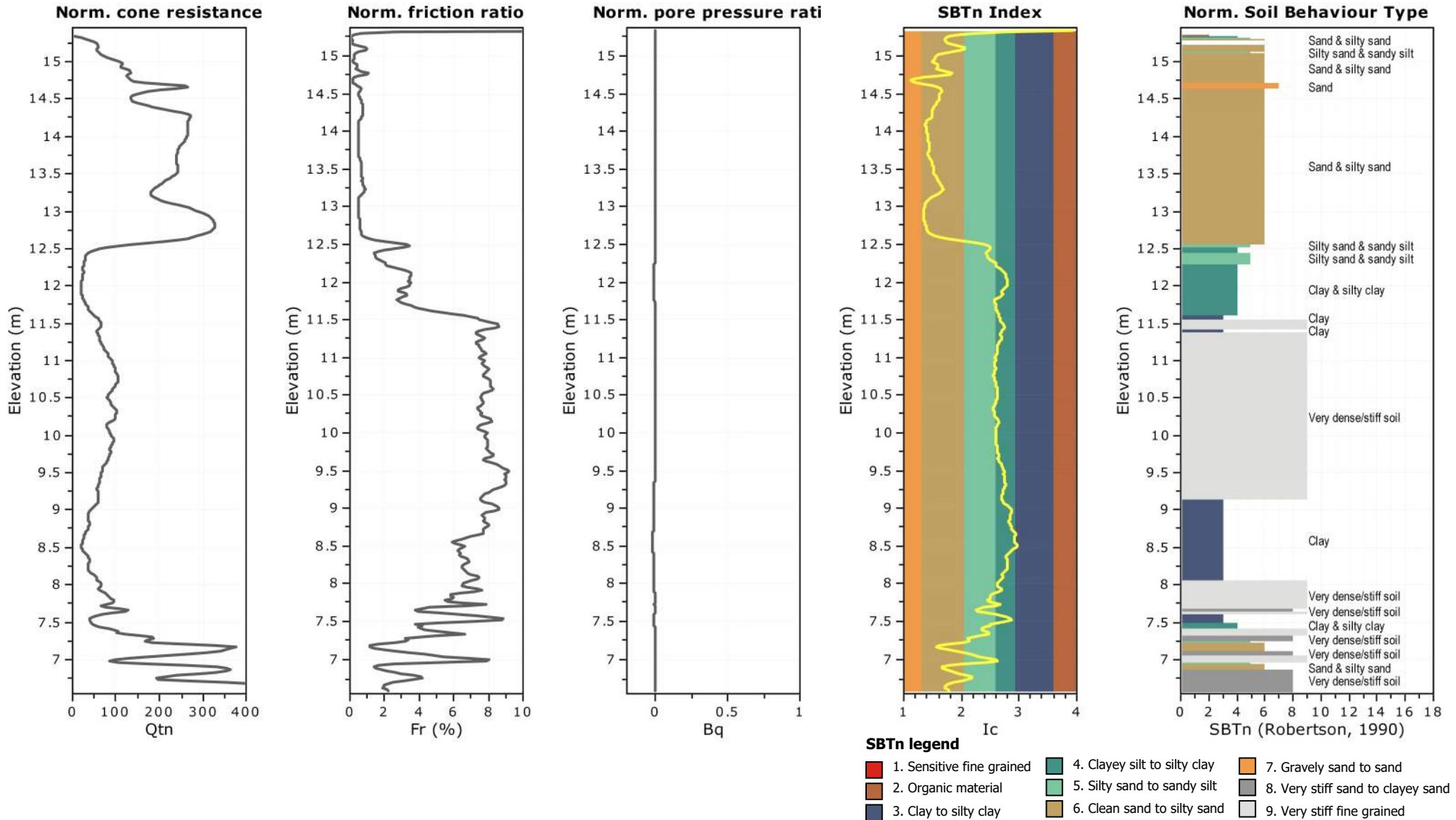
Project:

Location:



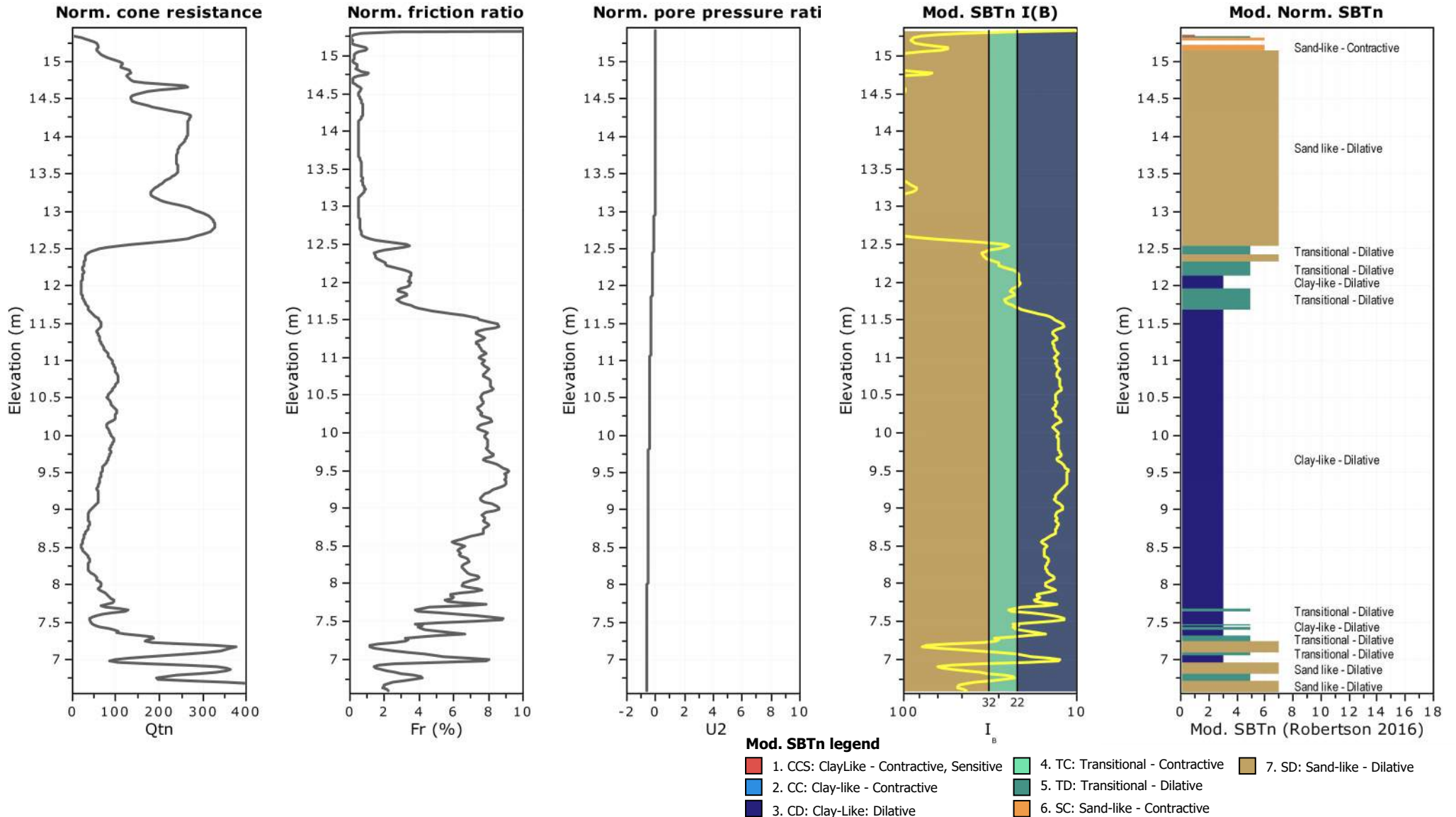
Project:

Location:



Project:

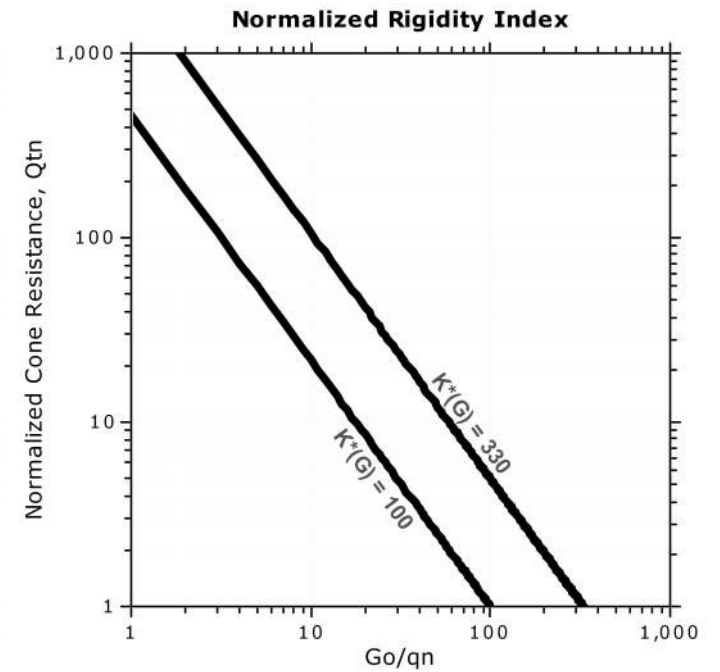
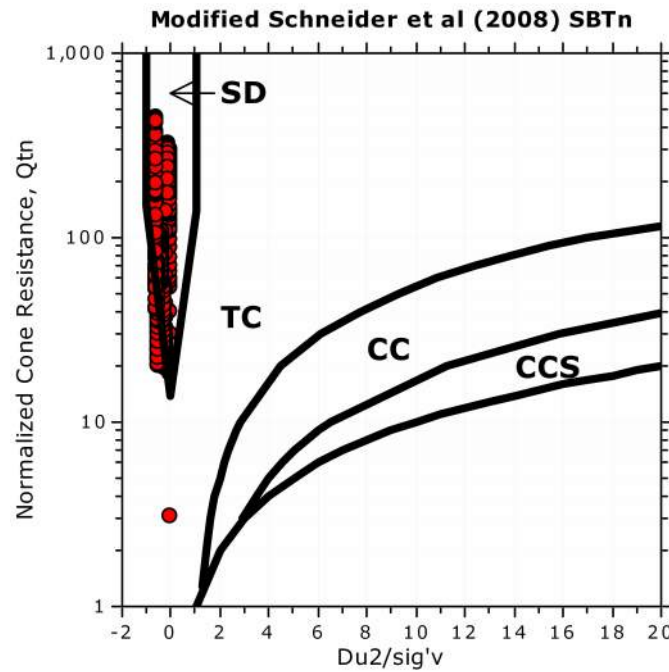
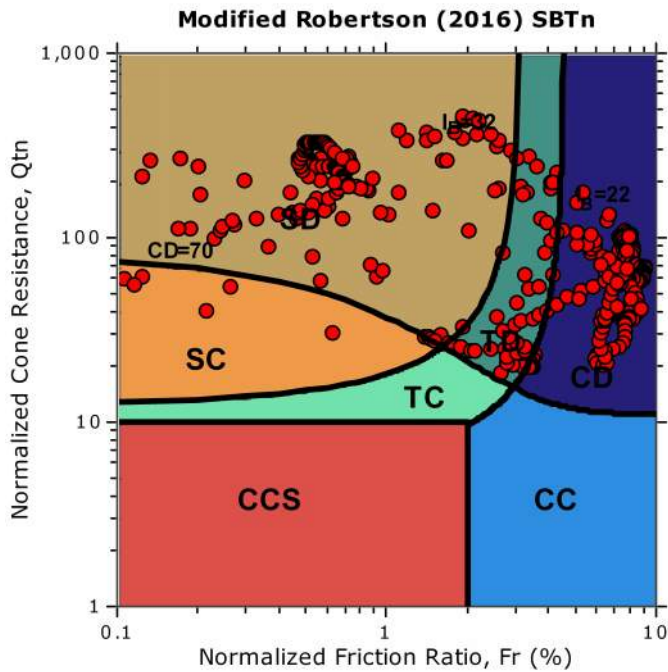
Location:



Project:

Location:

Updated SBTn plots

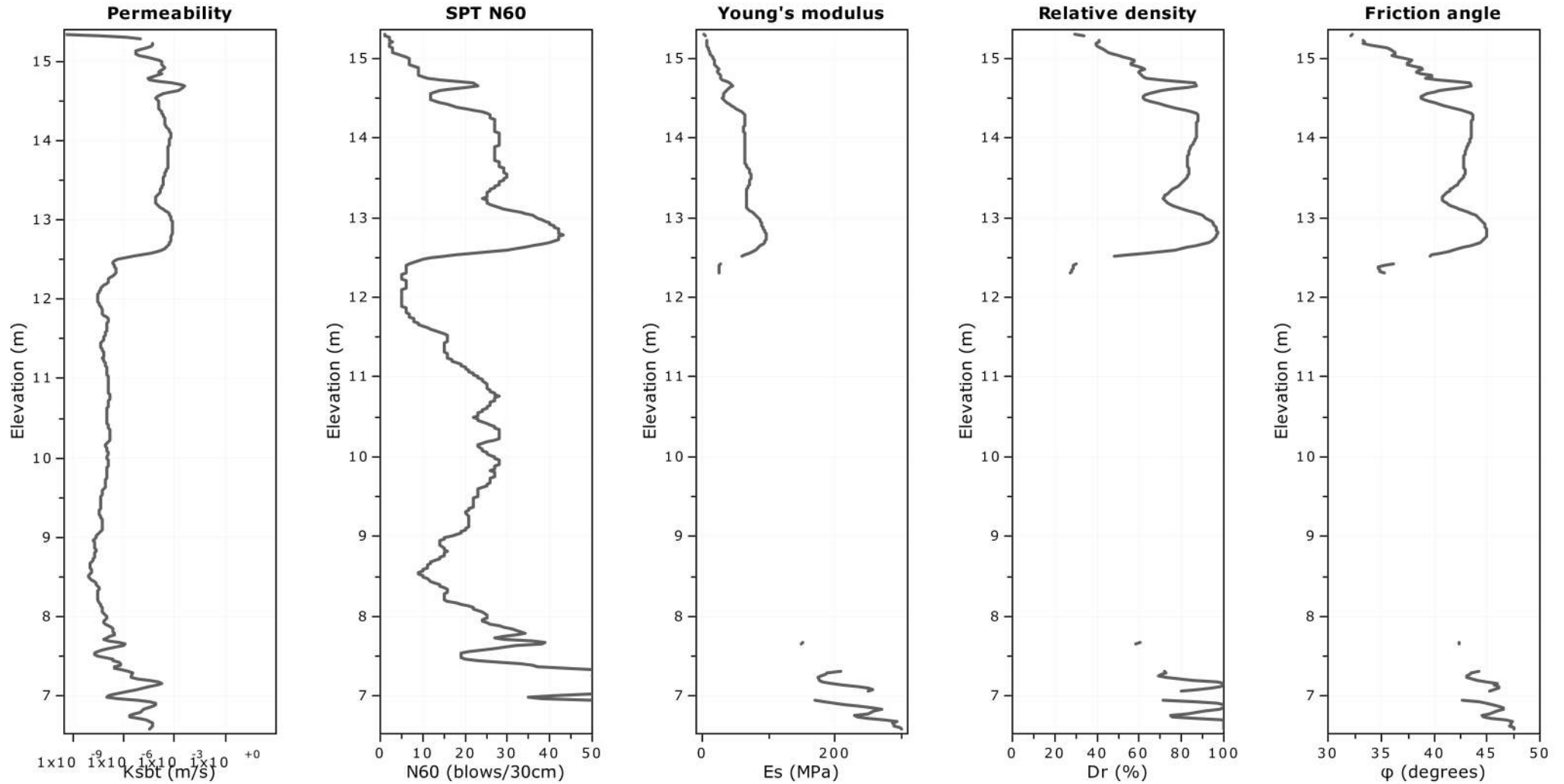


- CCS: Clay-like - Contractive - Sensitive
- CC: Clay-like - Contractive
- CD: Clay-like - Dilative
- TC: Transitional - Contractive
- TD: Transitional - Dilative
- SC: Sand-like - Contractive
- SD: Sand-like - Dilative

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

Project:

Location:



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)

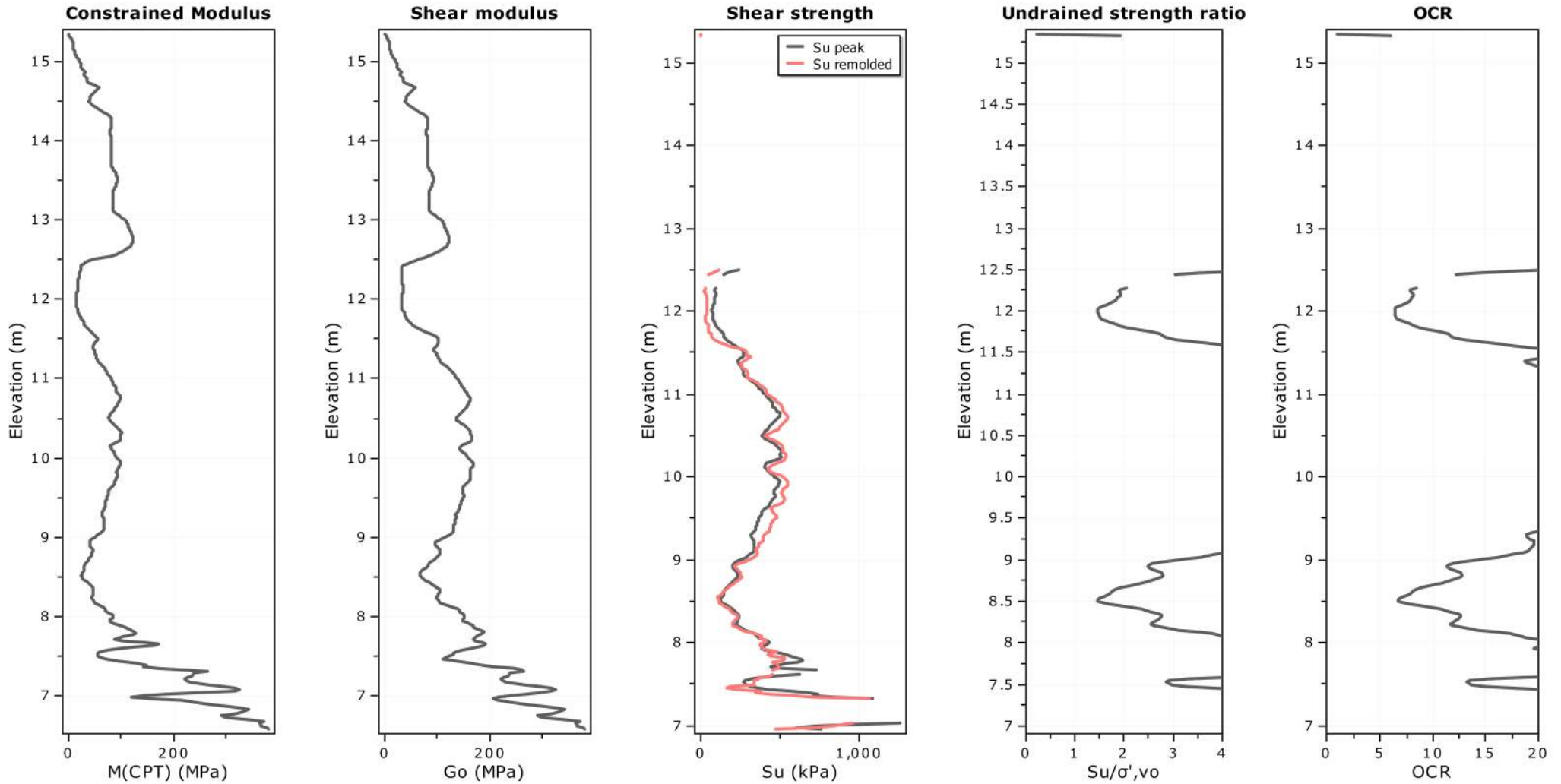
Relative density constant, C_{Dr} : 350.0

Phi: Based on Kulhawy & Mayne (1990)

● User defined estimation data

Project:

Location:



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

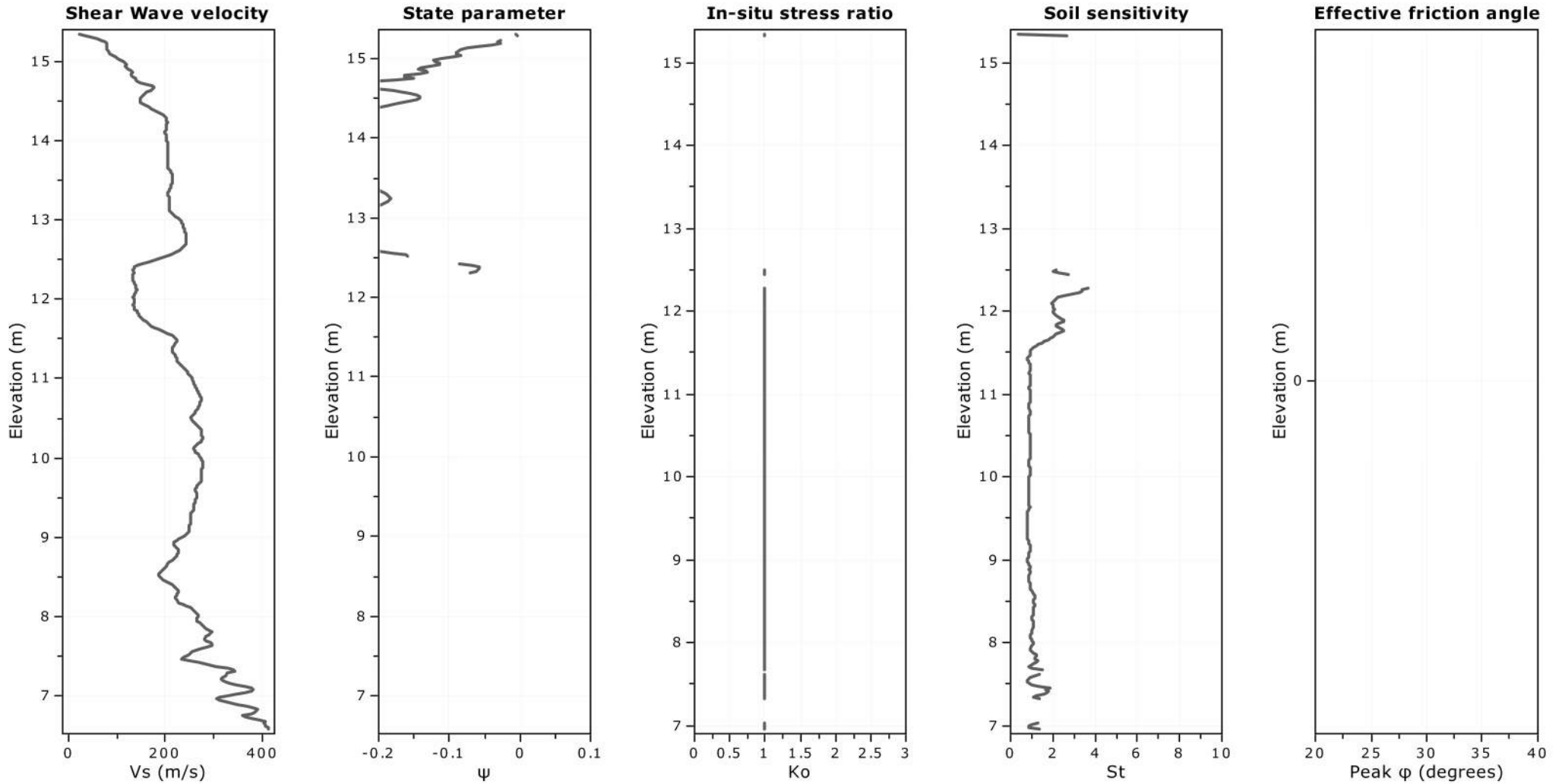
OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:

Location:



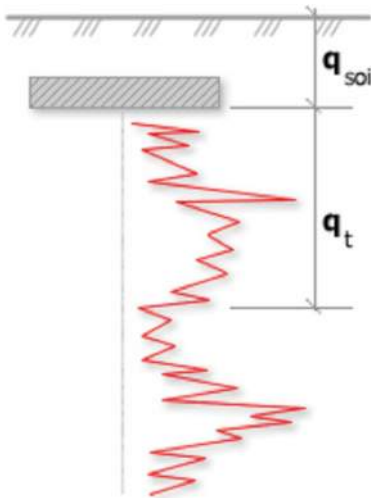
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

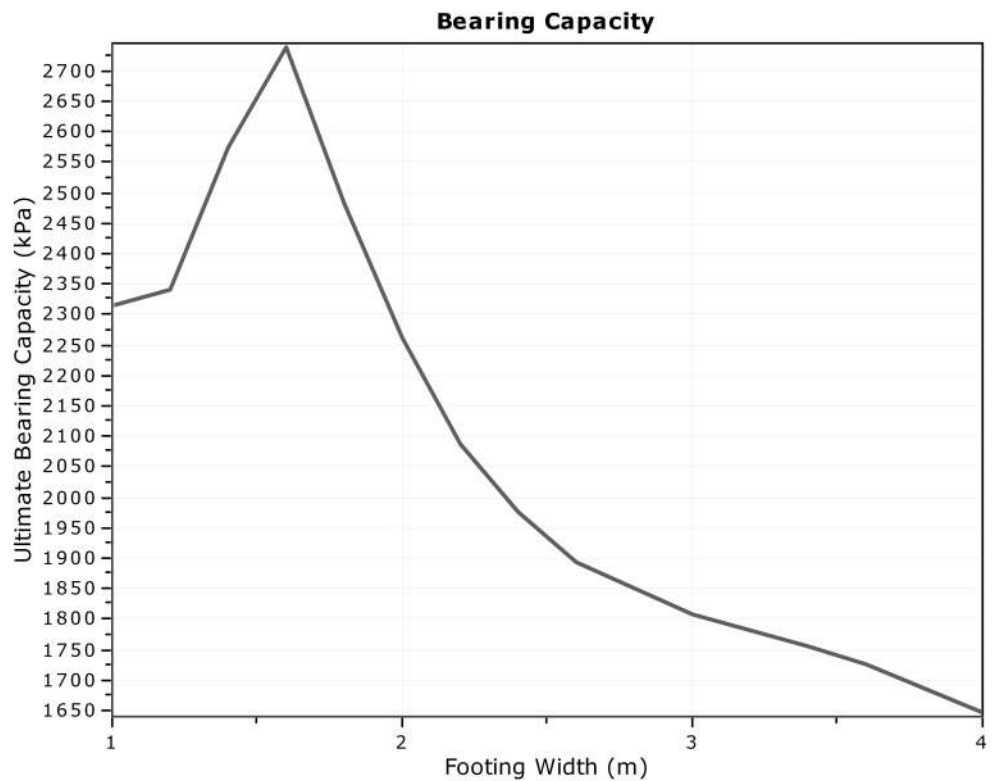
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

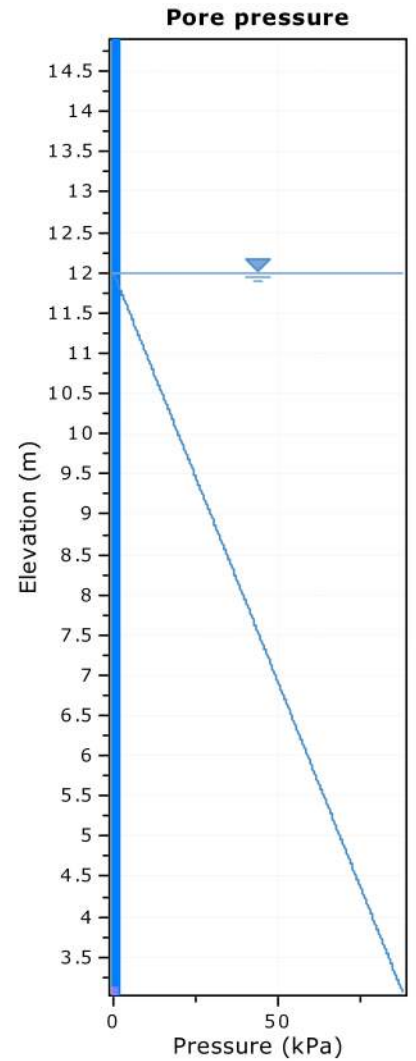
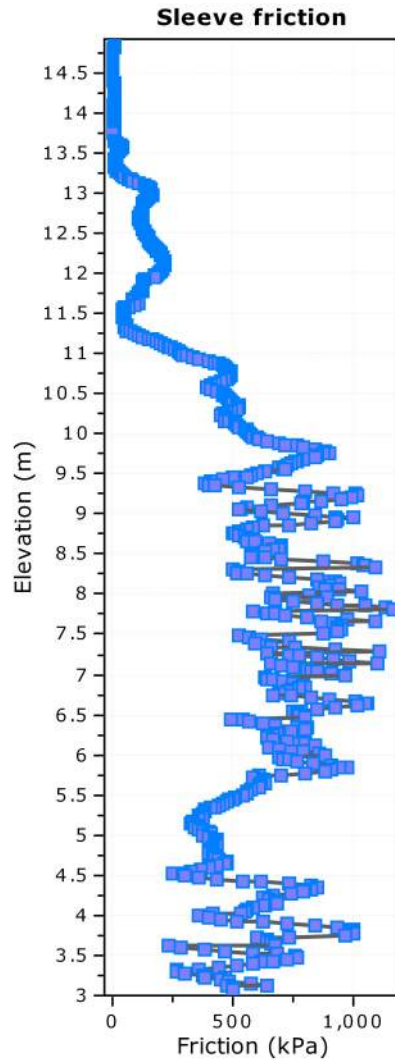
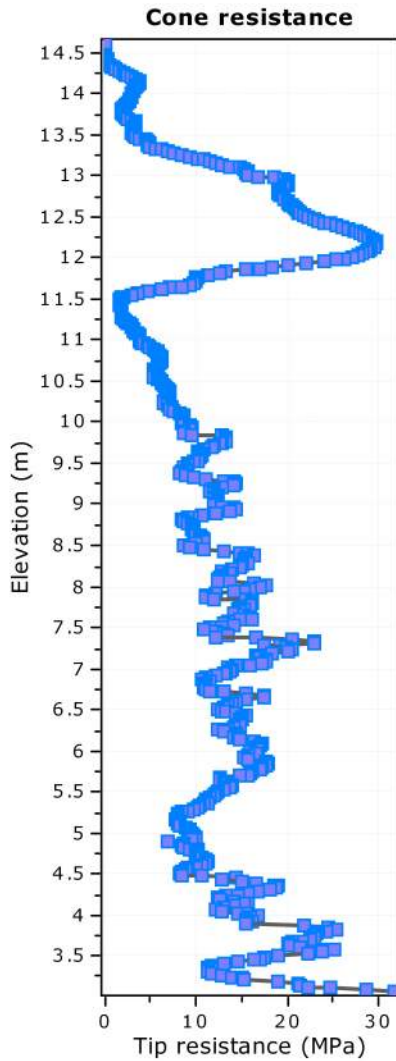


:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	11.53	0.20	9.50	2314.53
2	1.20	0.50	2.30	11.66	0.20	9.50	2340.85
3	1.40	0.50	2.60	12.82	0.20	9.50	2572.94
4	1.60	0.50	2.90	13.65	0.20	9.50	2739.04
5	1.80	0.50	3.20	12.37	0.20	9.50	2483.07
6	2.00	0.50	3.50	11.26	0.20	9.50	2261.16
7	2.20	0.50	3.80	10.40	0.20	9.50	2088.77
8	2.40	0.50	4.10	9.82	0.20	9.50	1973.91
9	2.60	0.50	4.40	9.41	0.20	9.50	1891.72
10	2.80	0.50	4.70	9.20	0.20	9.50	1849.24
11	3.00	0.50	5.00	9.00	0.20	9.50	1808.75
12	3.20	0.50	5.30	8.86	0.20	9.50	1780.94
13	3.40	0.50	5.60	8.72	0.20	9.50	1754.06
14	3.60	0.50	5.90	8.58	0.20	9.50	1725.55
15	3.80	0.50	6.20	8.39	0.20	9.50	1687.55
16	4.00	0.50	6.50	8.18	0.20	9.50	1646.43

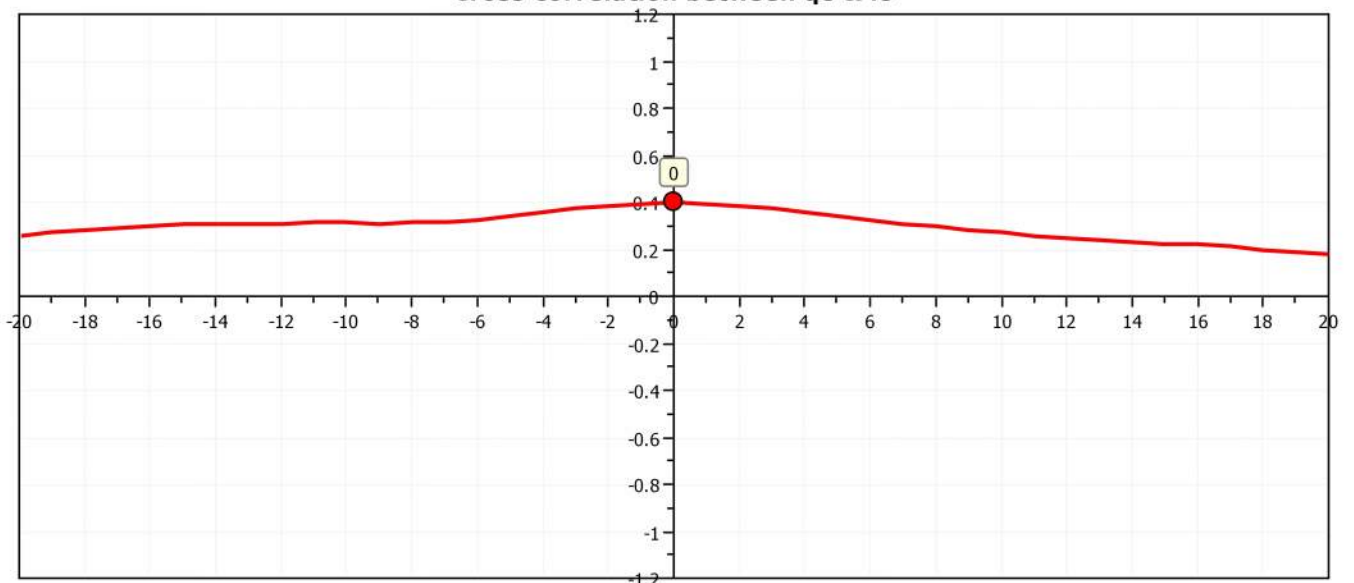
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

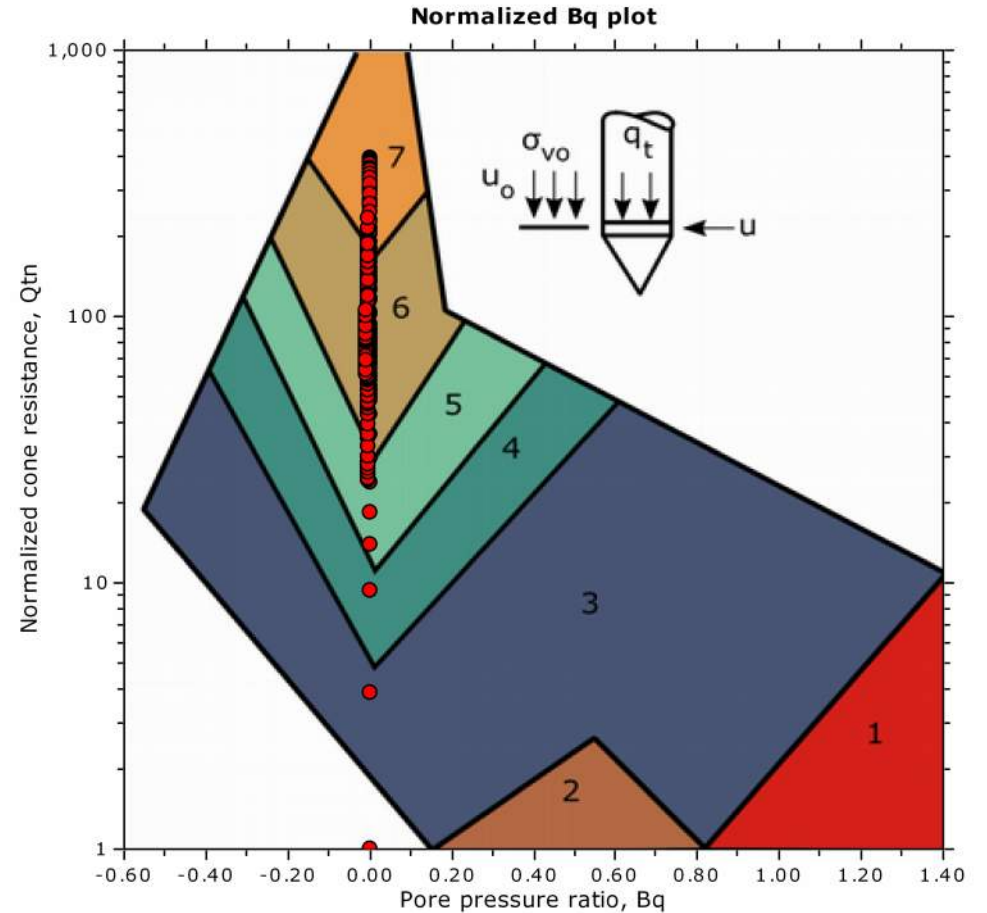
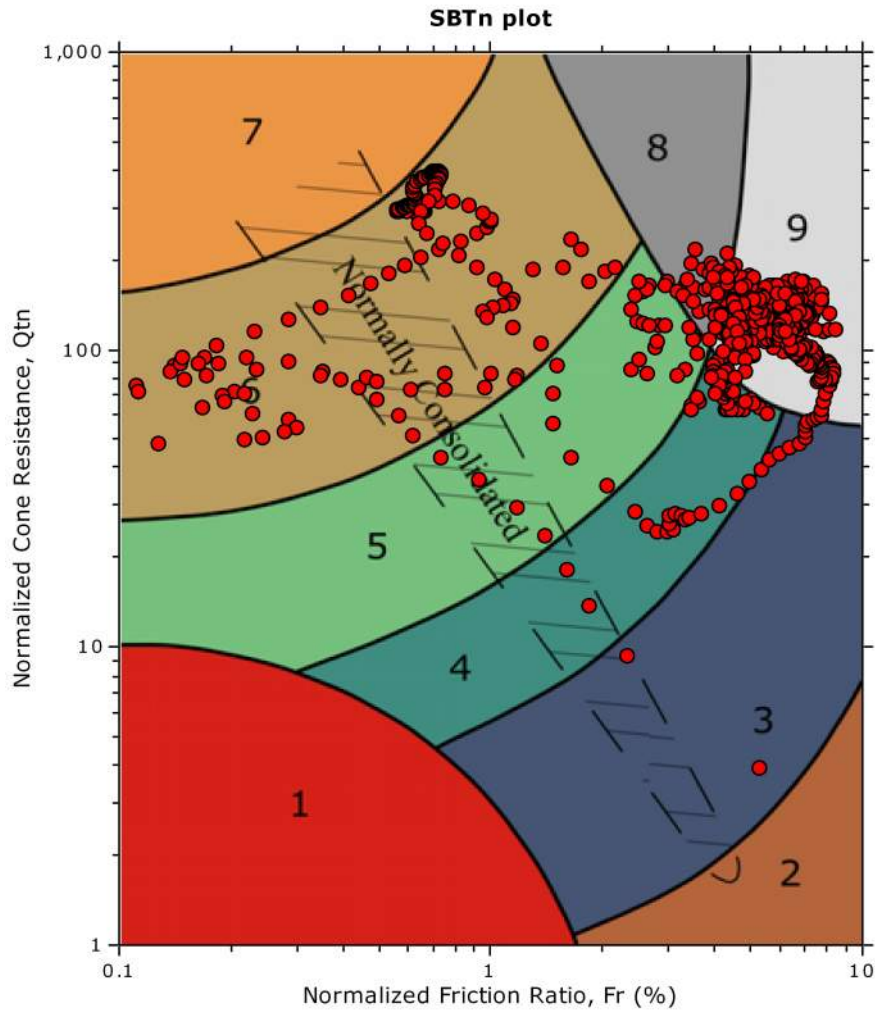




Project:

Location:

SBT - Bq plots (normalized)



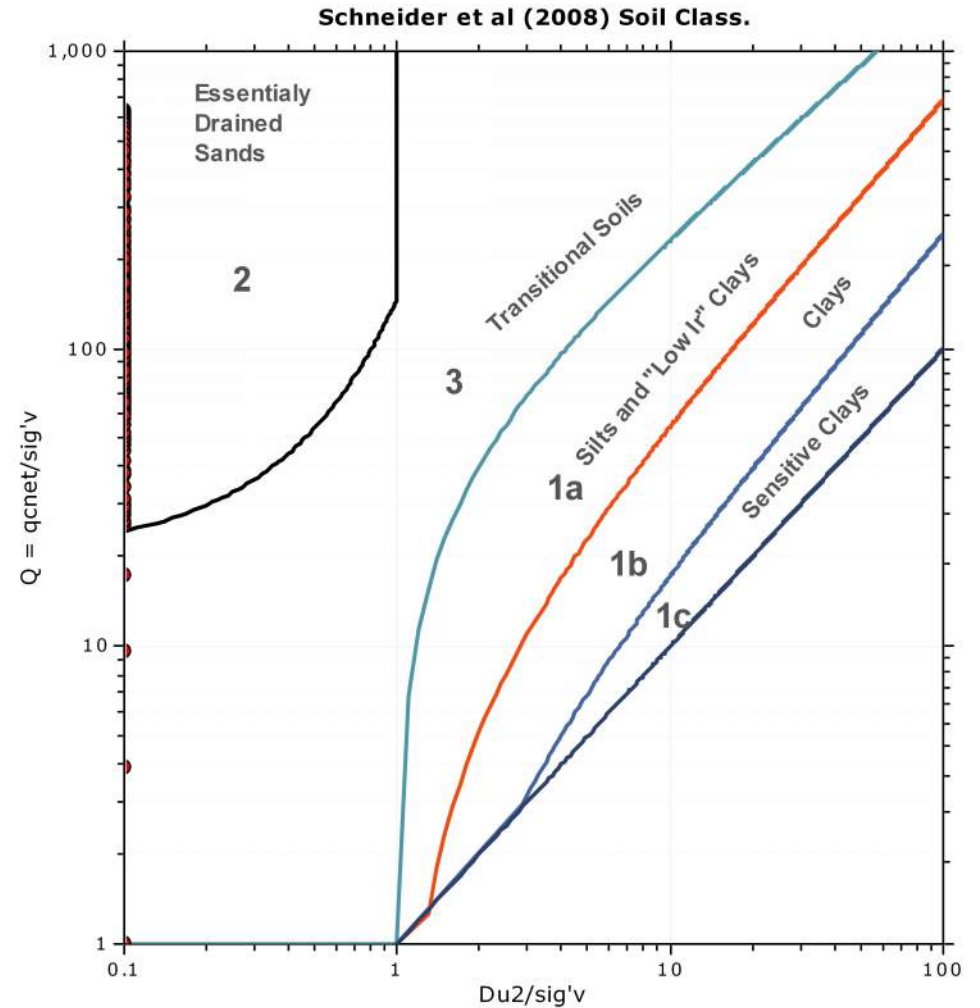
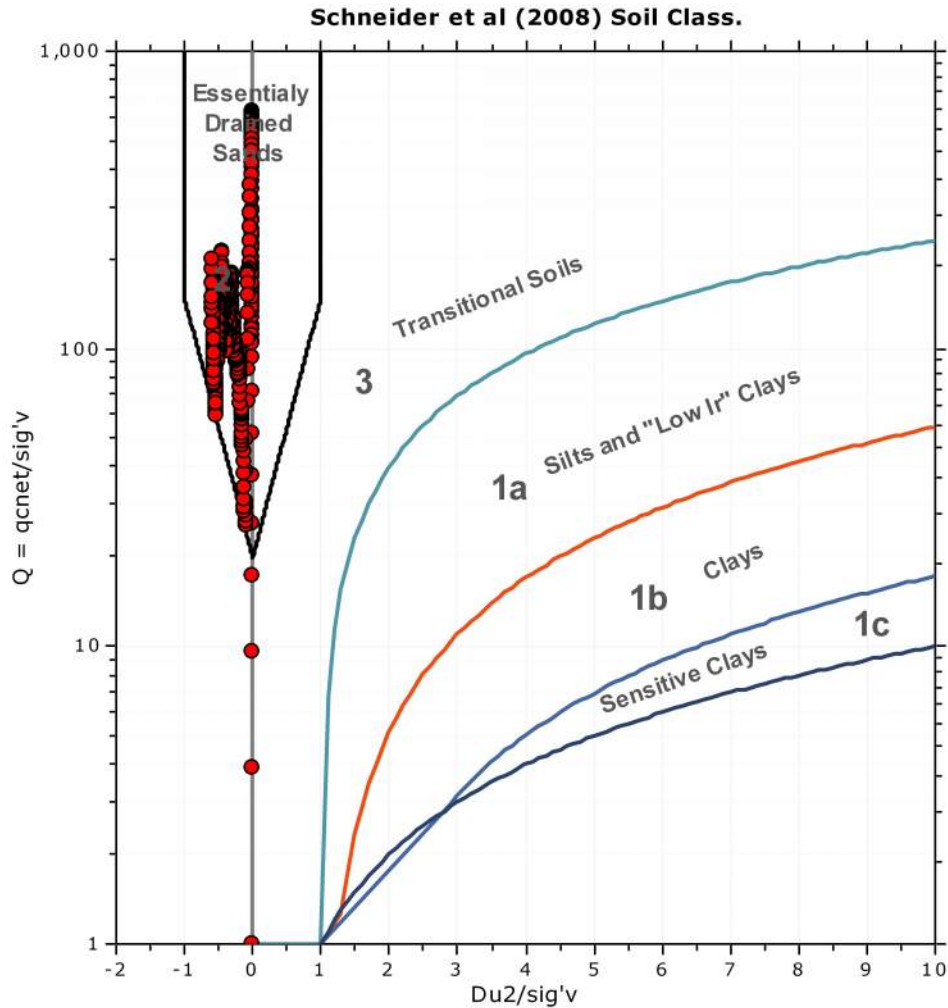
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

Project:

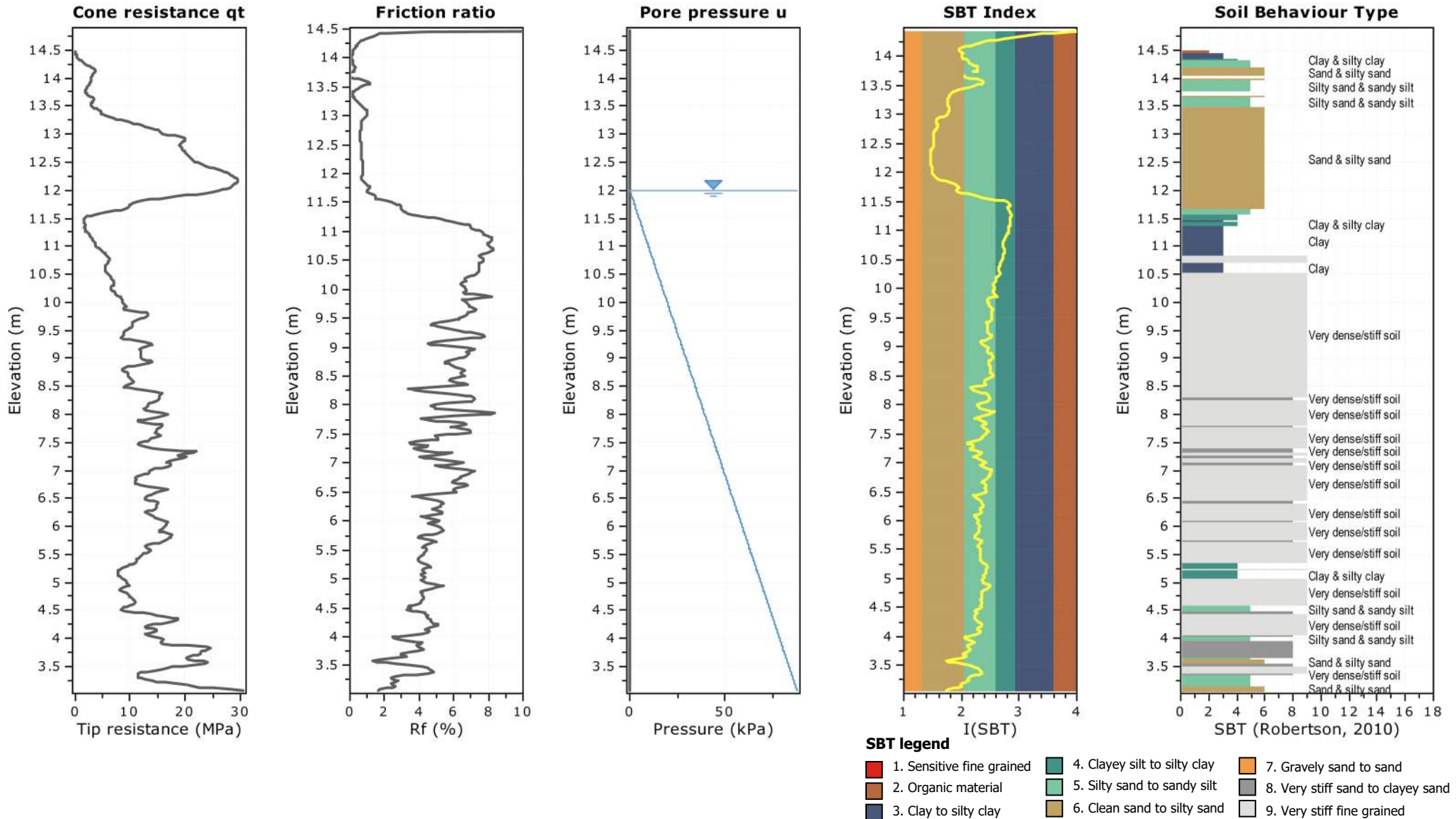
Location:

Bq plots (Schneider)

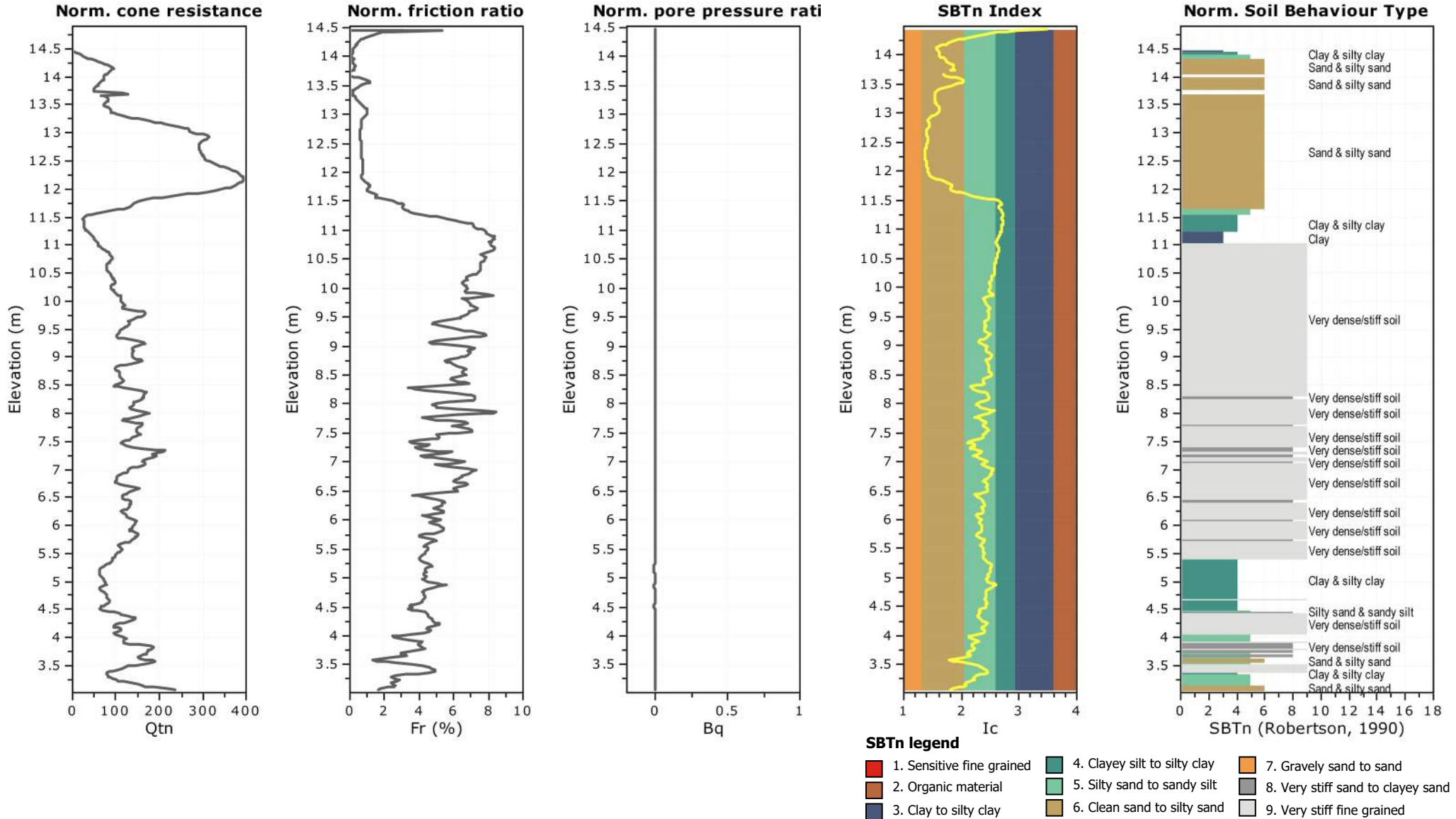


Project:

Location:

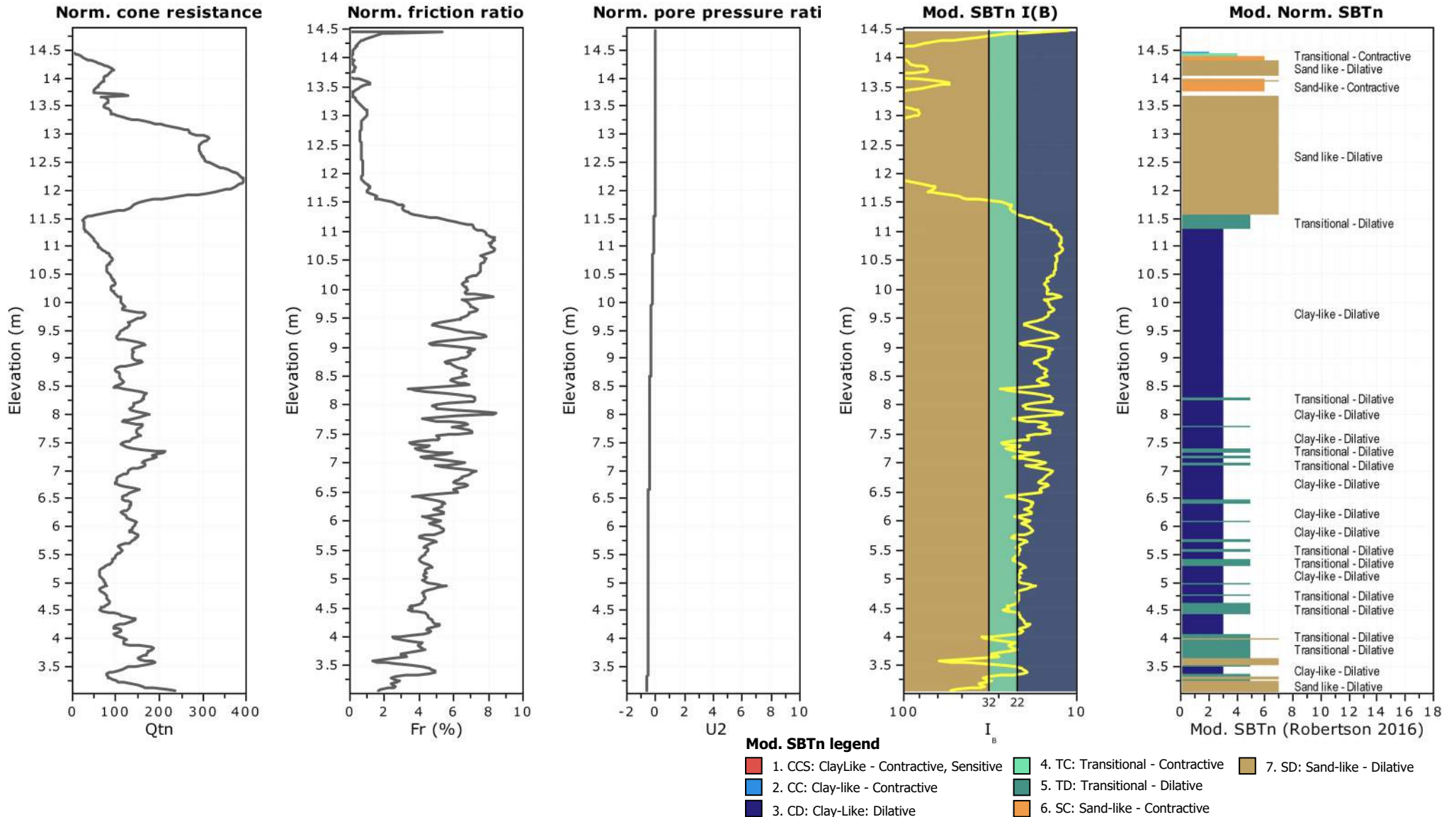


Project:
Location:



Project:

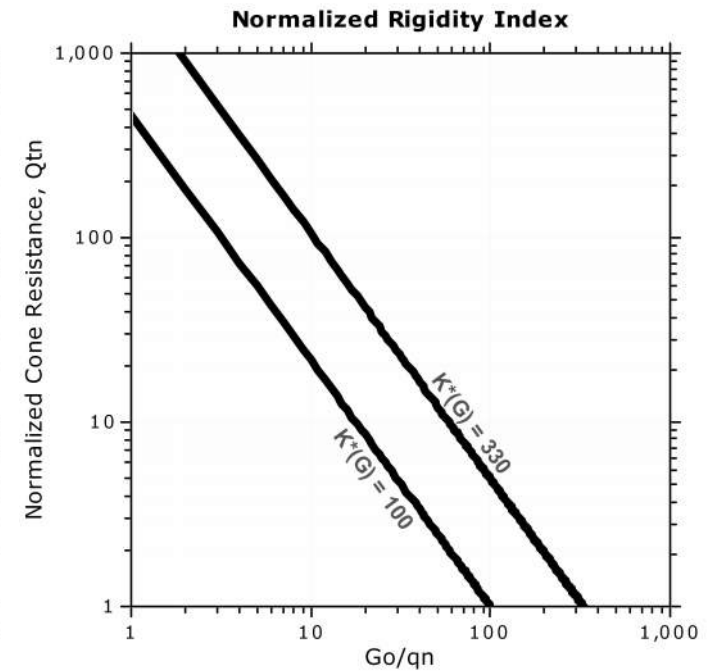
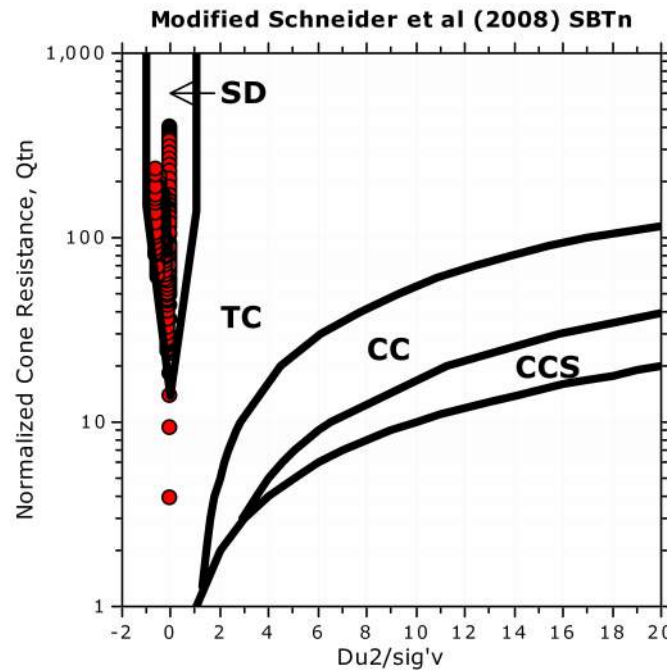
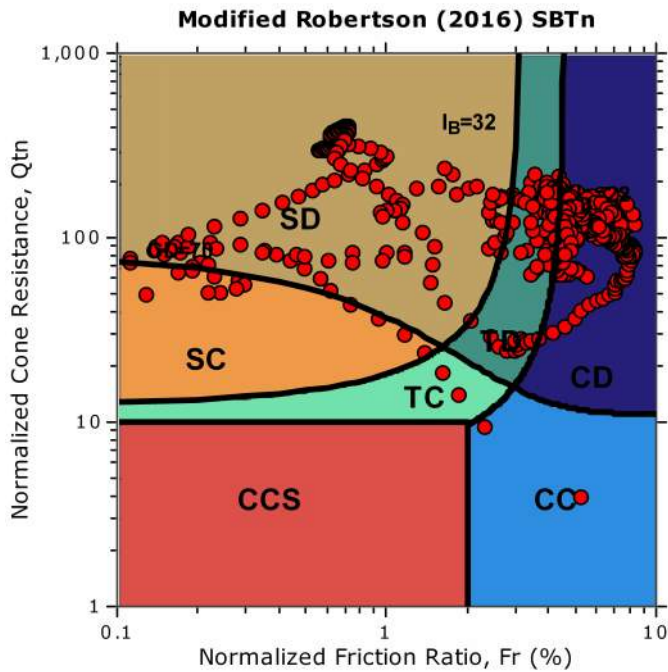
Location:



Project:

Location:

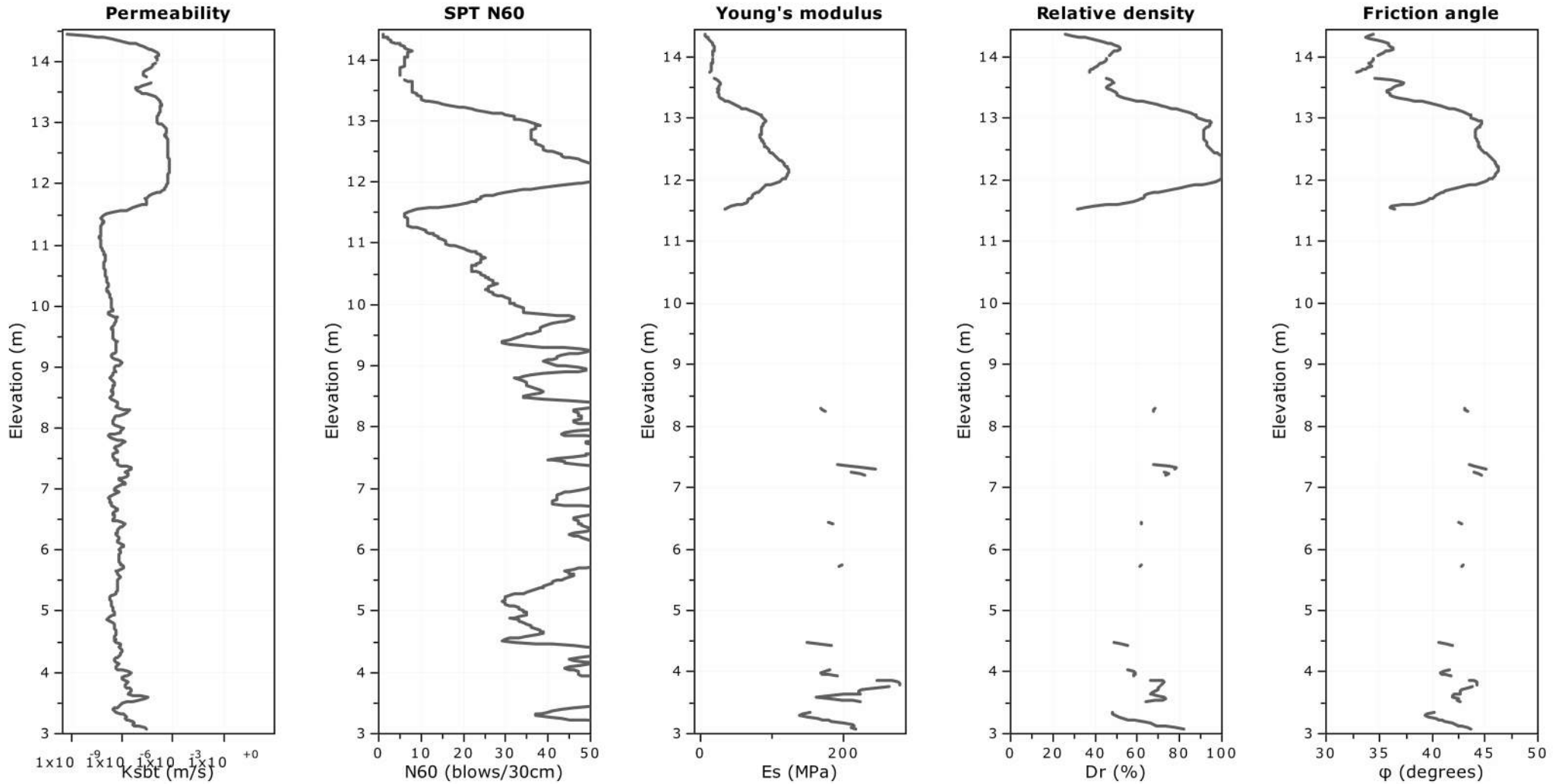
Updated SBTn plots



- 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)

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

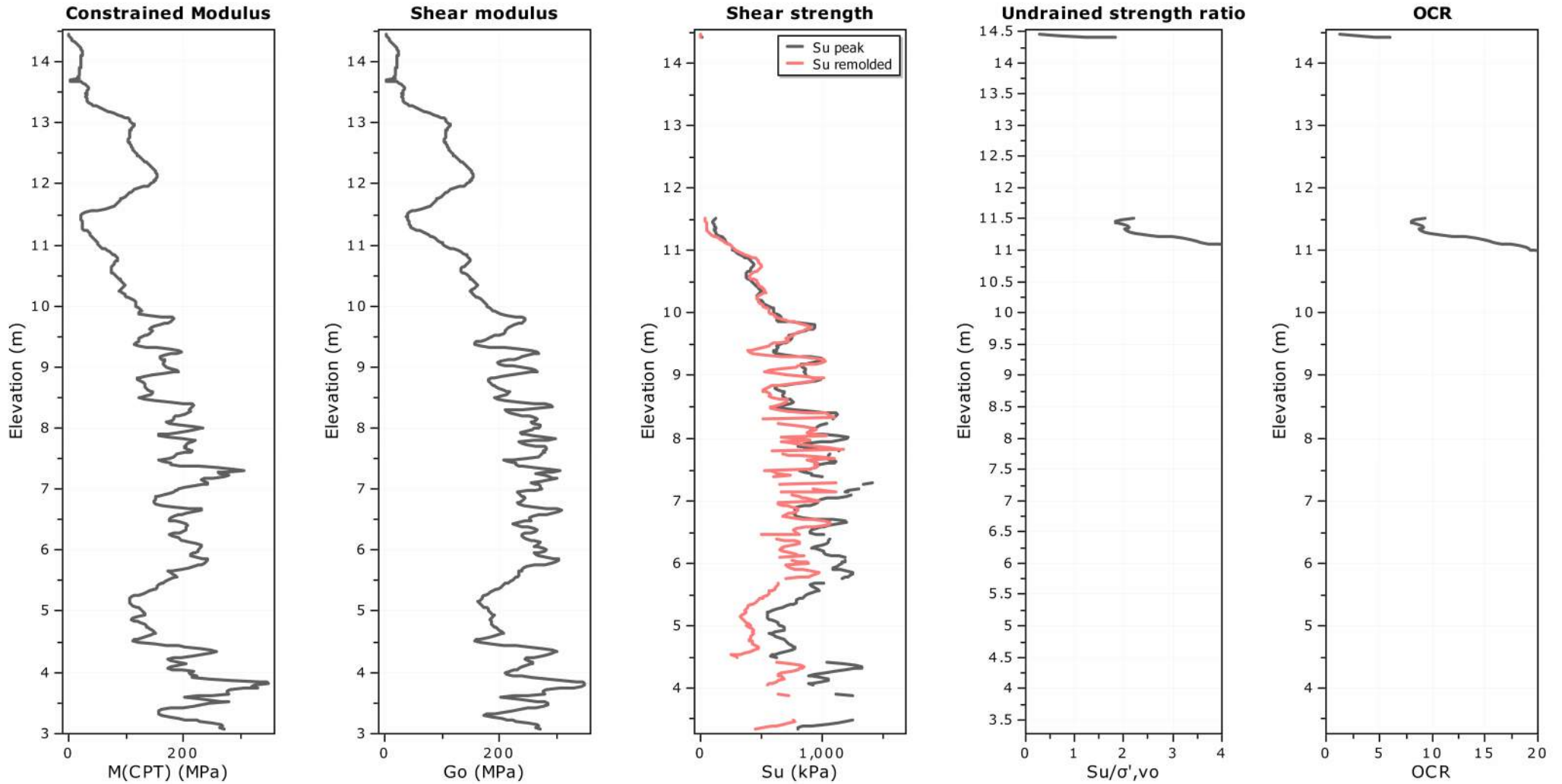
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

●— User defined estimation data

Project:
Location:

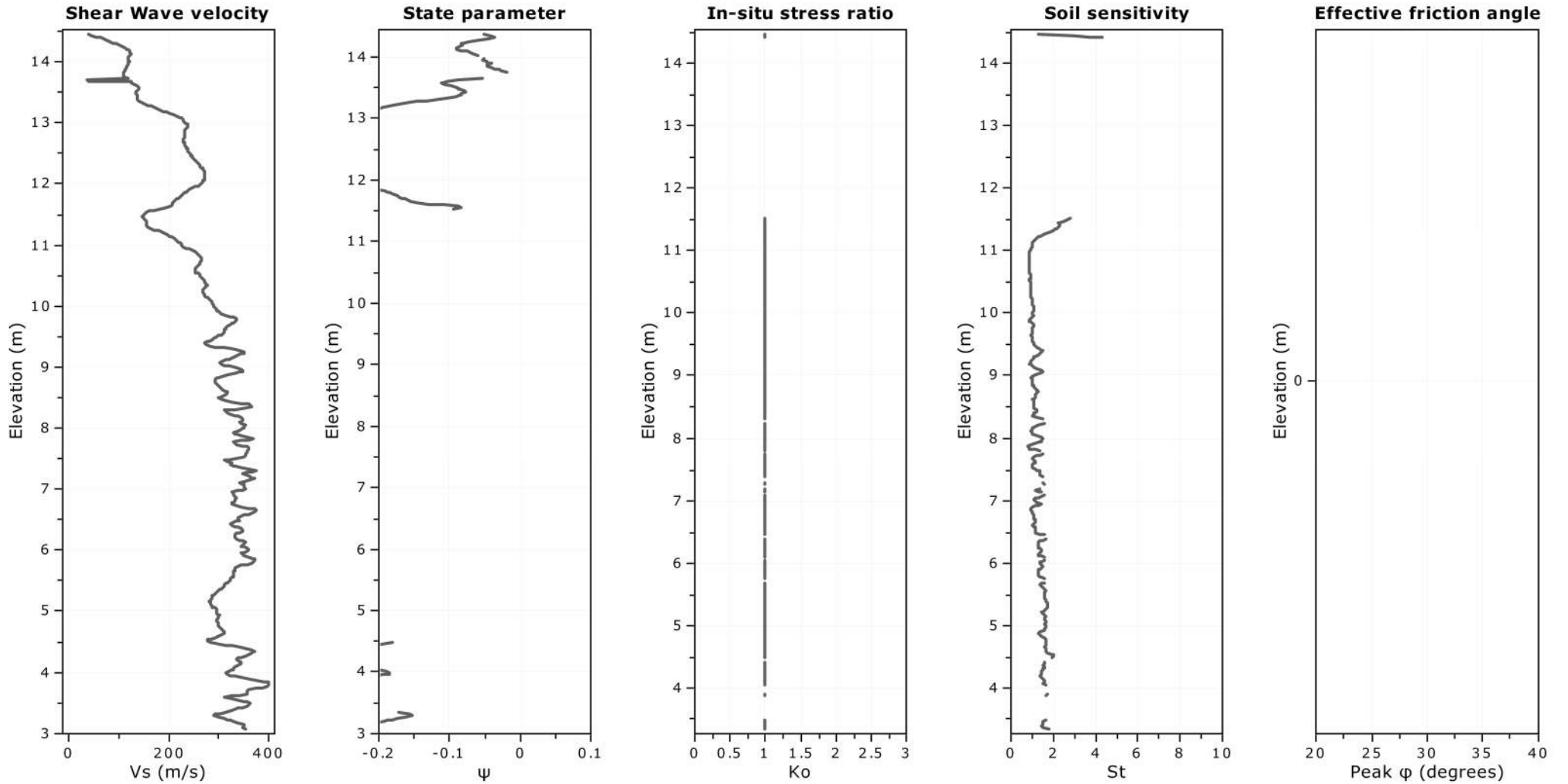


Calculation parameters

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

Project:
Location:



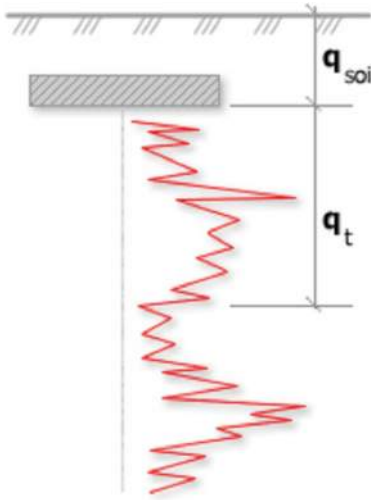
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:

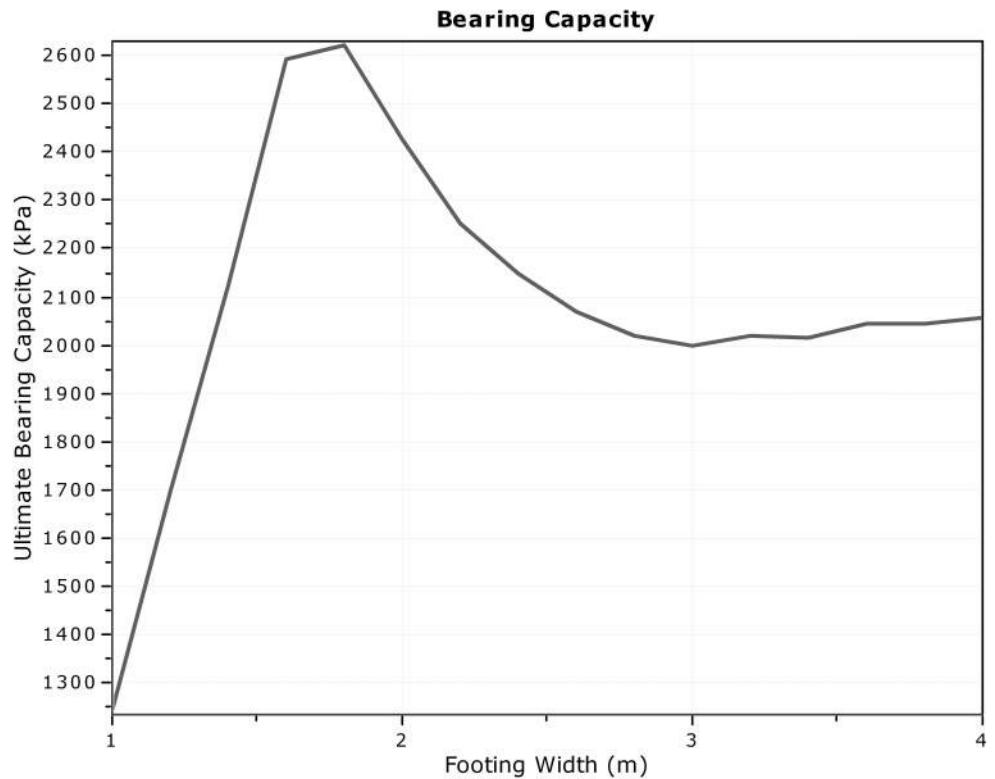


Bearing Capacity calculation is performed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

- R_k : Bearing capacity factor
- q_t : Average corrected cone resistance over calculation depth
- q_{soil} : Pressure applied by soil above footing

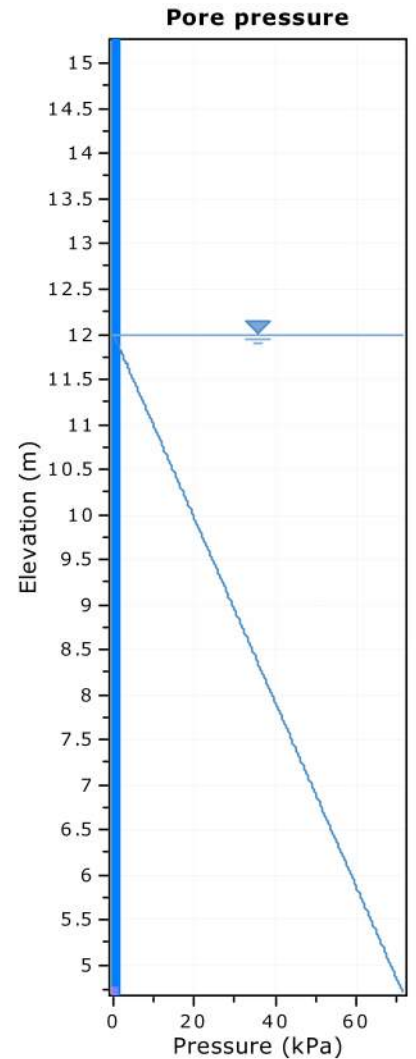
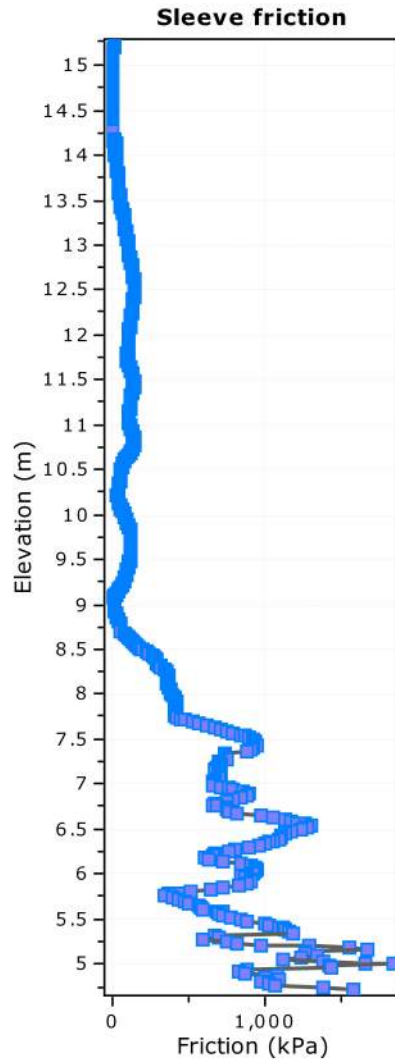
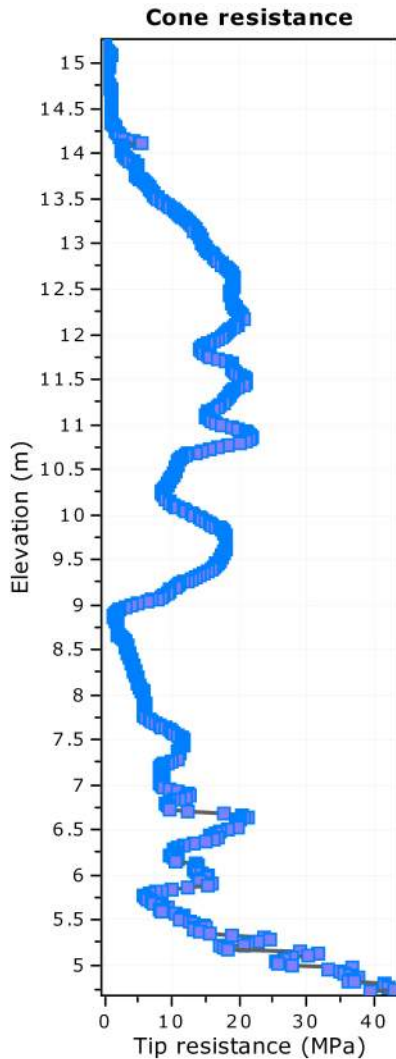


:: Tabular results ::

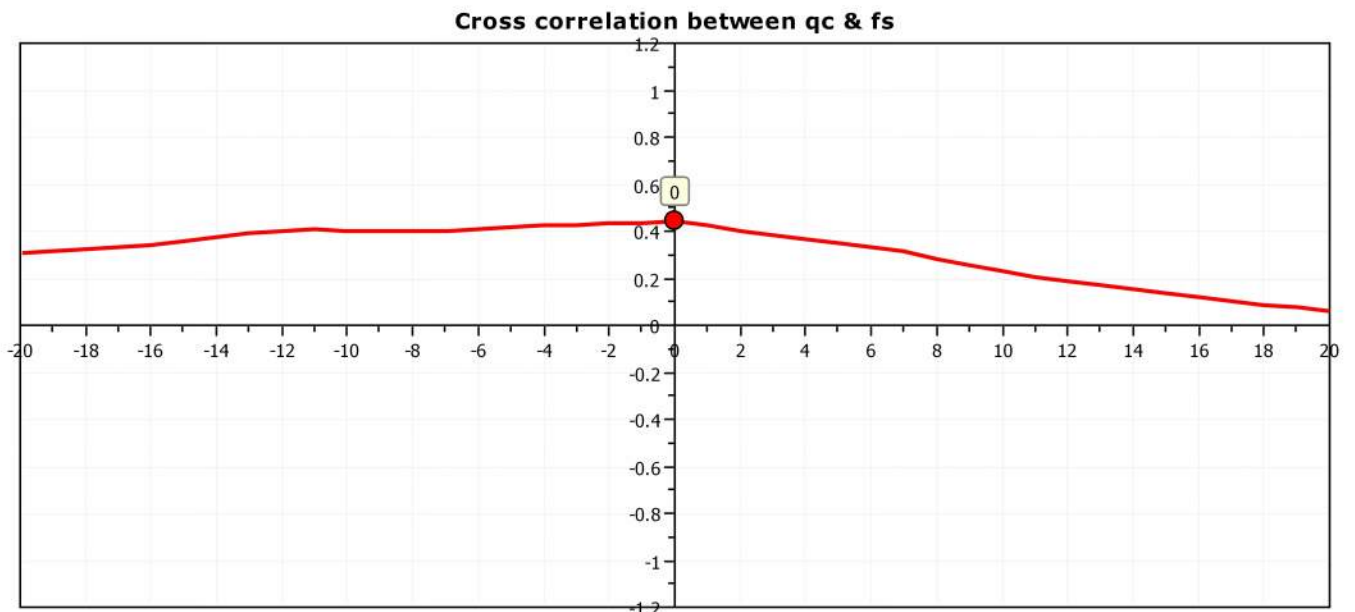
No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	6.17	0.20	9.50	1243.33
2	1.20	0.50	2.30	8.43	0.20	9.50	1694.65
3	1.40	0.50	2.60	10.56	0.20	9.50	2121.39
4	1.60	0.50	2.90	12.92	0.20	9.50	2593.27
5	1.80	0.50	3.20	13.06	0.20	9.50	2621.22
6	2.00	0.50	3.50	12.08	0.20	9.50	2425.40
7	2.20	0.50	3.80	11.21	0.20	9.50	2251.72
8	2.40	0.50	4.10	10.69	0.20	9.50	2146.51
9	2.60	0.50	4.40	10.30	0.20	9.50	2070.23
10	2.80	0.50	4.70	10.05	0.20	9.50	2020.12
11	3.00	0.50	5.00	9.95	0.20	9.50	1999.55
12	3.20	0.50	5.30	10.05	0.20	9.50	2019.60
13	3.40	0.50	5.60	10.04	0.20	9.50	2017.03
14	3.60	0.50	5.90	10.17	0.20	9.50	2042.69
15	3.80	0.50	6.20	10.18	0.20	9.50	2045.67
16	4.00	0.50	6.50	10.23	0.20	9.50	2056.43

Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

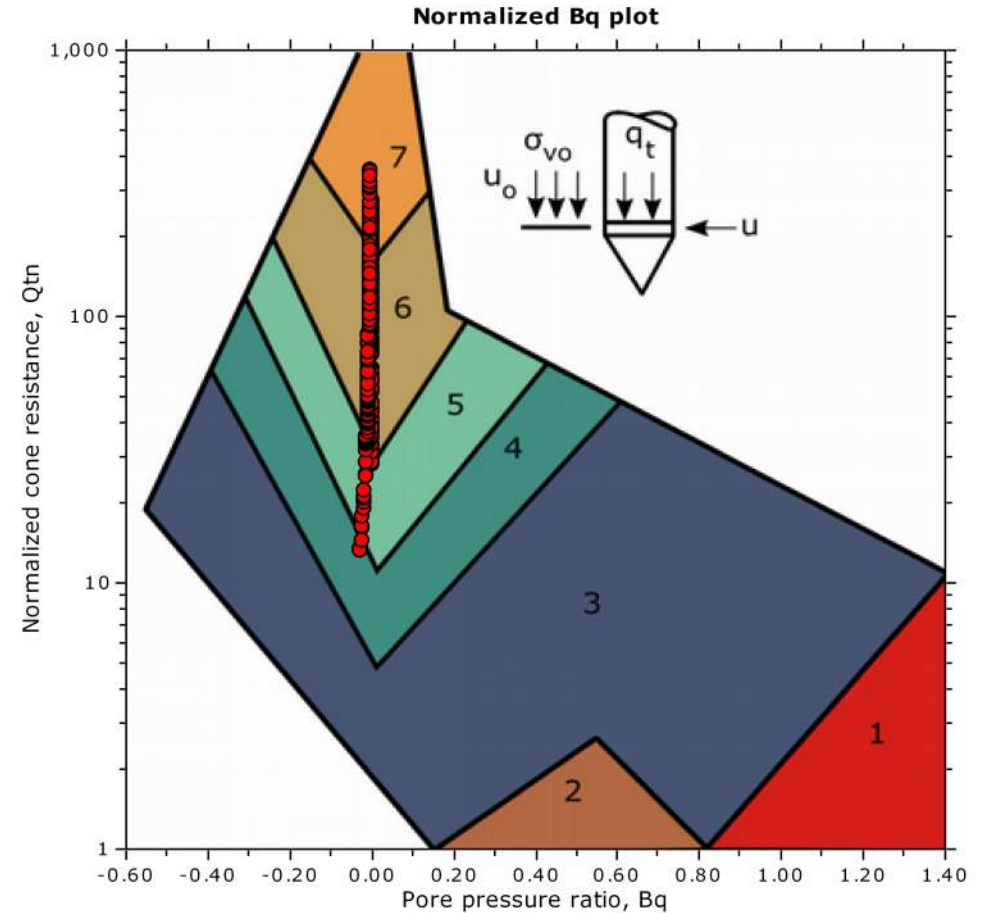
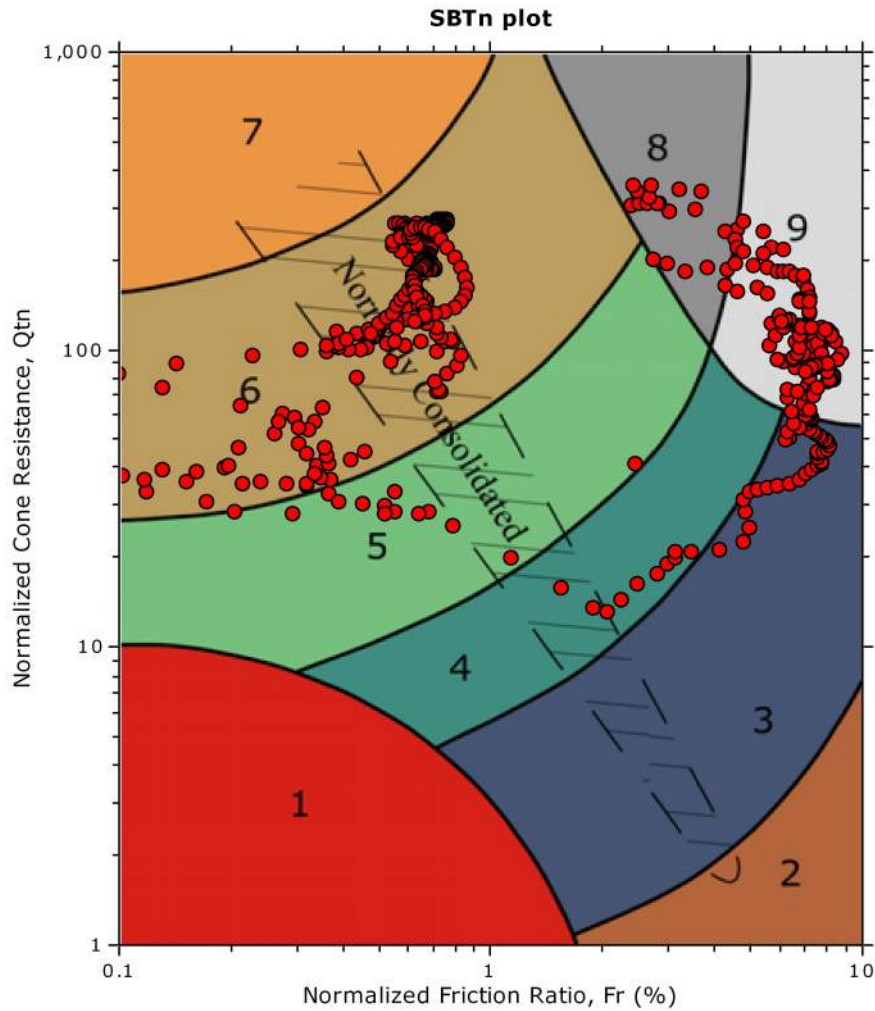




Project:

Location:

SBT - Bq plots (normalized)



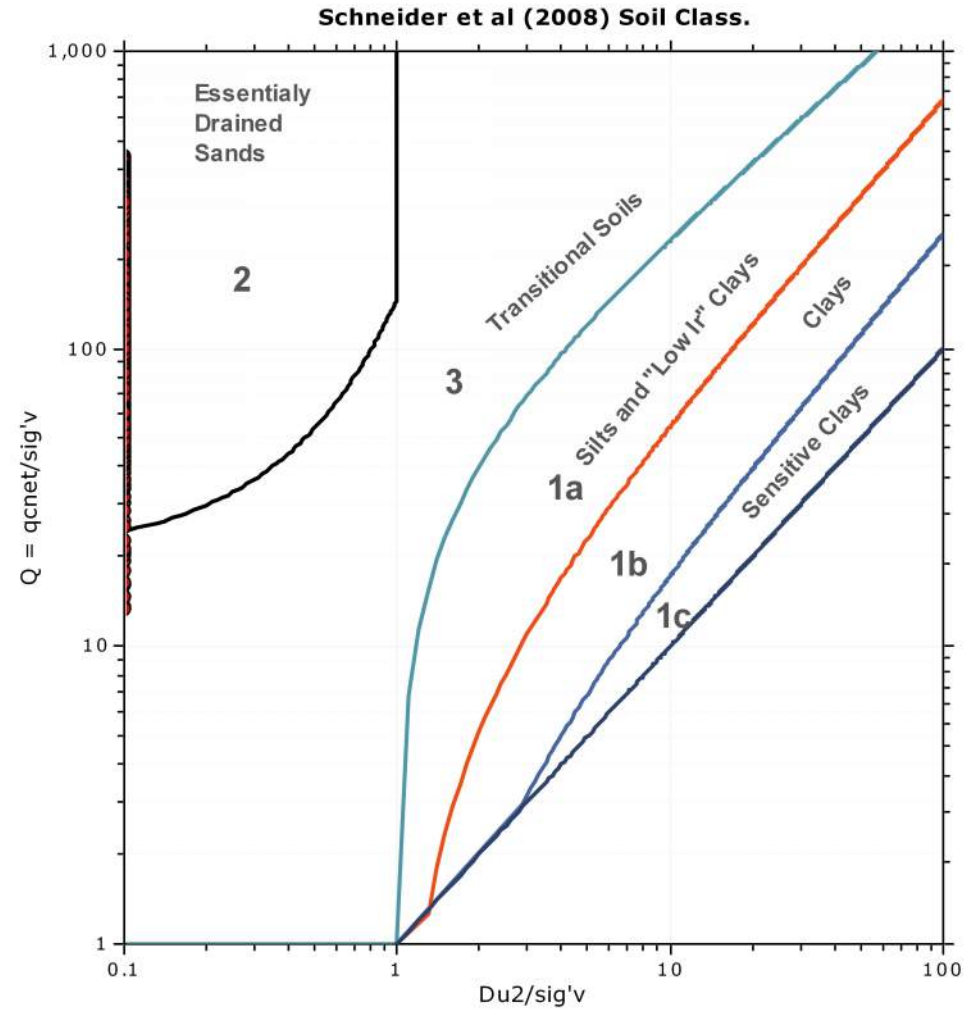
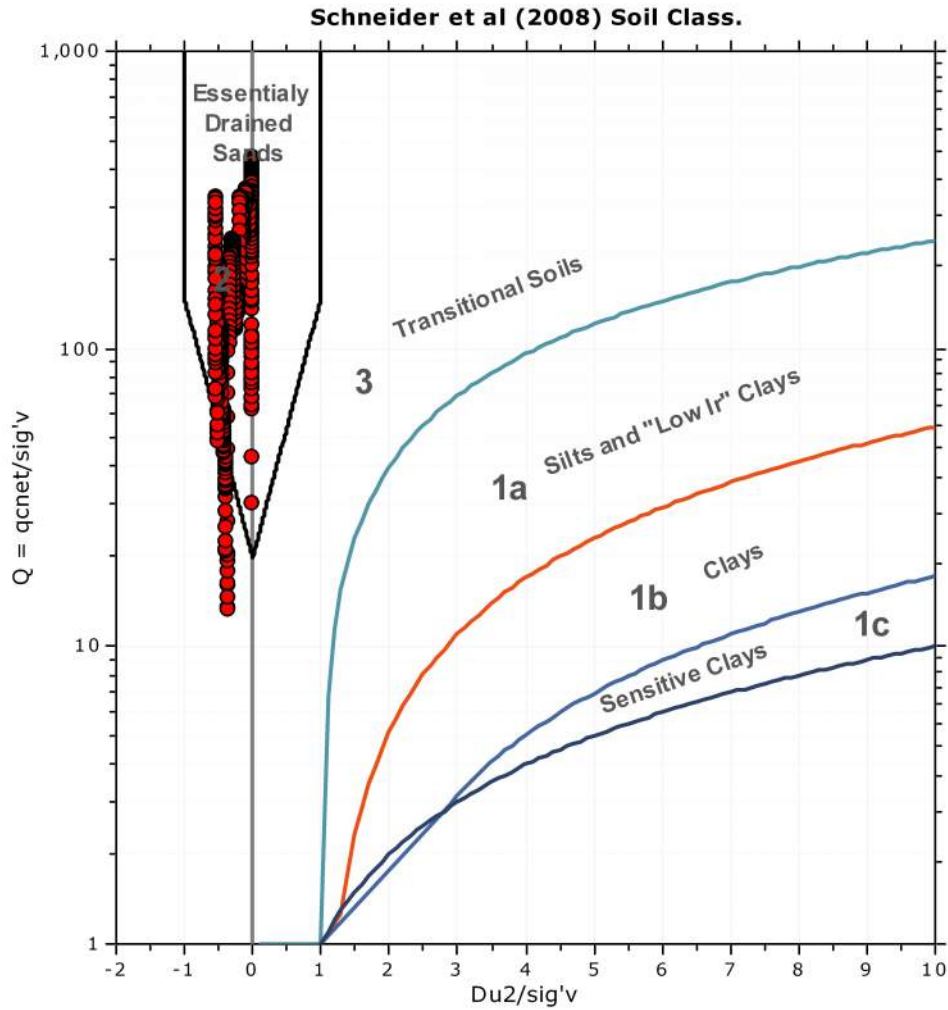
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

Project:

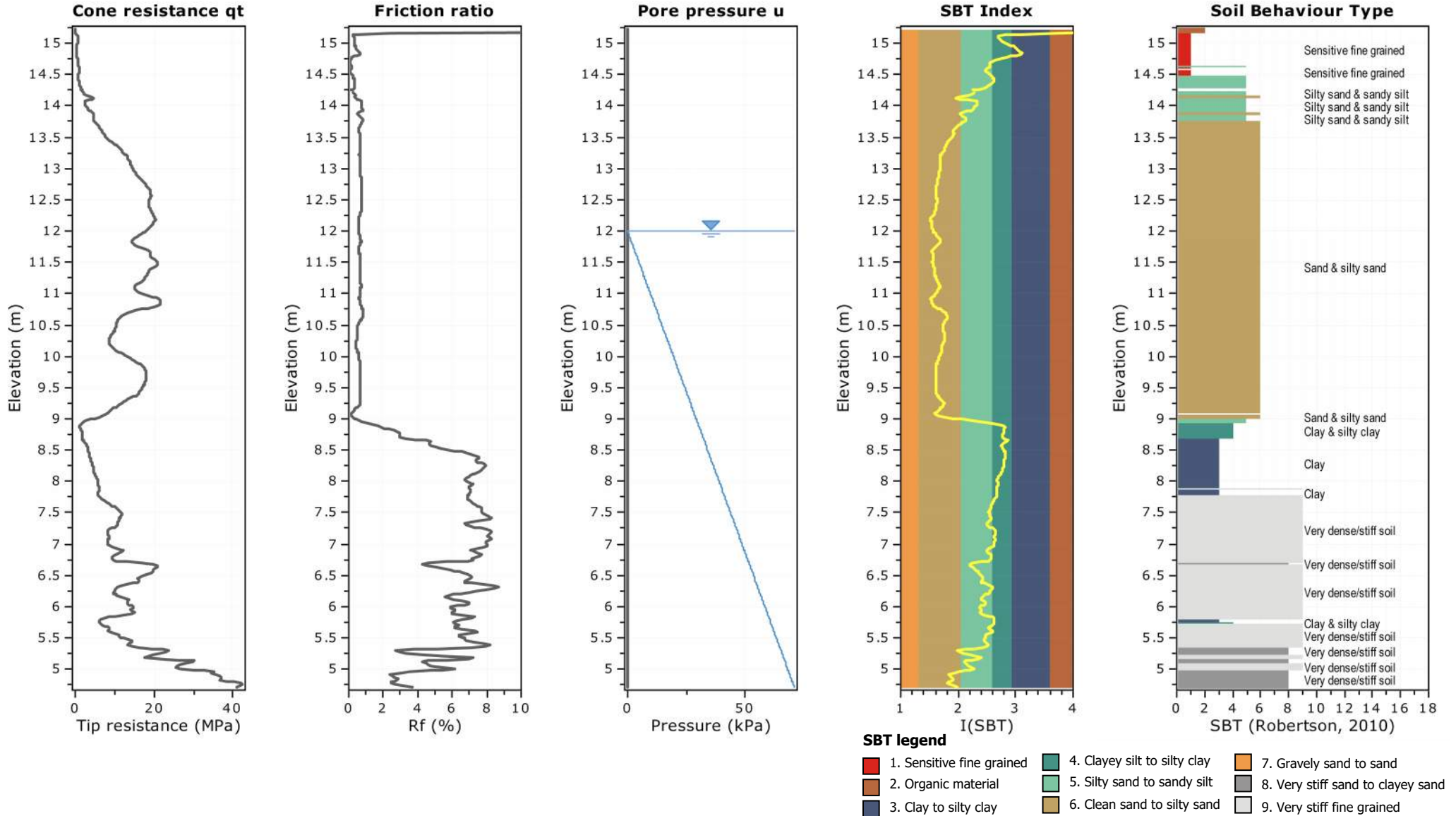
Location:

Bq plots (Schneider)



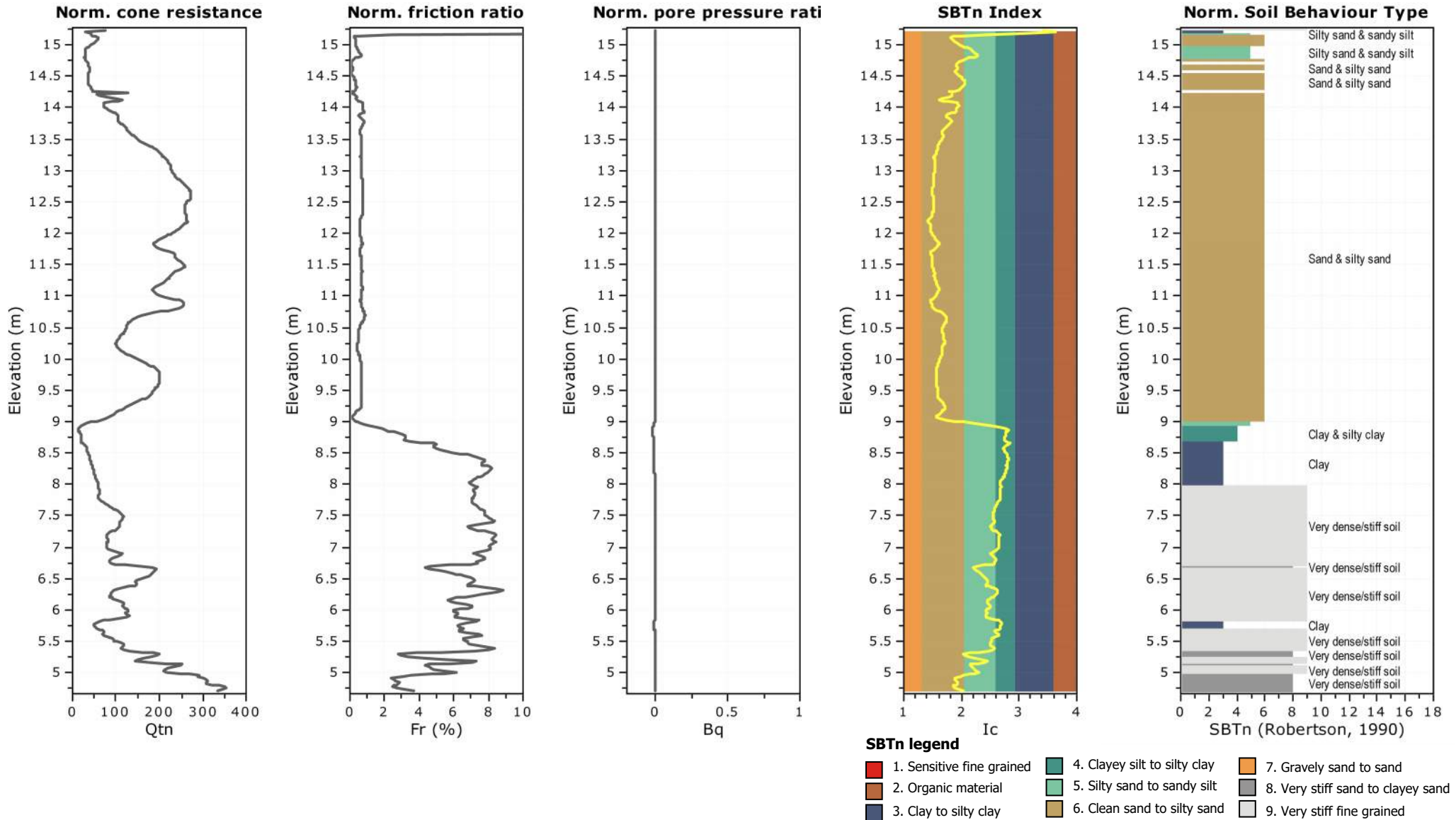
Project:

Location:

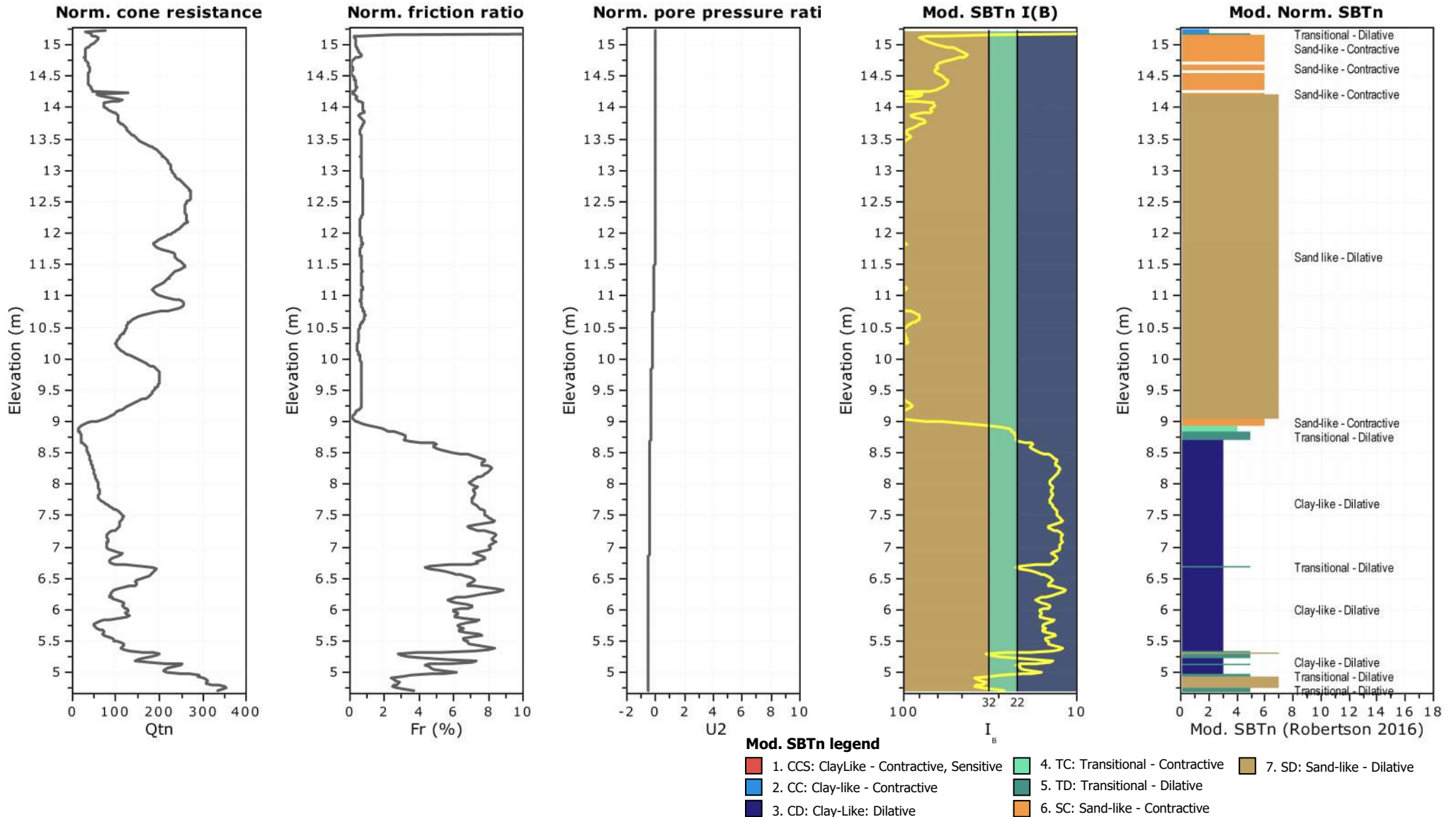


Project:

Location:



Project:
Location:

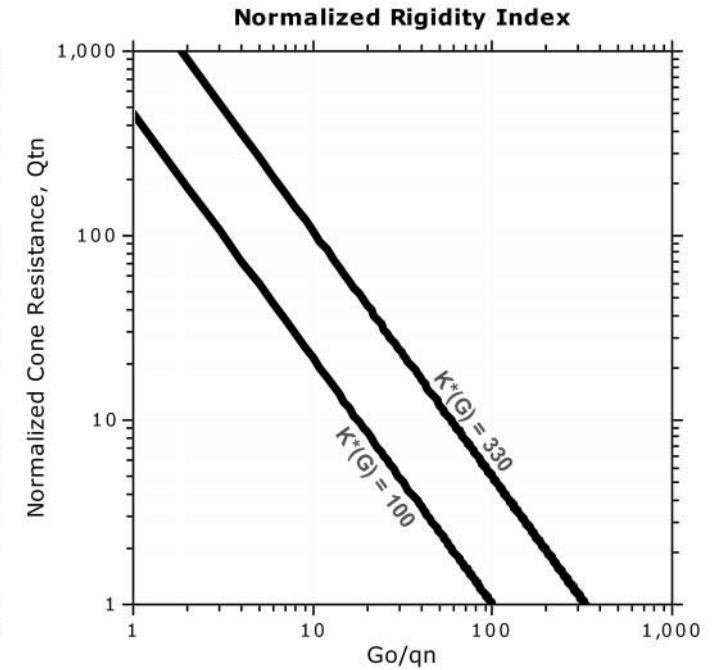
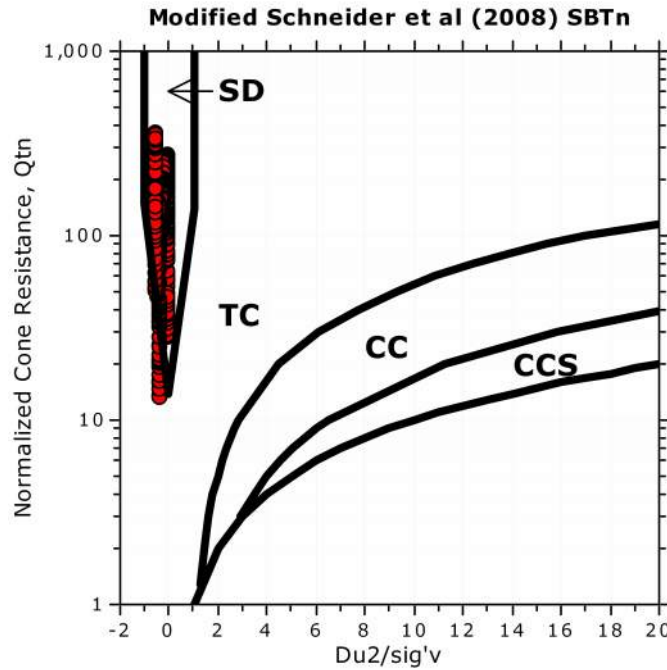
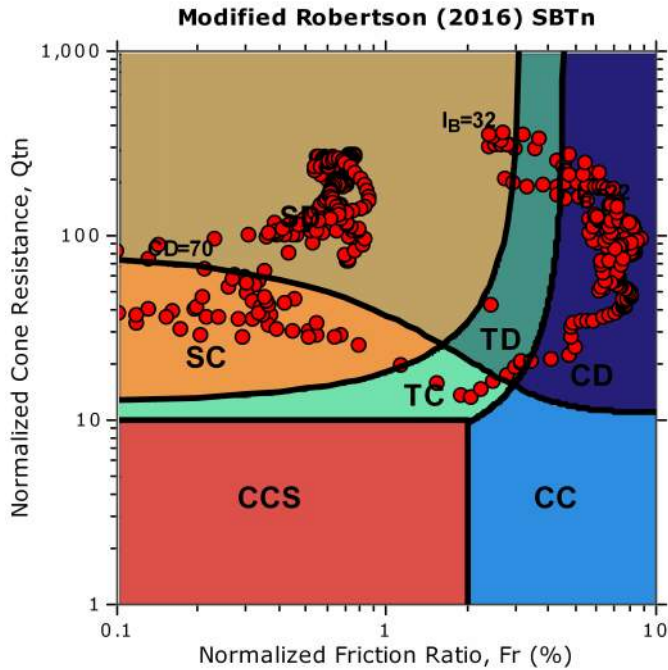




Project:

Location:

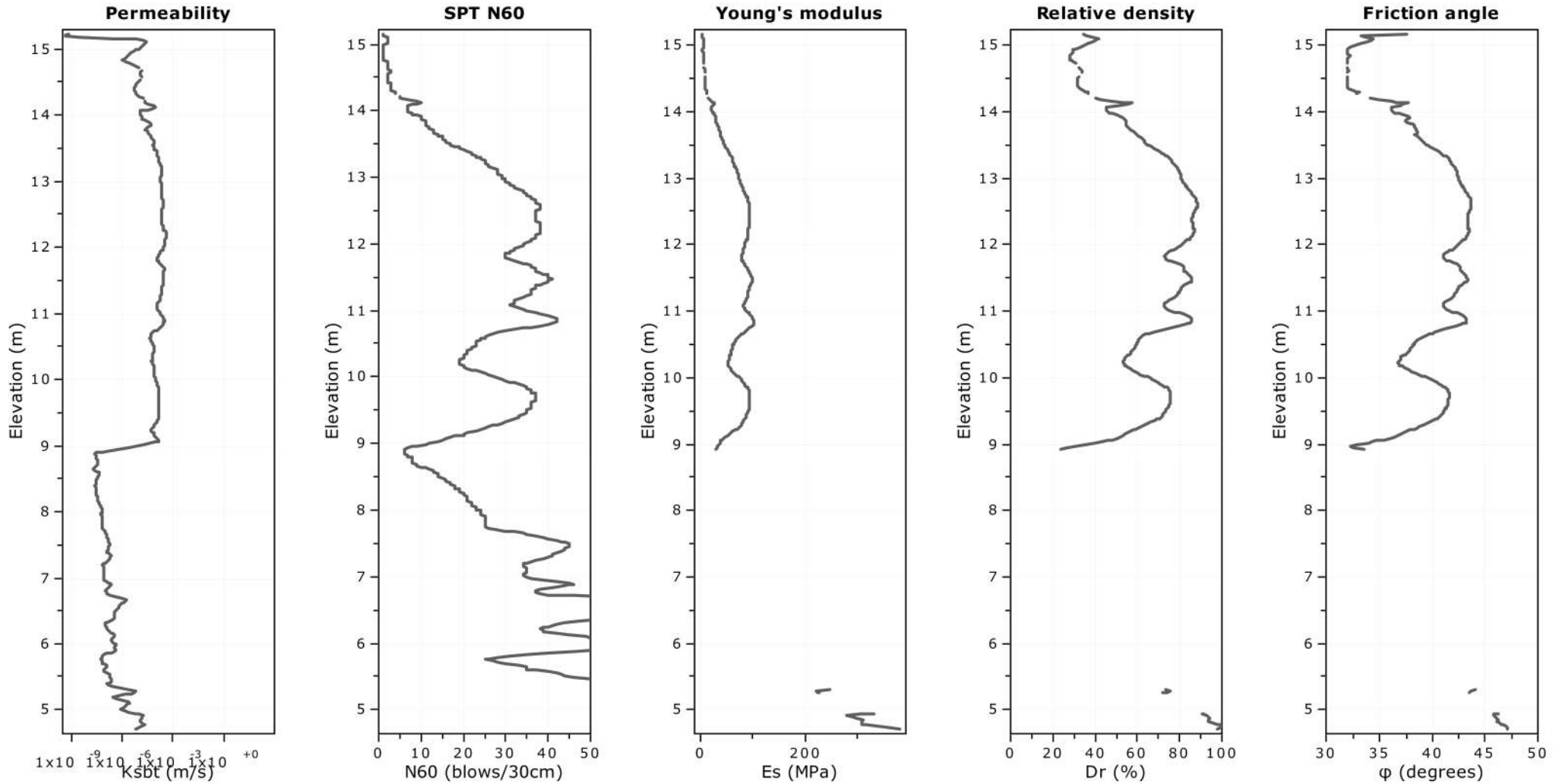
Updated SBTn plots



- 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)

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

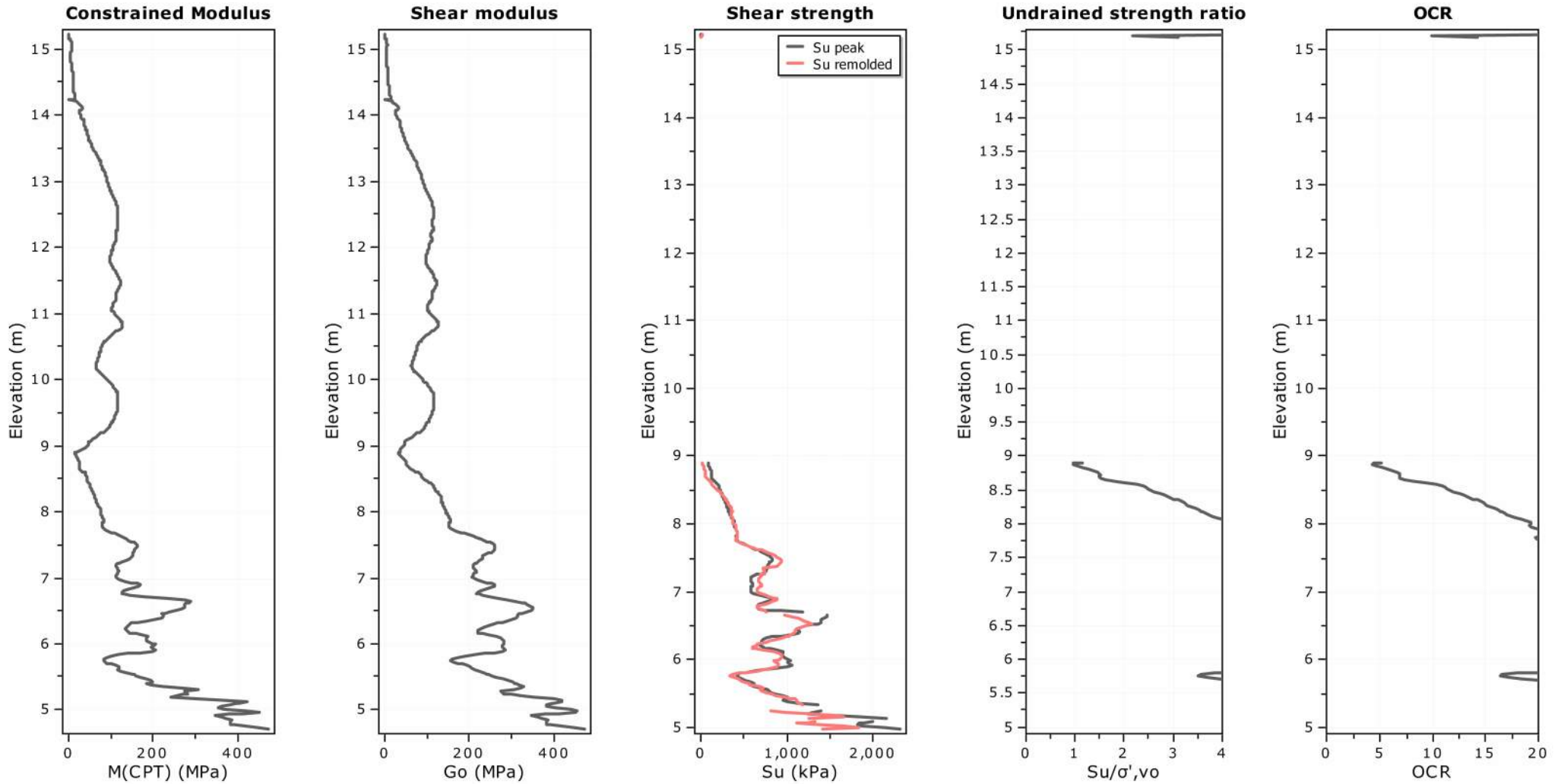
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

● User defined estimation data

Project:
Location:

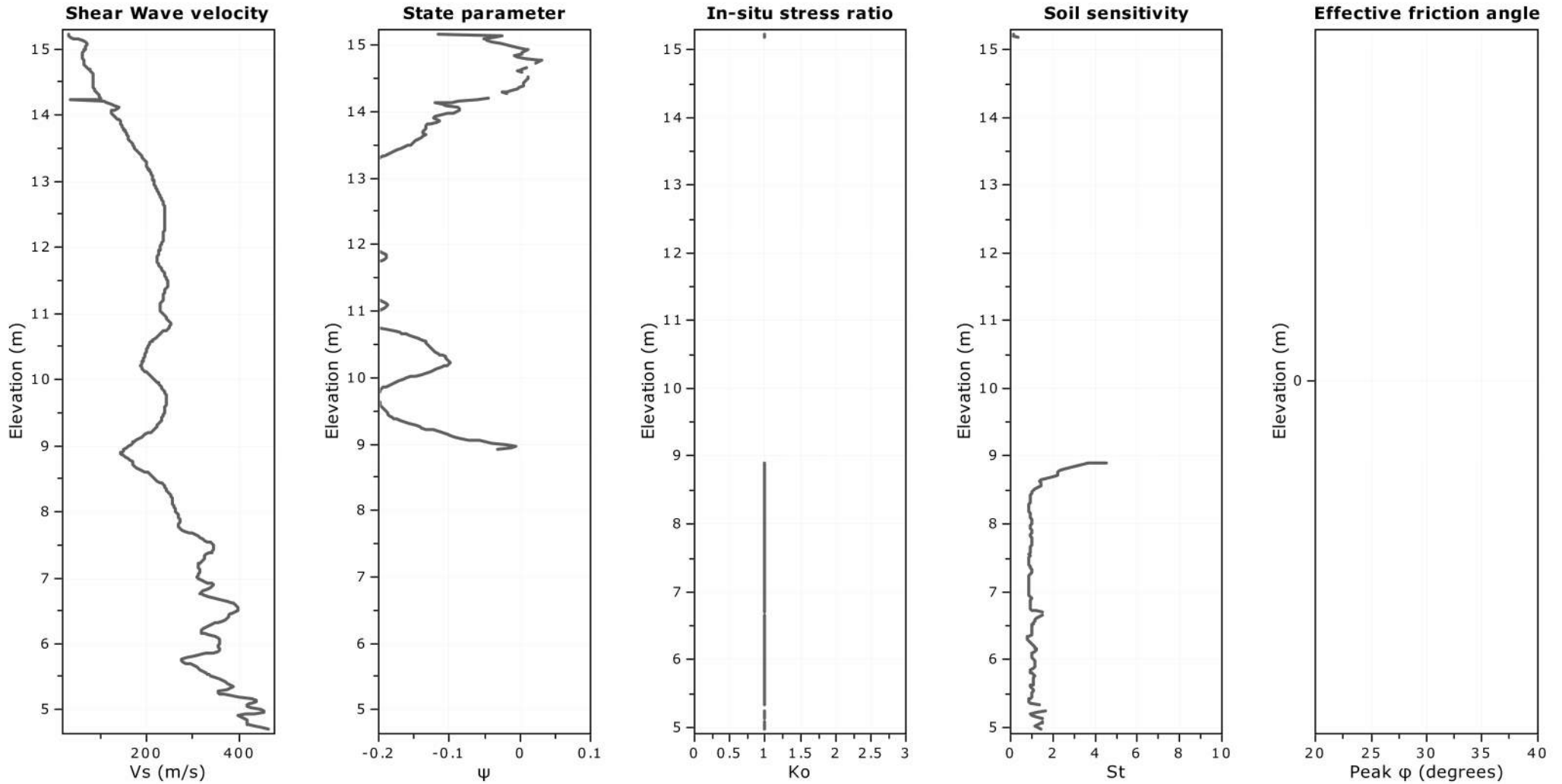


Calculation parameters

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

Project:
Location:



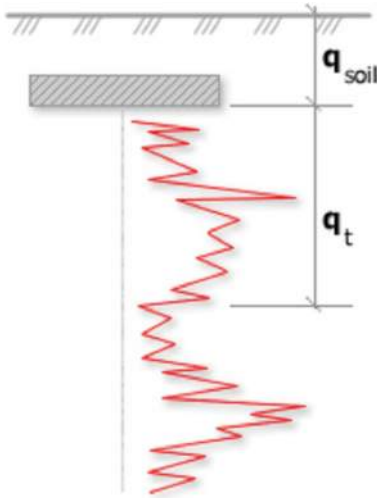
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:

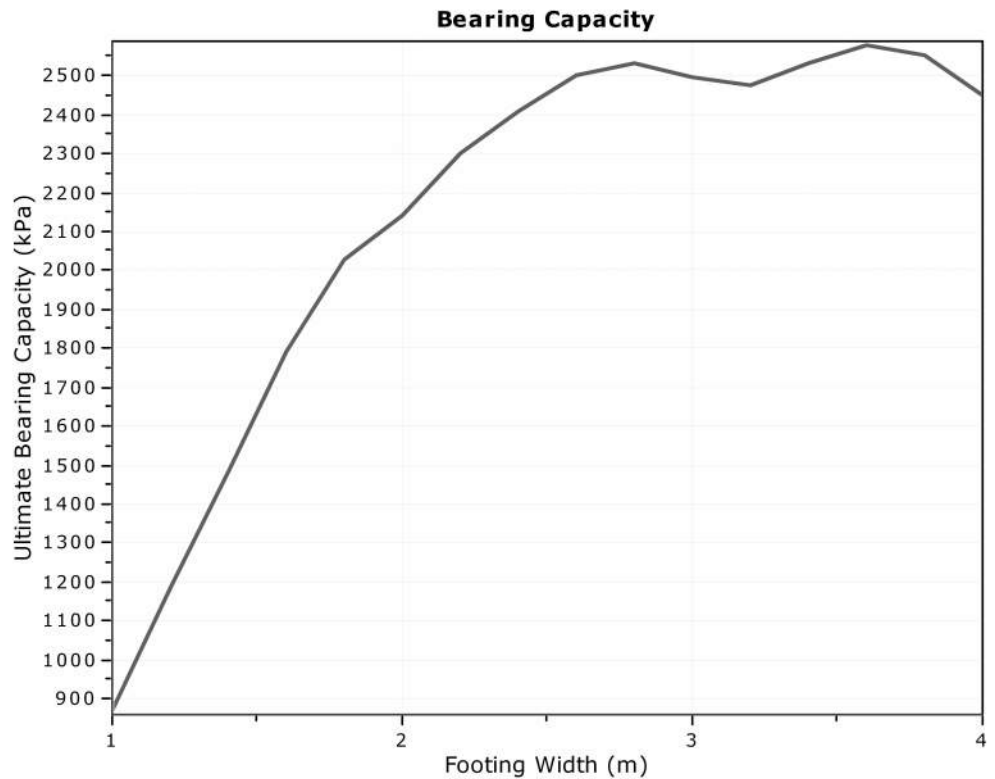


Bearing Capacity calculation is performed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

- R_k : Bearing capacity factor
- q_t : Average corrected cone resistance over calculation depth
- q_{soil} : Pressure applied by soil above footing

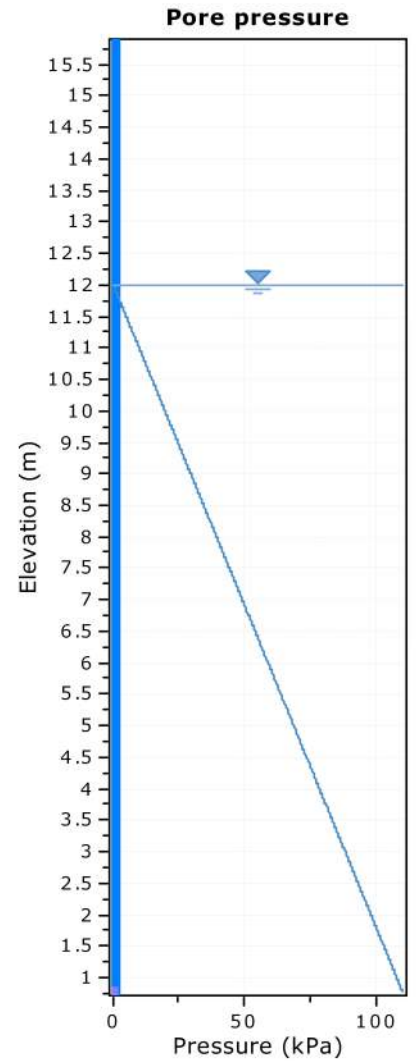
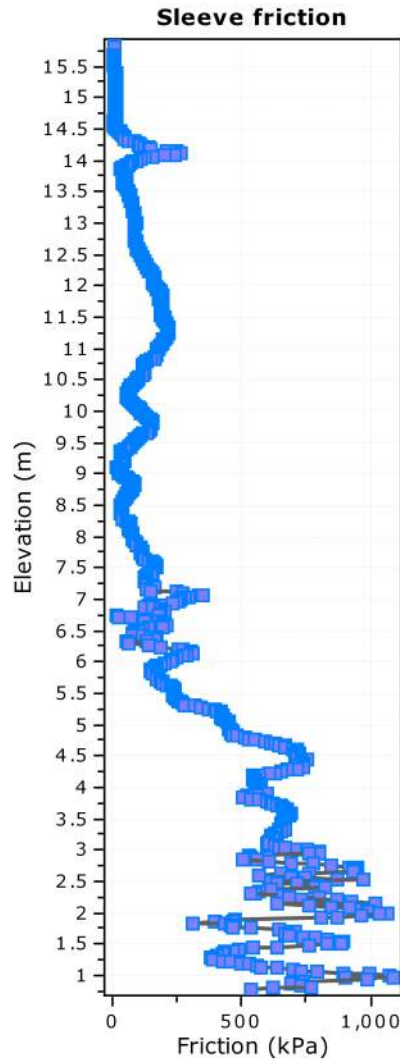
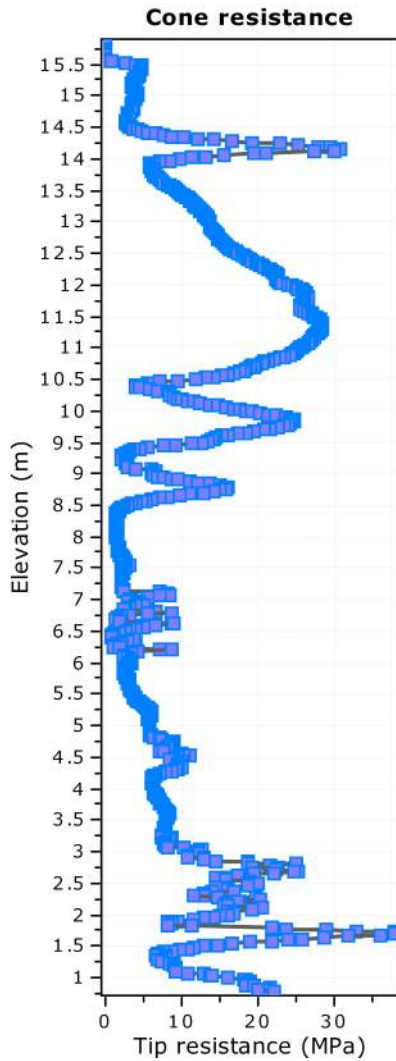


:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	4.30	0.20	9.50	869.42
2	1.20	0.50	2.30	5.88	0.20	9.50	1185.96
3	1.40	0.50	2.60	7.37	0.20	9.50	1484.34
4	1.60	0.50	2.90	8.90	0.20	9.50	1789.92
5	1.80	0.50	3.20	10.09	0.20	9.50	2026.99
6	2.00	0.50	3.50	10.67	0.20	9.50	2143.30
7	2.20	0.50	3.80	11.46	0.20	9.50	2301.60
8	2.40	0.50	4.10	12.00	0.20	9.50	2410.21
9	2.60	0.50	4.40	12.47	0.20	9.50	2503.41
10	2.80	0.50	4.70	12.62	0.20	9.50	2534.35
11	3.00	0.50	5.00	12.43	0.20	9.50	2494.90
12	3.20	0.50	5.30	12.33	0.20	9.50	2476.11
13	3.40	0.50	5.60	12.62	0.20	9.50	2533.18
14	3.60	0.50	5.90	12.85	0.20	9.50	2579.09
15	3.80	0.50	6.20	12.72	0.20	9.50	2554.00
16	4.00	0.50	6.50	12.21	0.20	9.50	2451.20

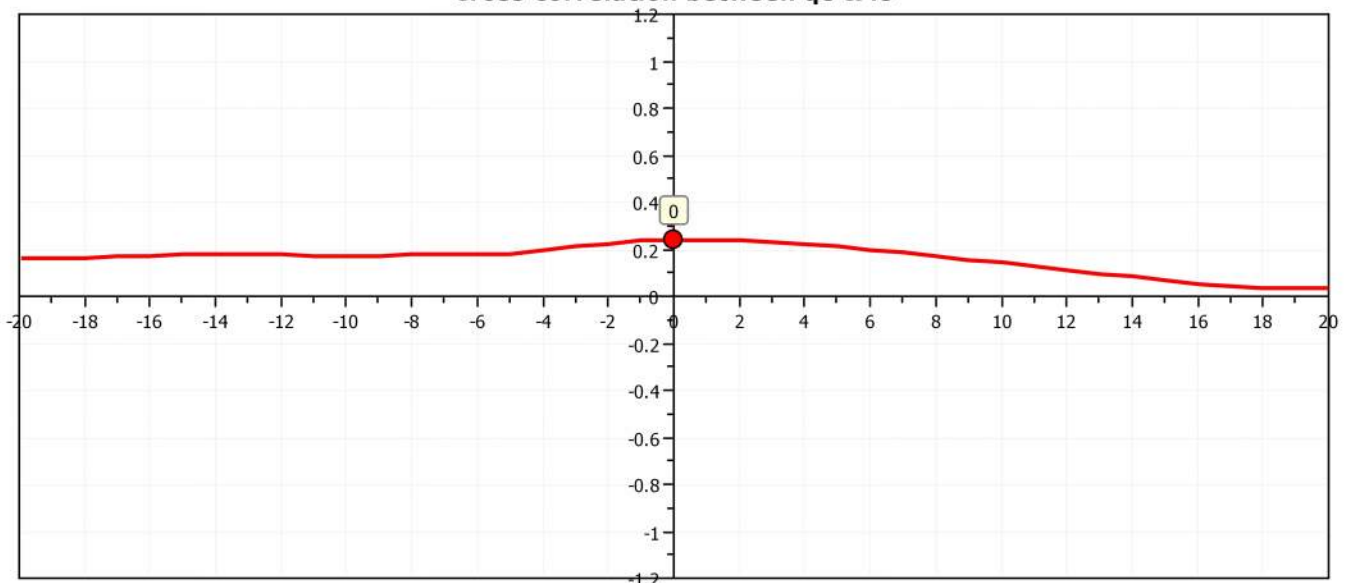
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

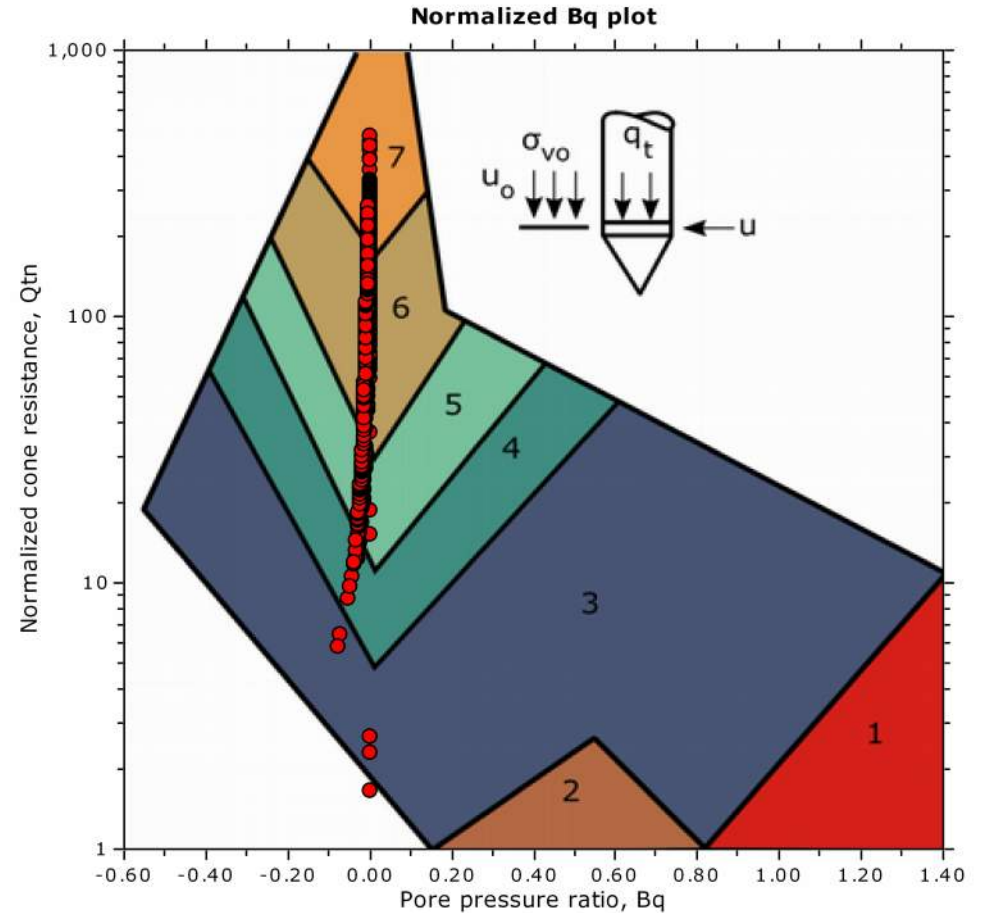
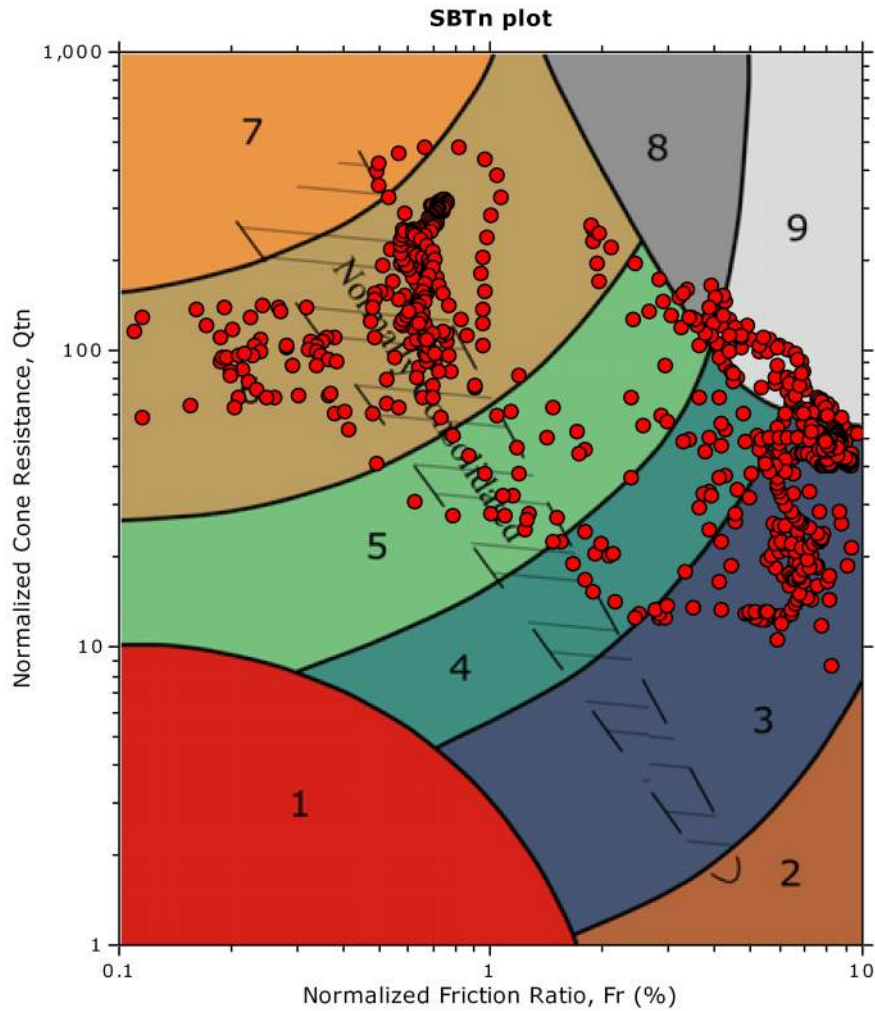




Project:

Location:

SBT - Bq plots (normalized)



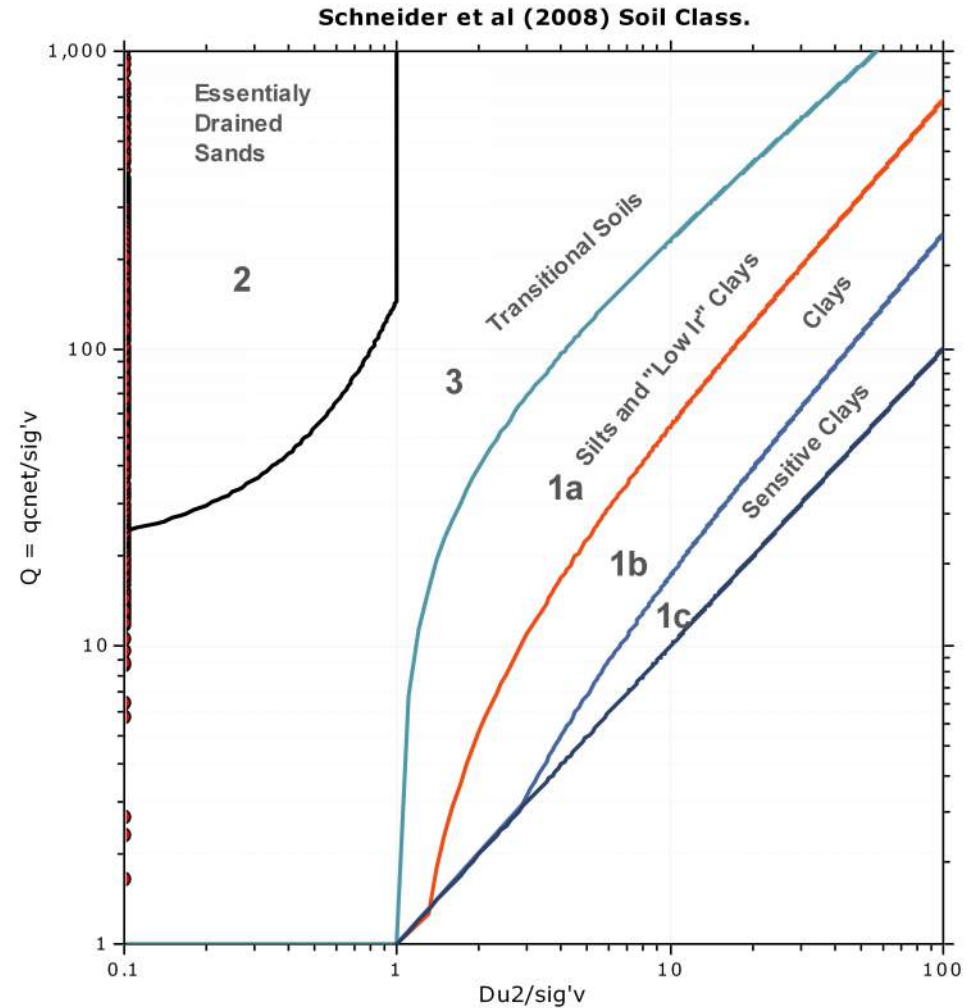
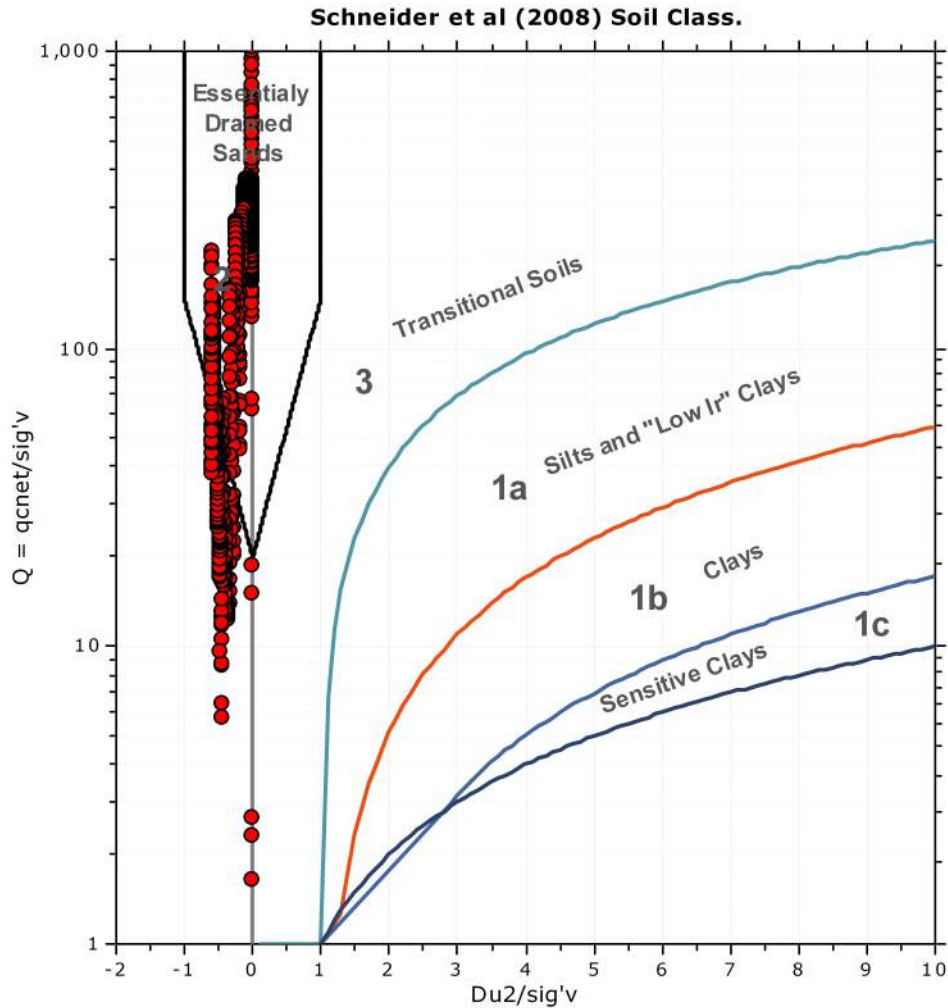
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

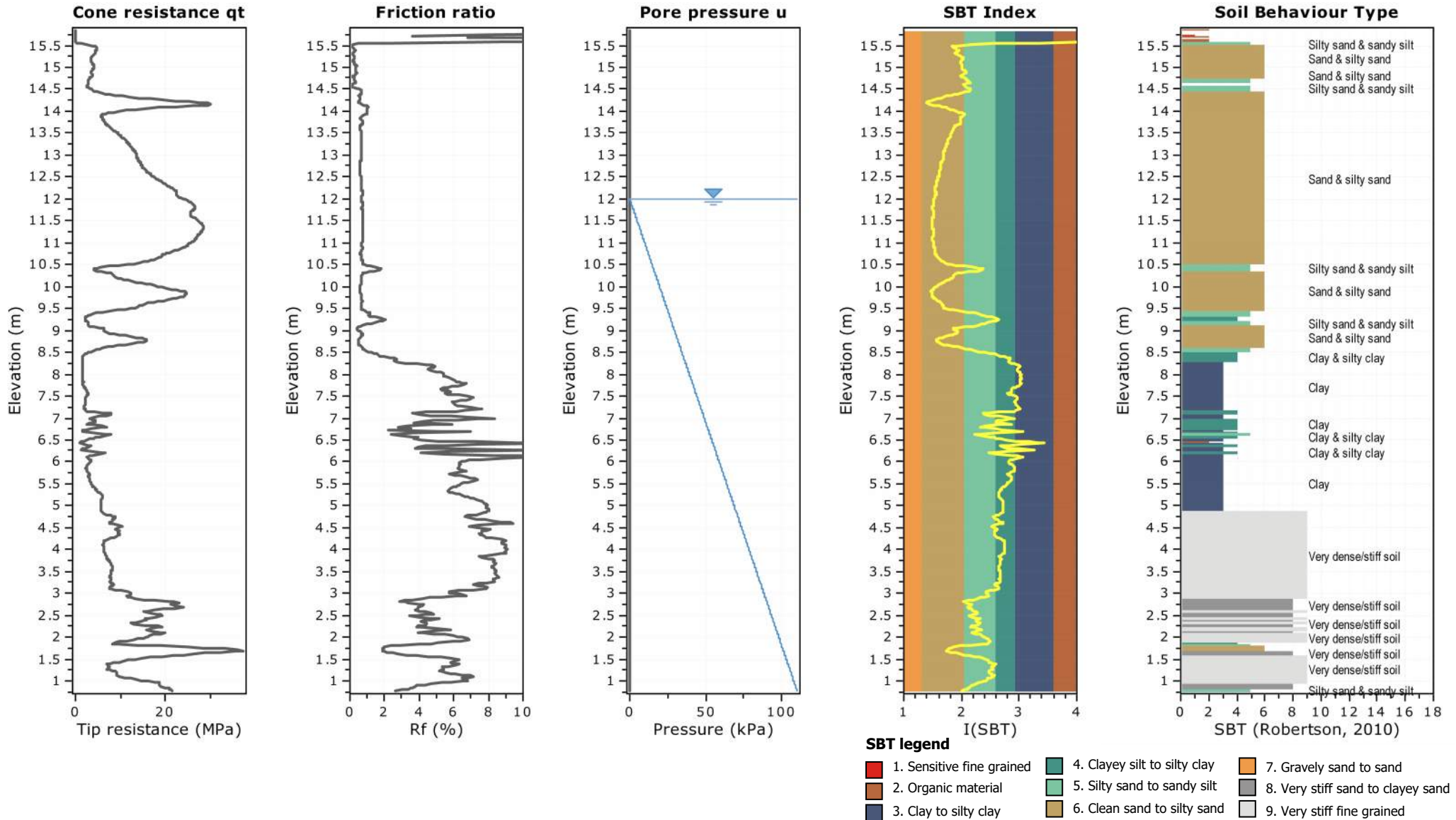
Project:

Location:

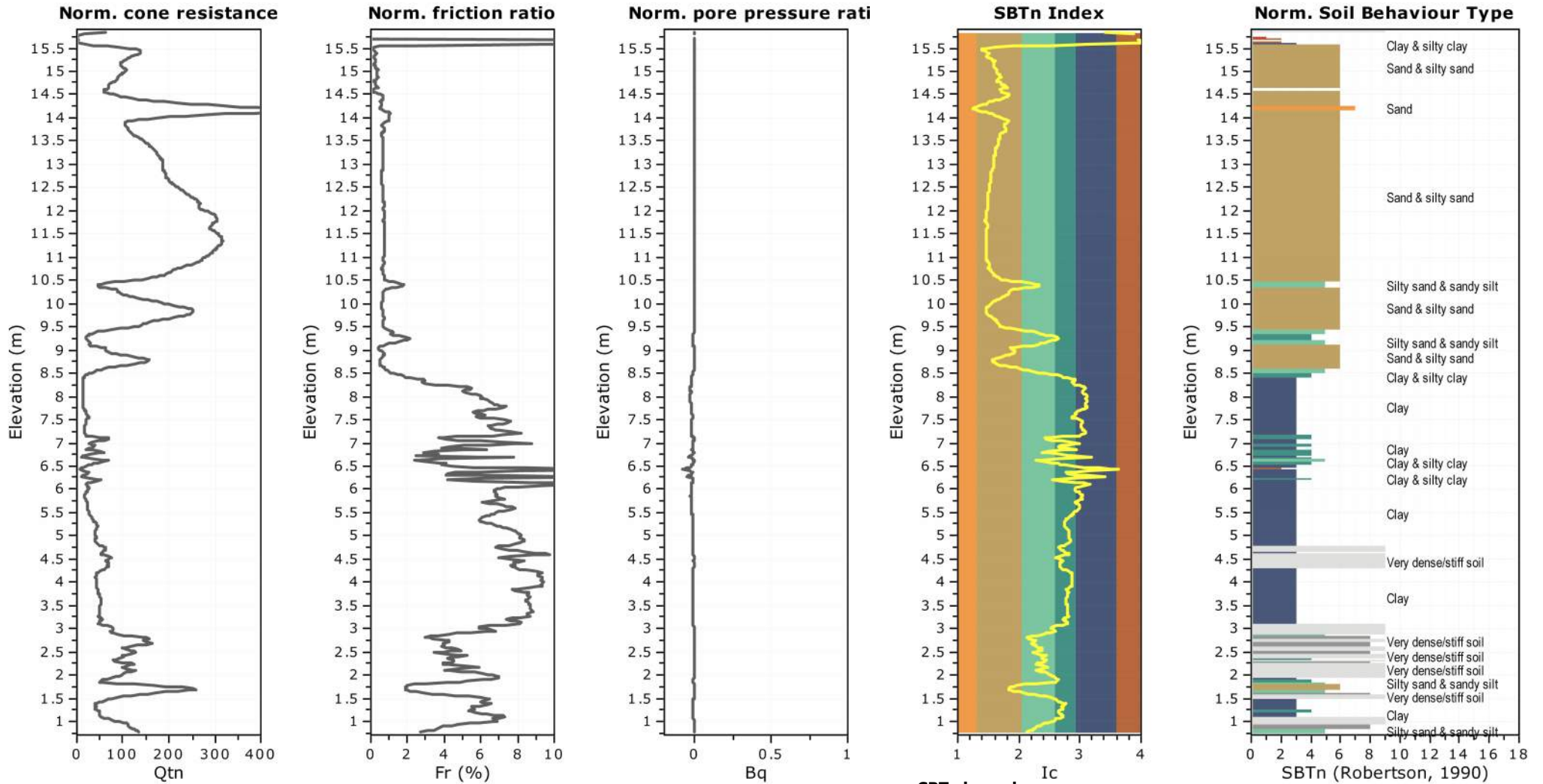
Bq plots (Schneider)



Project:
Location:



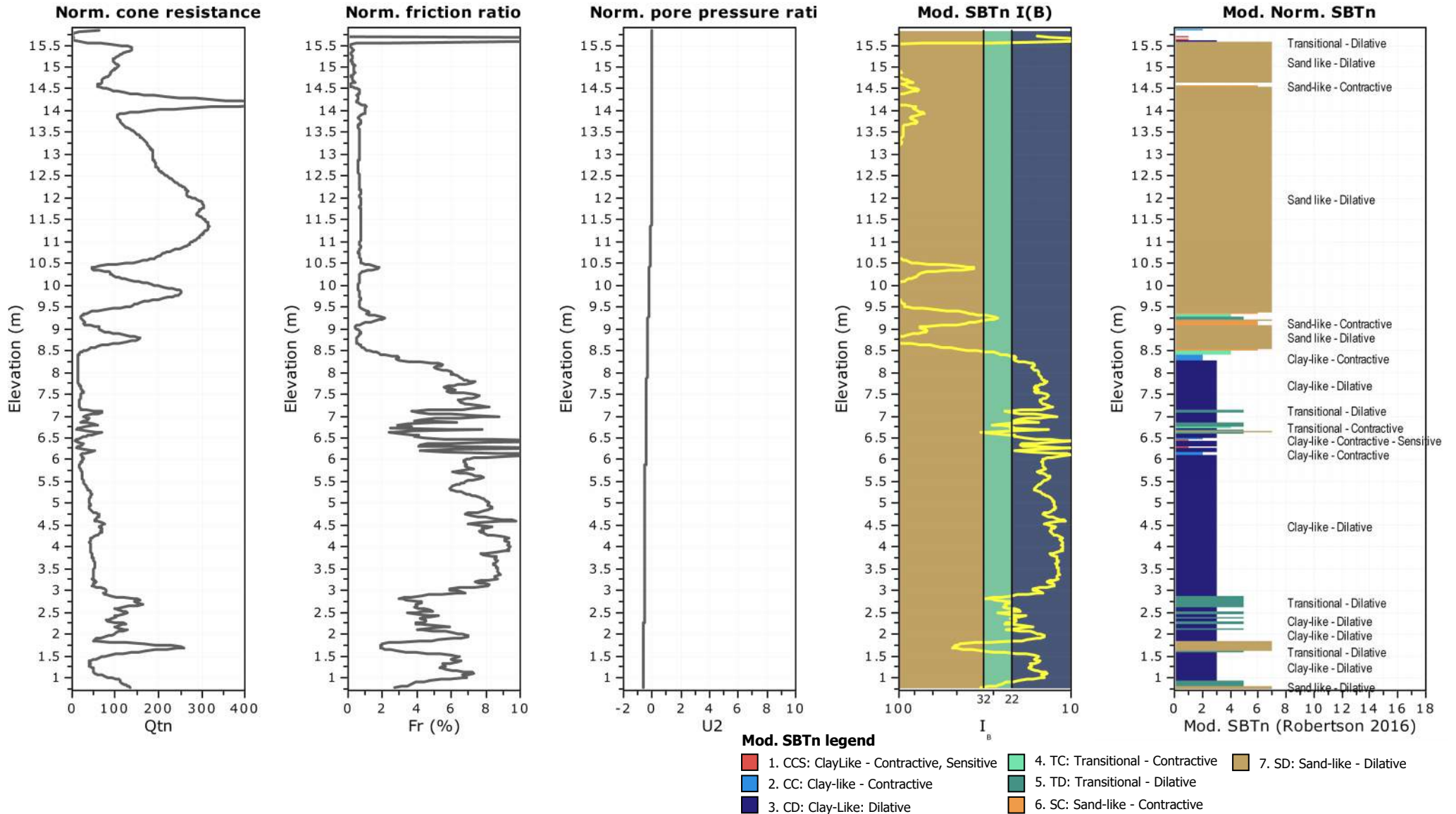
Project:
Location:



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 |

Project:
Location:

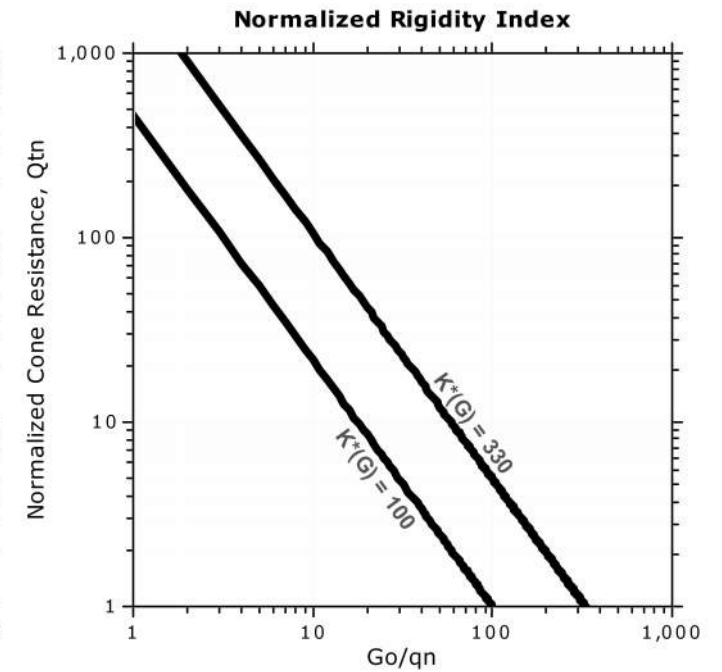
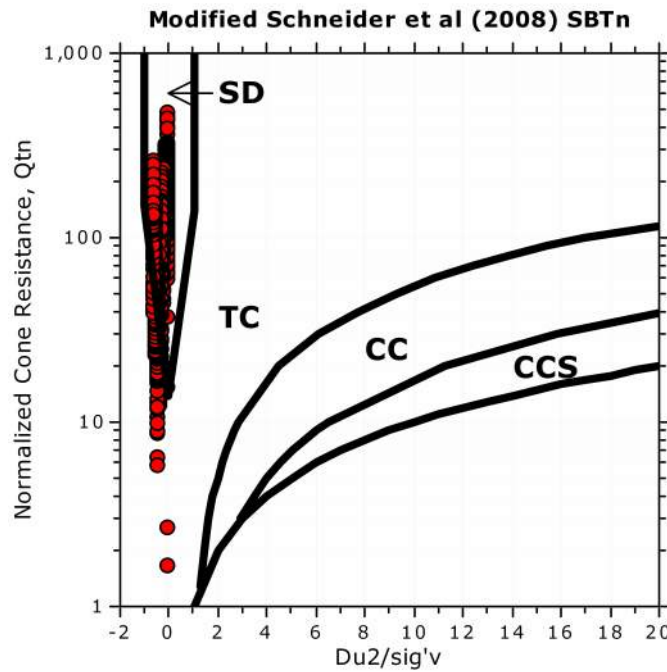
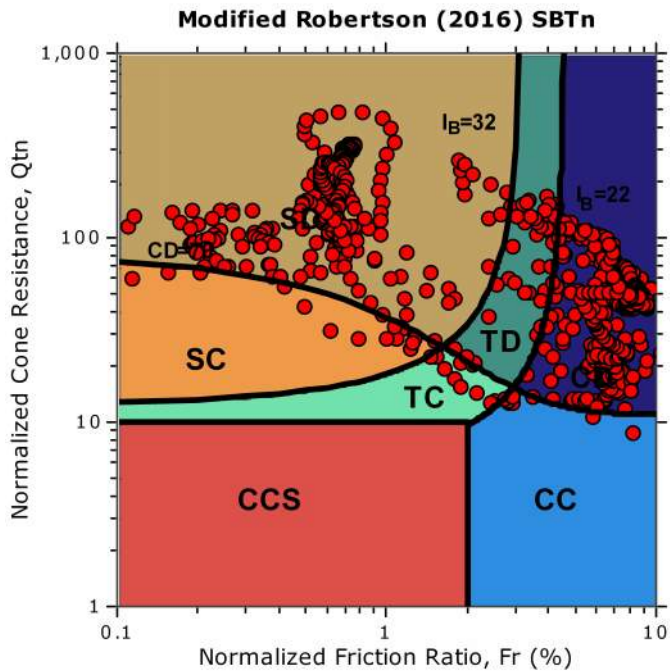




Project:

Location:

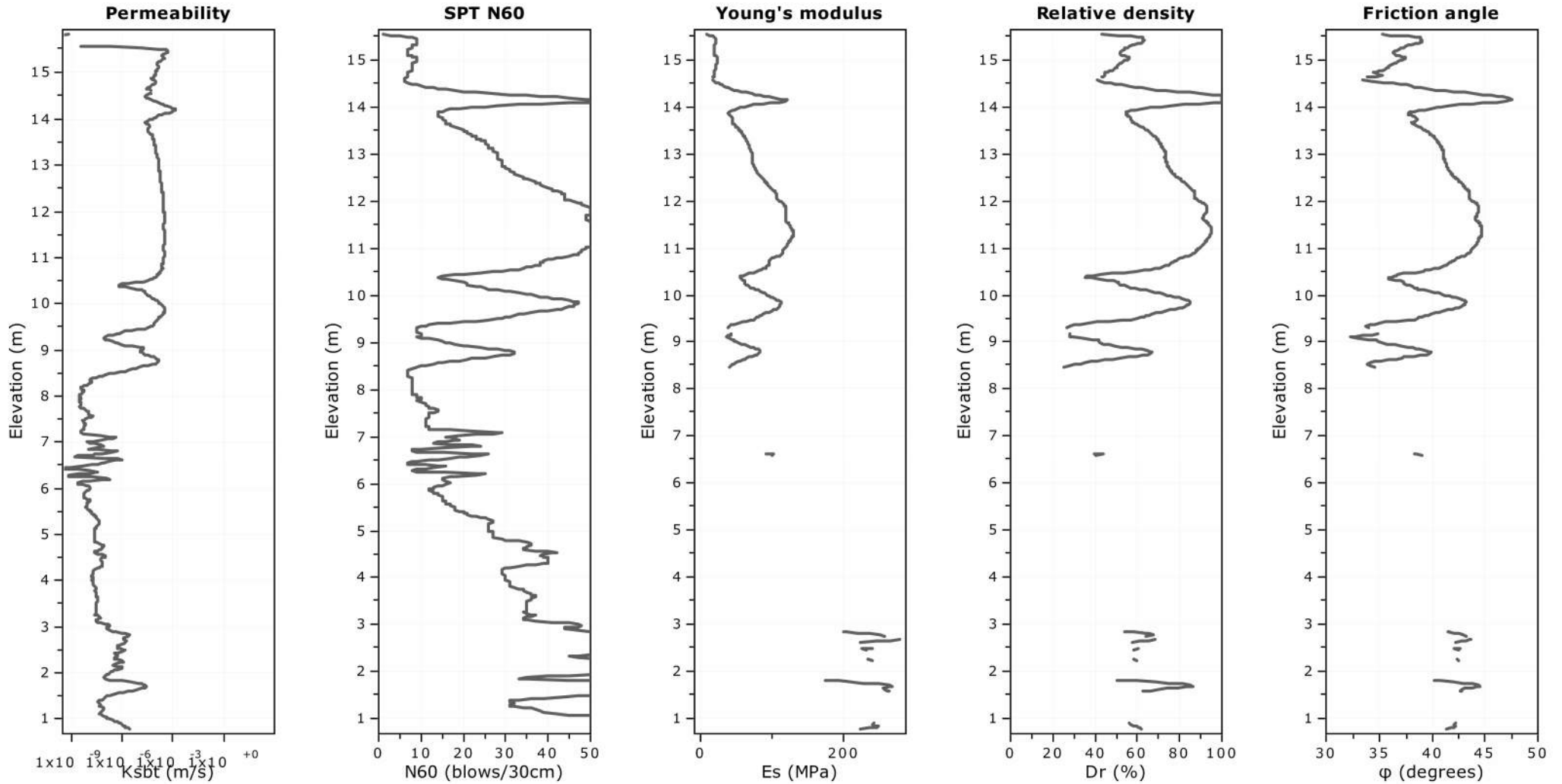
Updated SBTn plots



- 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)

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n

SPT N₆₀: Based on I_c and q_t

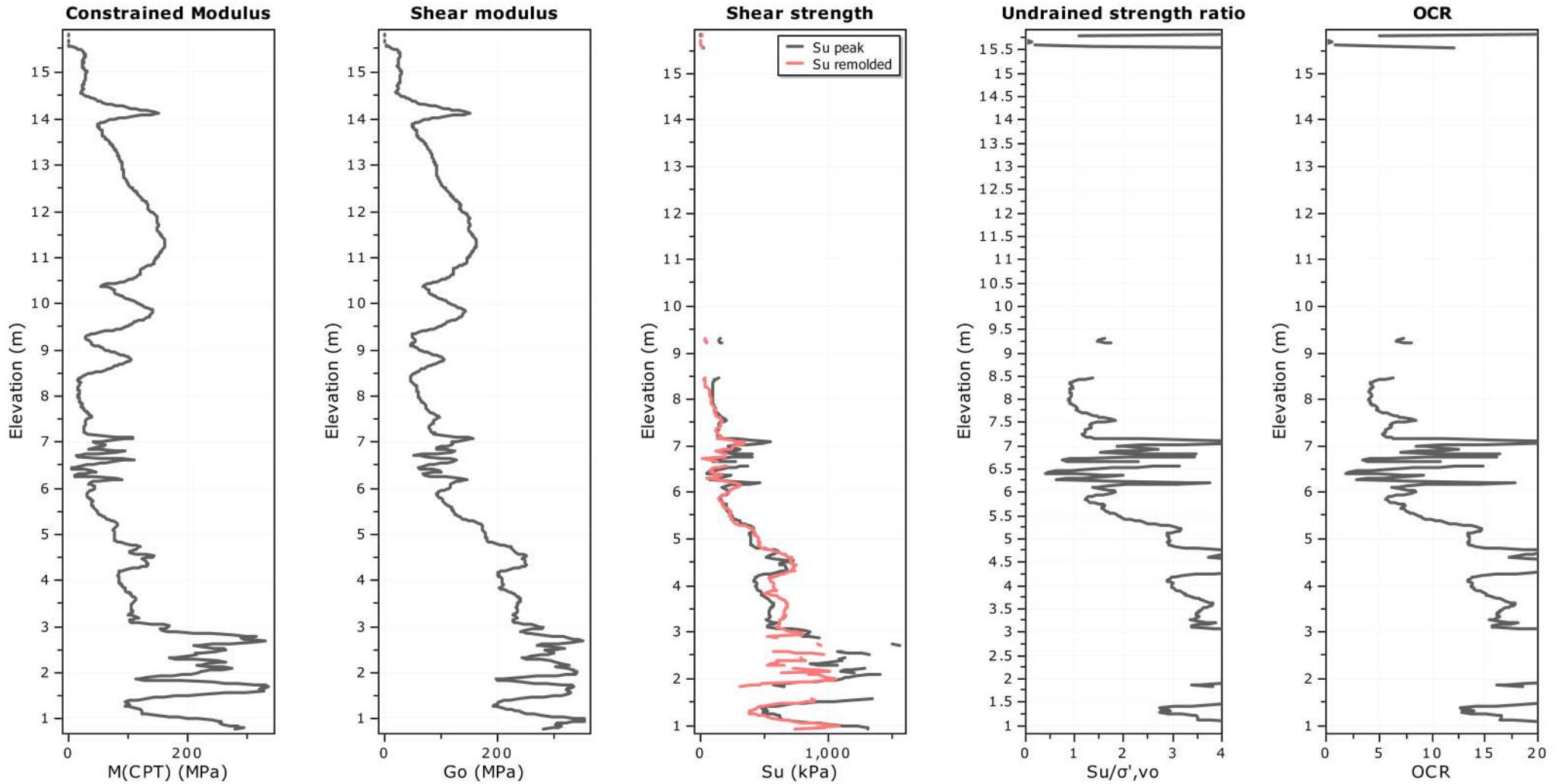
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

Relative density constant, C_{Dr}: 350.0

Phi: Based on Kulhawy & Mayne (1990)

● User defined estimation data

Project:
Location:

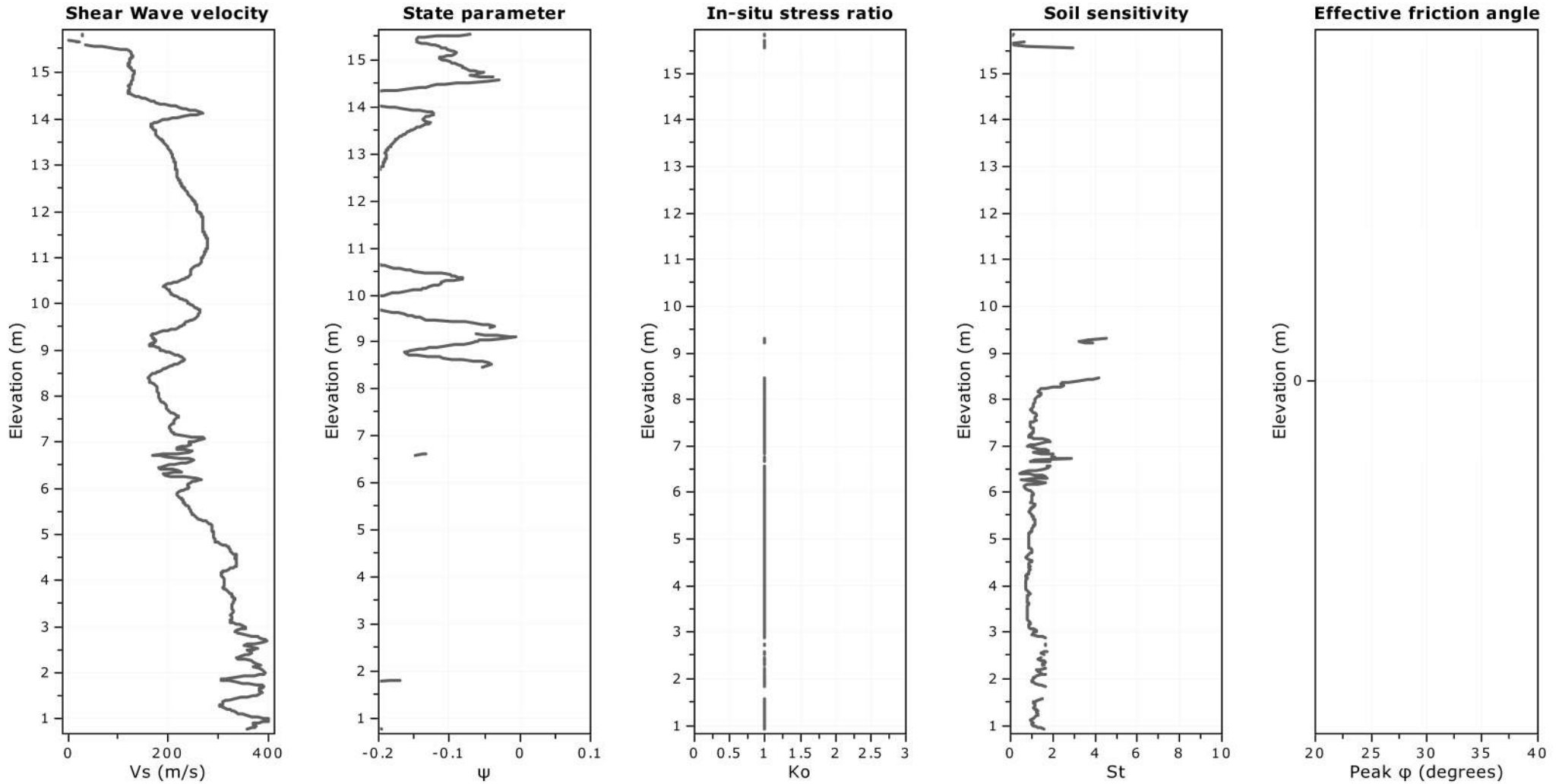


Calculation parameters

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

Project:
Location:



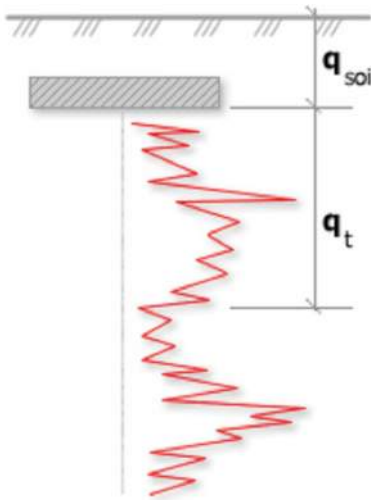
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

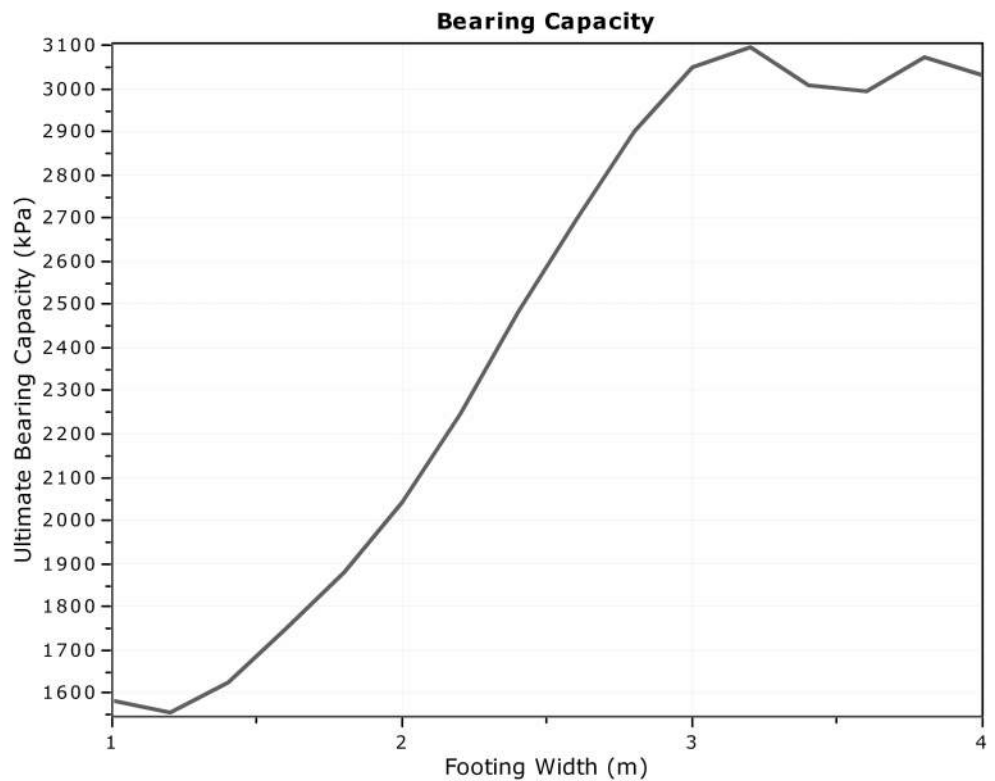
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

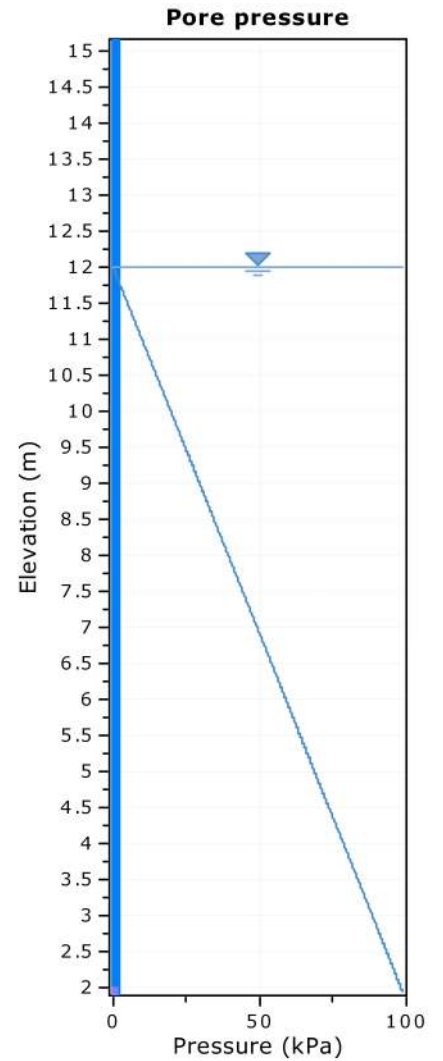
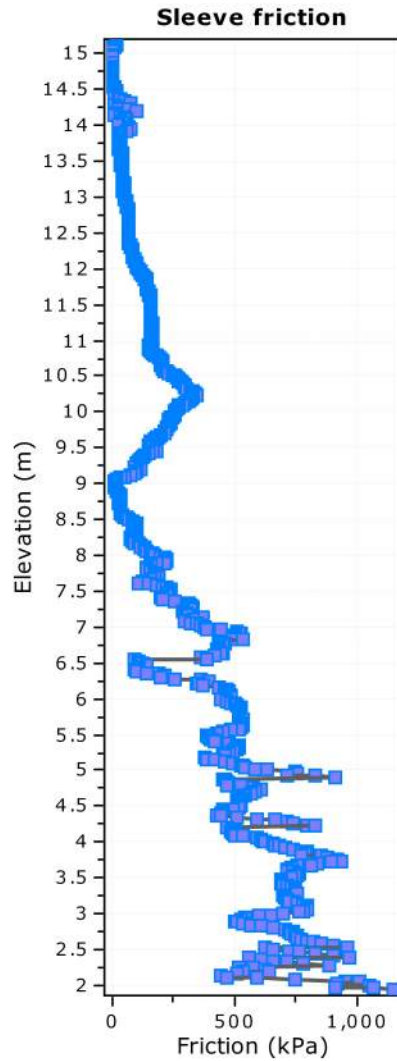
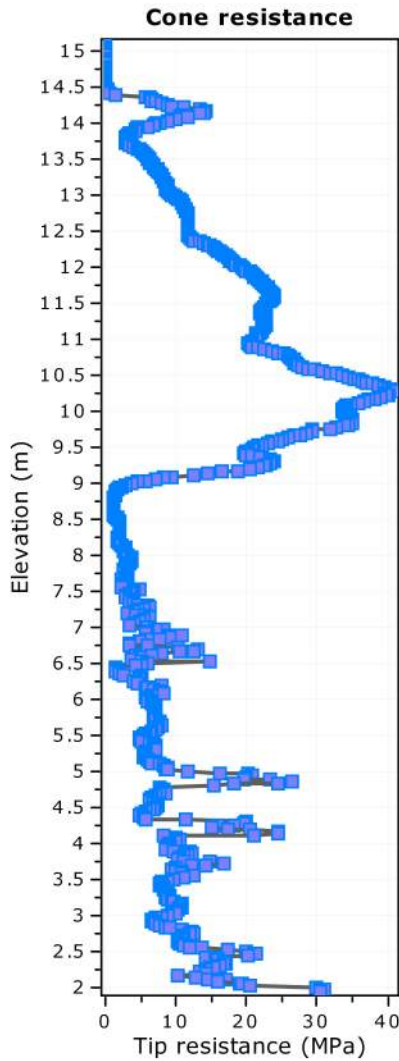


:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	7.86	0.20	9.50	1581.31
2	1.20	0.50	2.30	7.72	0.20	9.50	1553.74
3	1.40	0.50	2.60	8.07	0.20	9.50	1622.56
4	1.60	0.50	2.90	8.70	0.20	9.50	1750.21
5	1.80	0.50	3.20	9.34	0.20	9.50	1878.43
6	2.00	0.50	3.50	10.15	0.20	9.50	2040.44
7	2.20	0.50	3.80	11.19	0.20	9.50	2248.38
8	2.40	0.50	4.10	12.37	0.20	9.50	2483.53
9	2.60	0.50	4.40	13.43	0.20	9.50	2696.17
10	2.80	0.50	4.70	14.46	0.20	9.50	2902.30
11	3.00	0.50	5.00	15.20	0.20	9.50	3048.74
12	3.20	0.50	5.30	15.44	0.20	9.50	3097.25
13	3.40	0.50	5.60	14.99	0.20	9.50	3007.04
14	3.60	0.50	5.90	14.93	0.20	9.50	2994.64
15	3.80	0.50	6.20	15.33	0.20	9.50	3074.79
16	4.00	0.50	6.50	15.10	0.20	9.50	3029.88

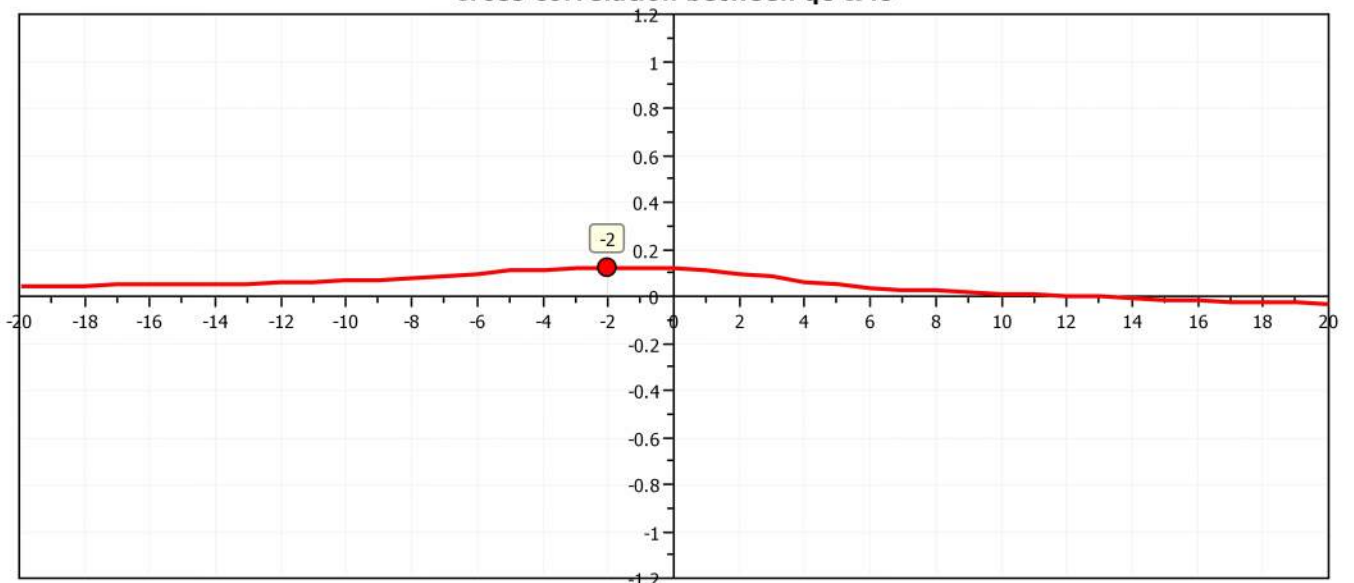
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

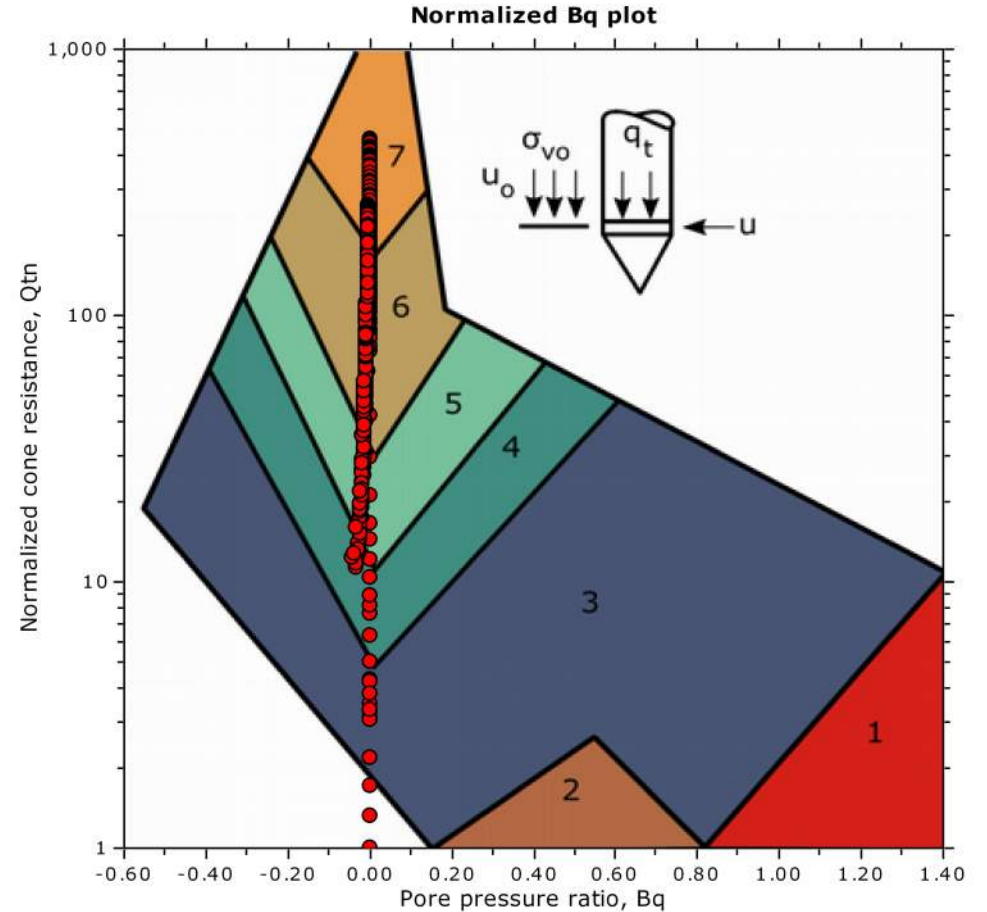
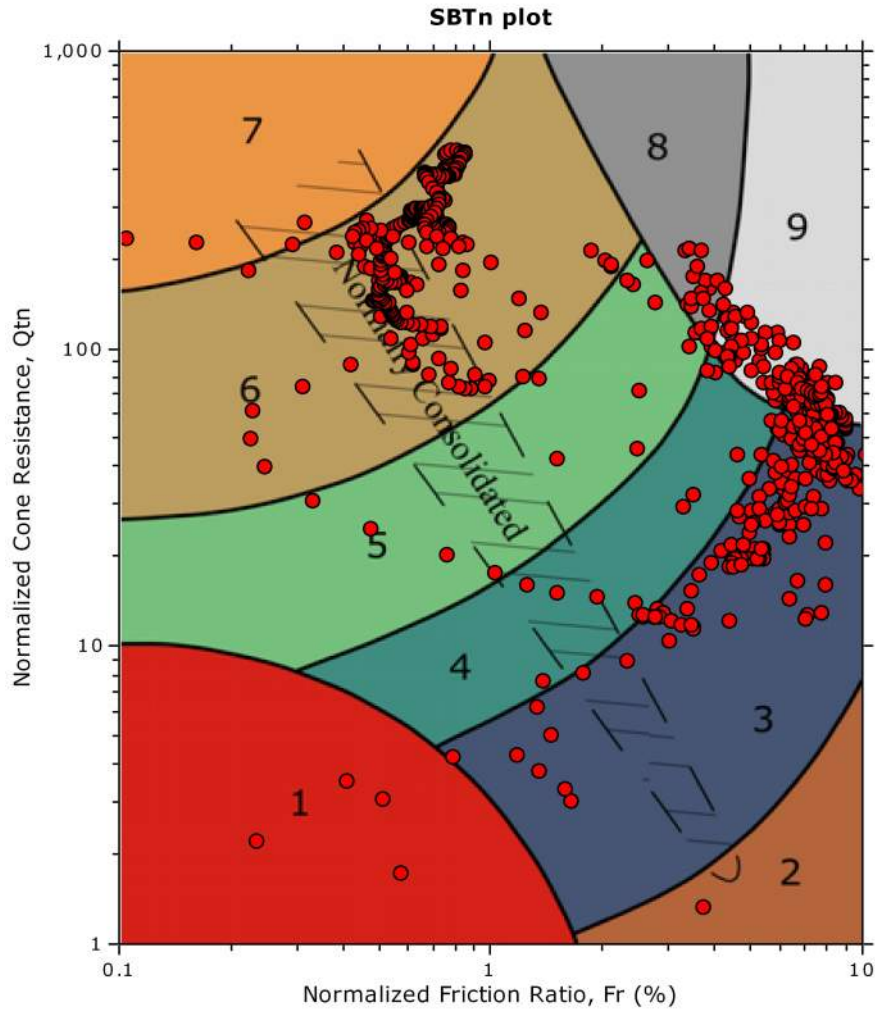




Project:

Location:

SBT - Bq plots (normalized)



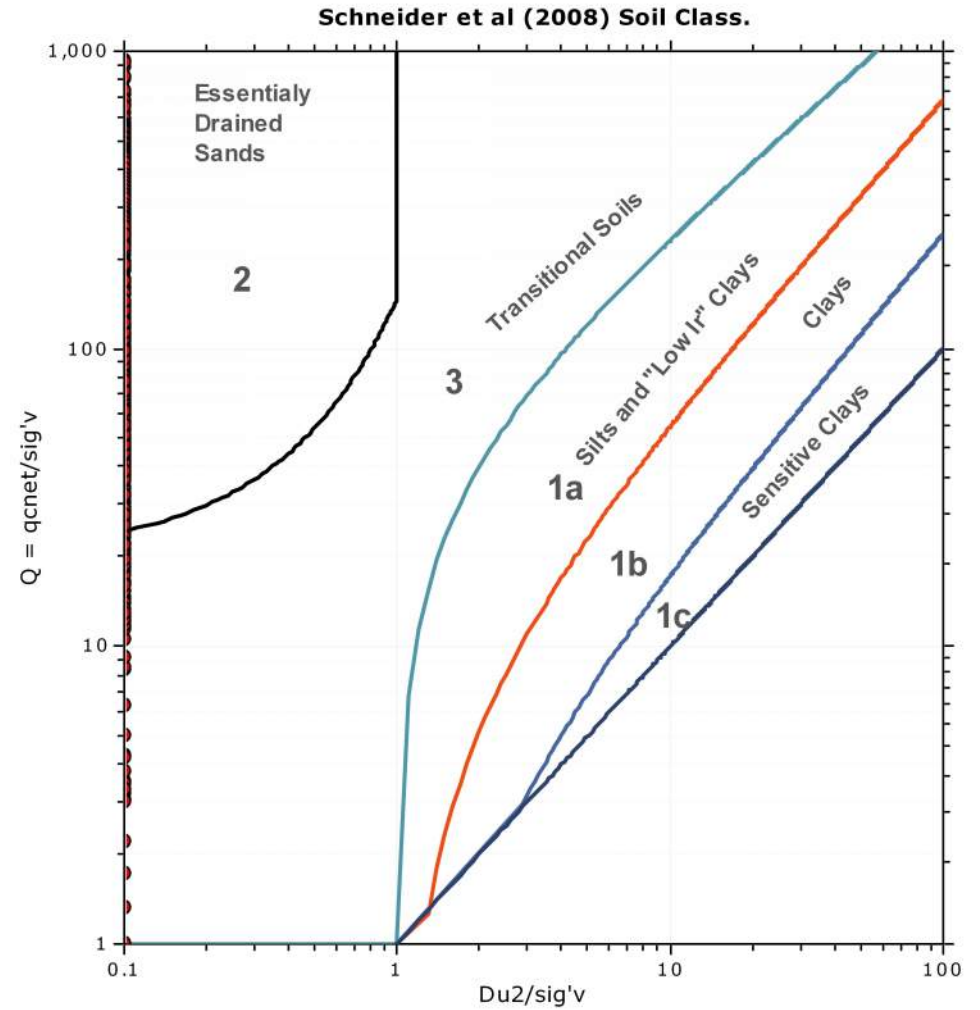
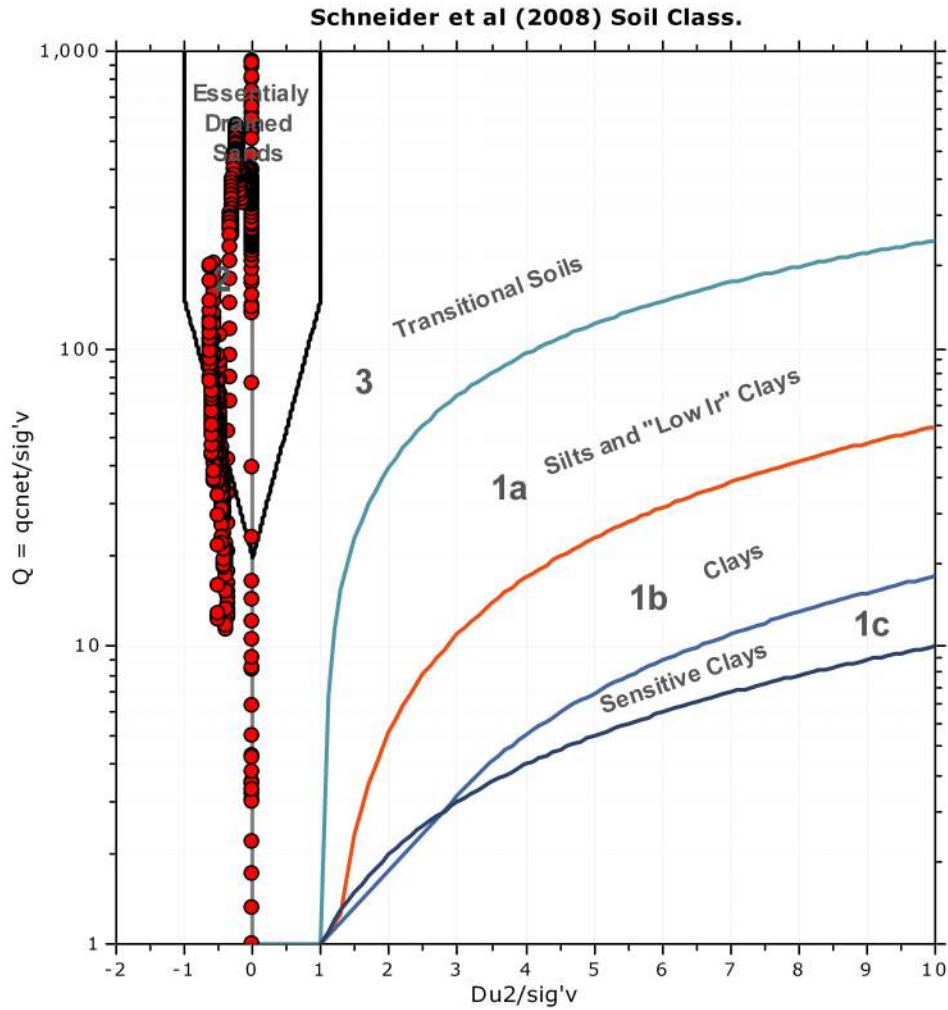
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

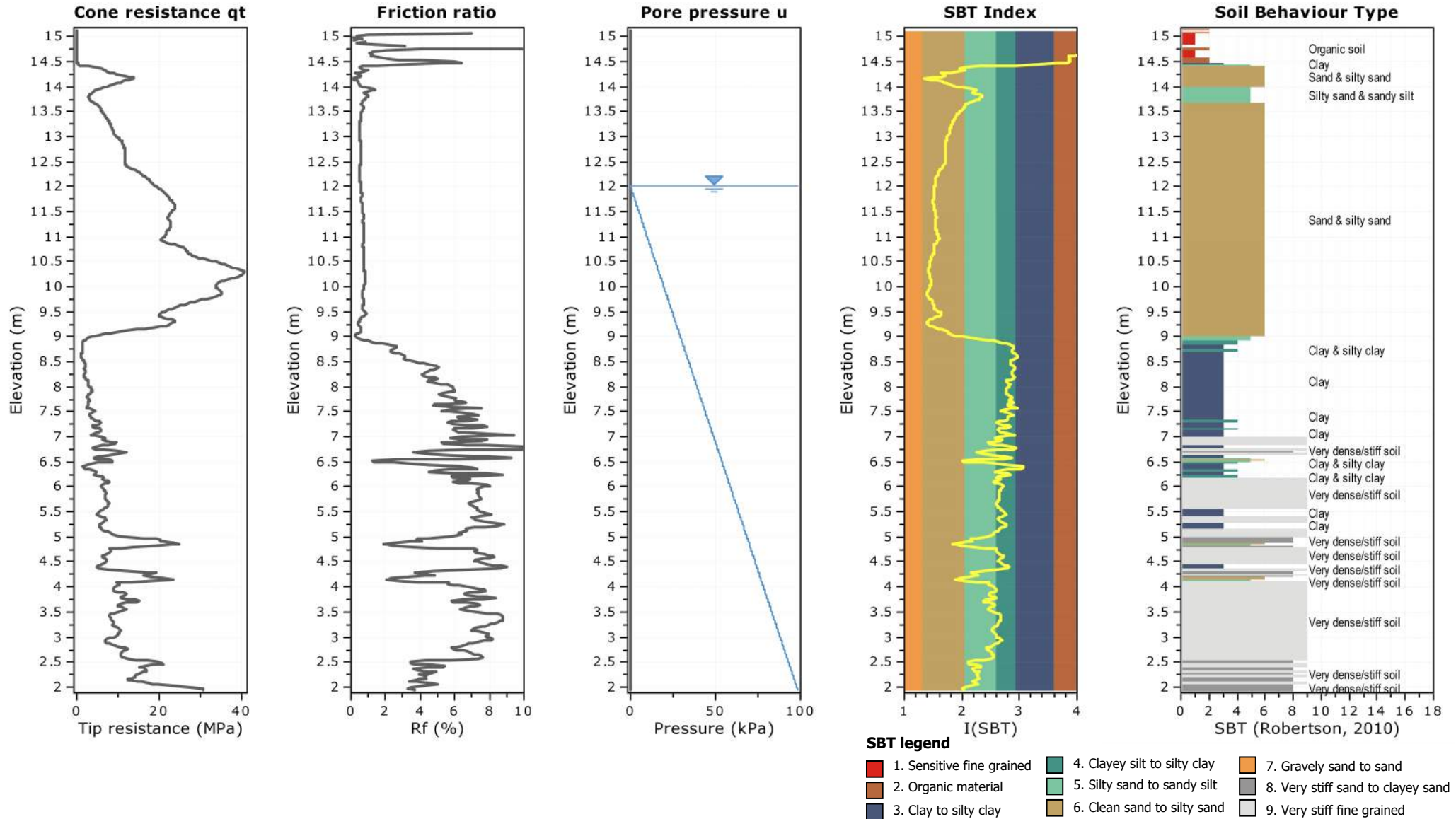
Project:

Location:

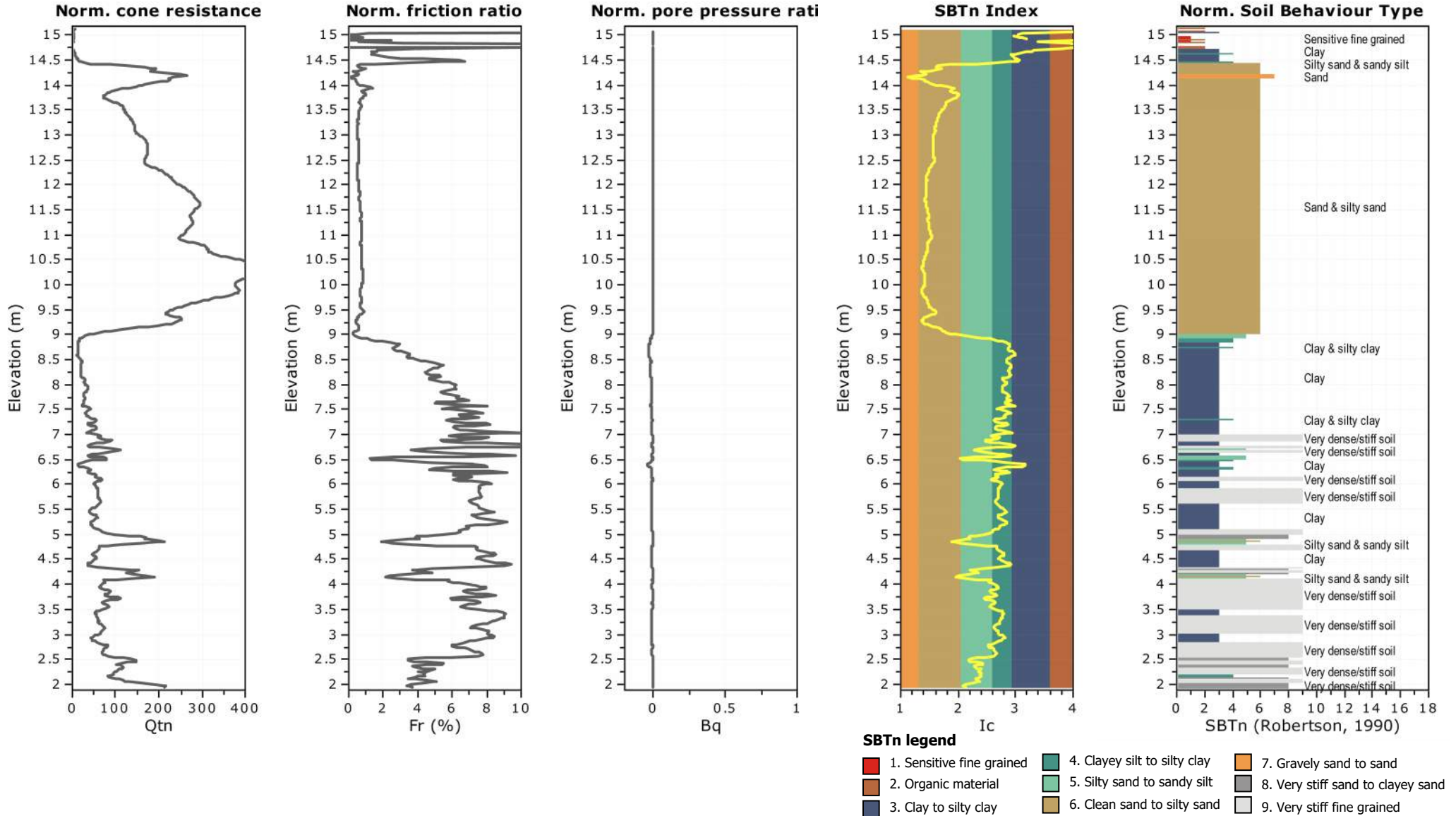
Bq plots (Schneider)



Project:
Location:

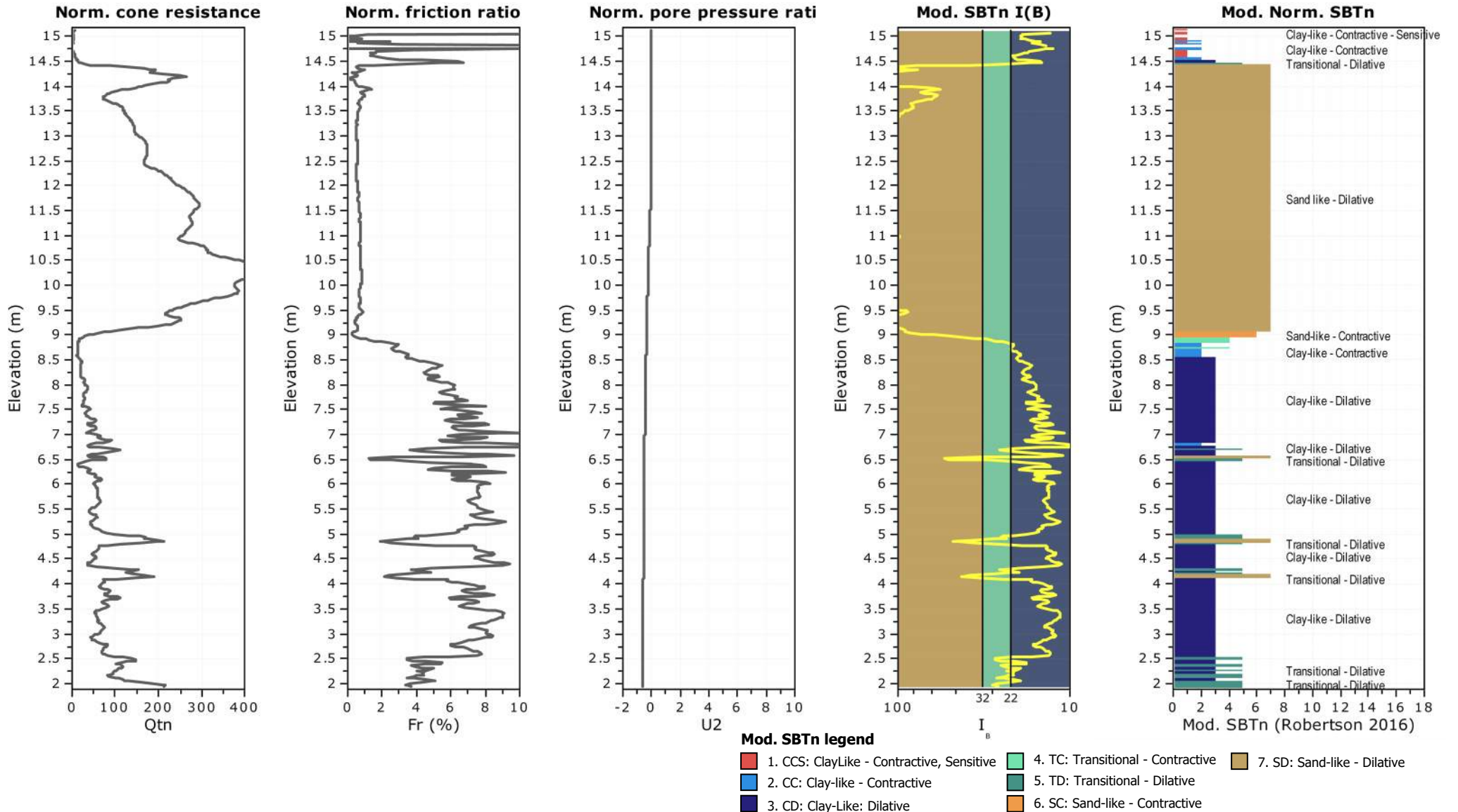


Project:
Location:



Project:

Location:

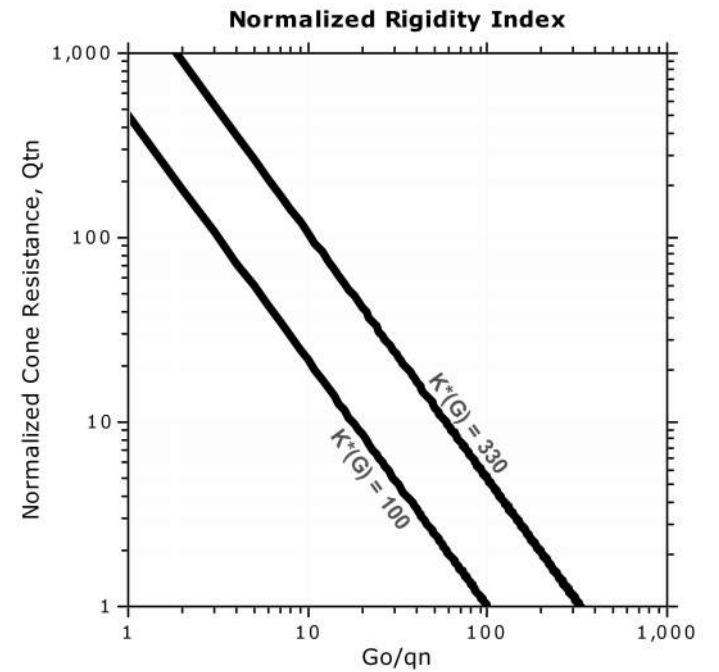
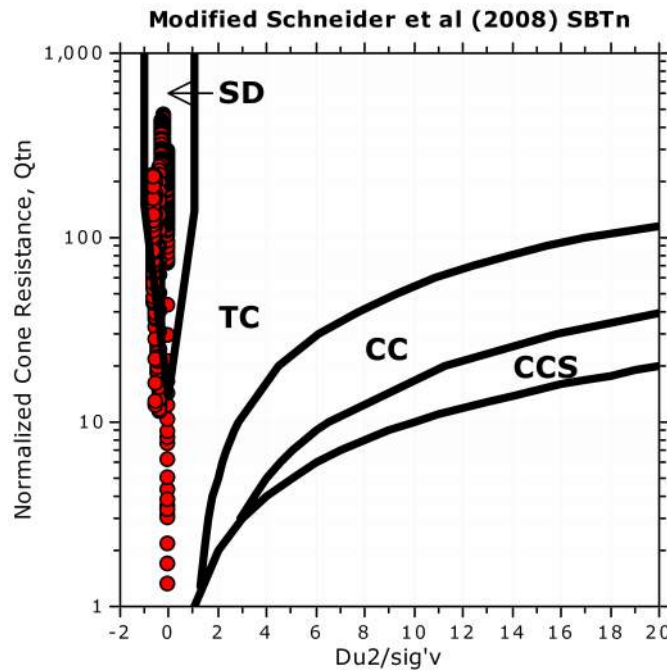
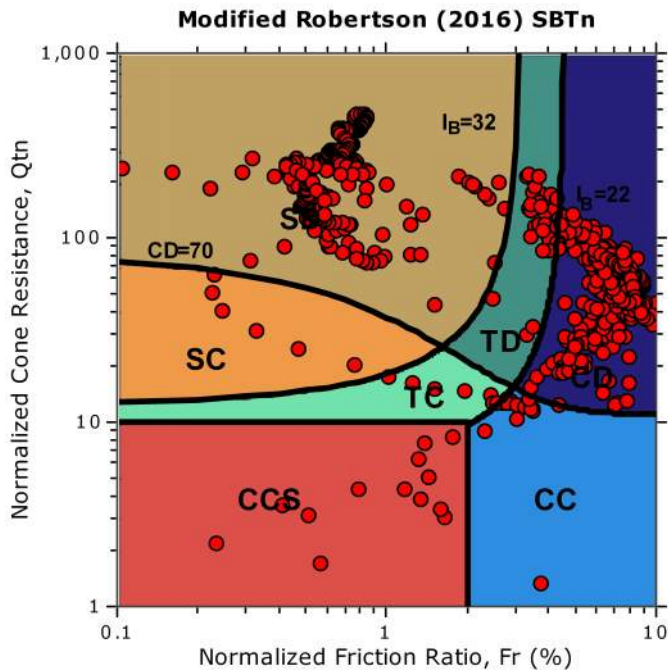




Project:

Location:

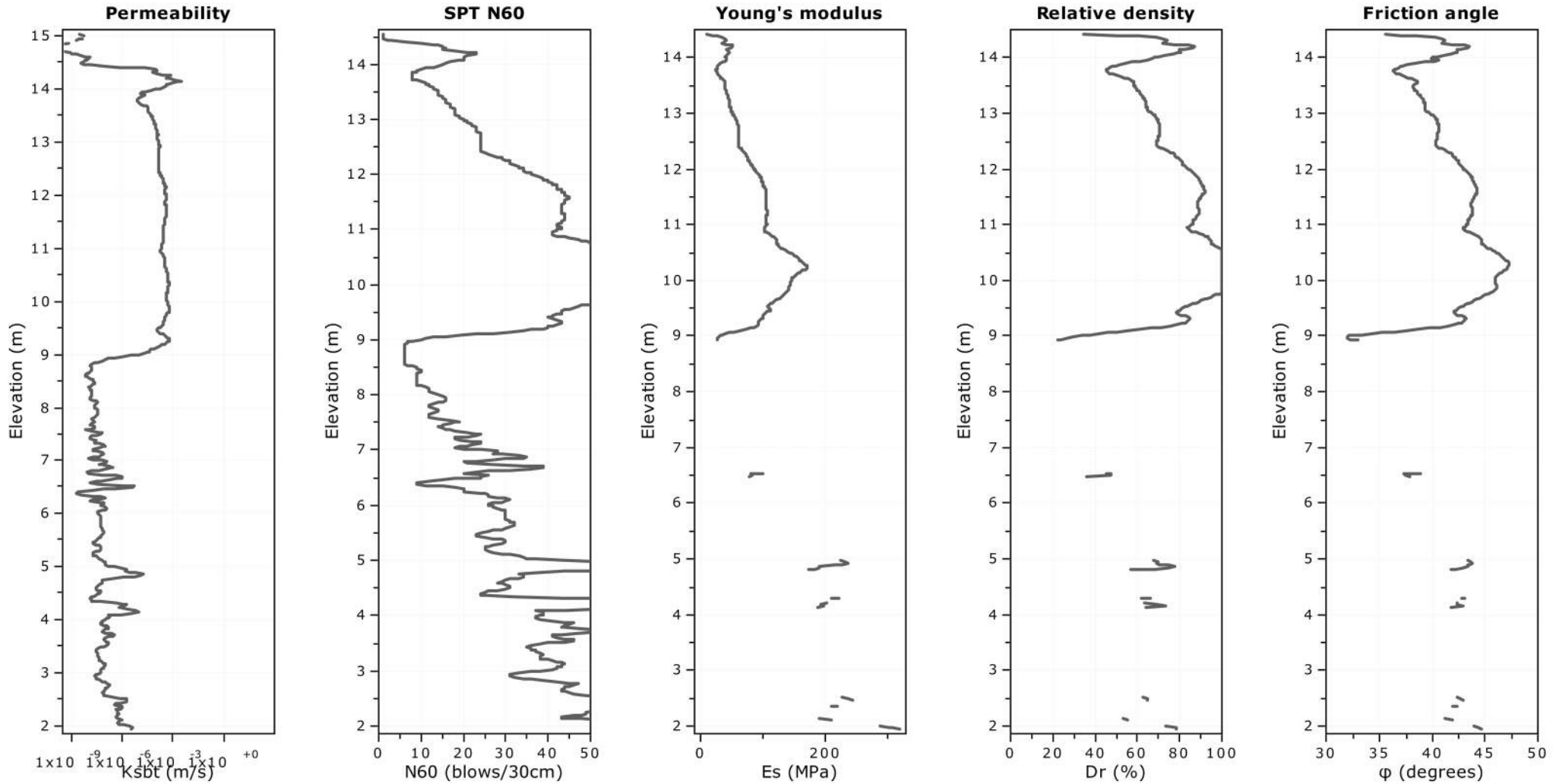
Updated SBTn plots



- 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)

Project:
Location:



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)

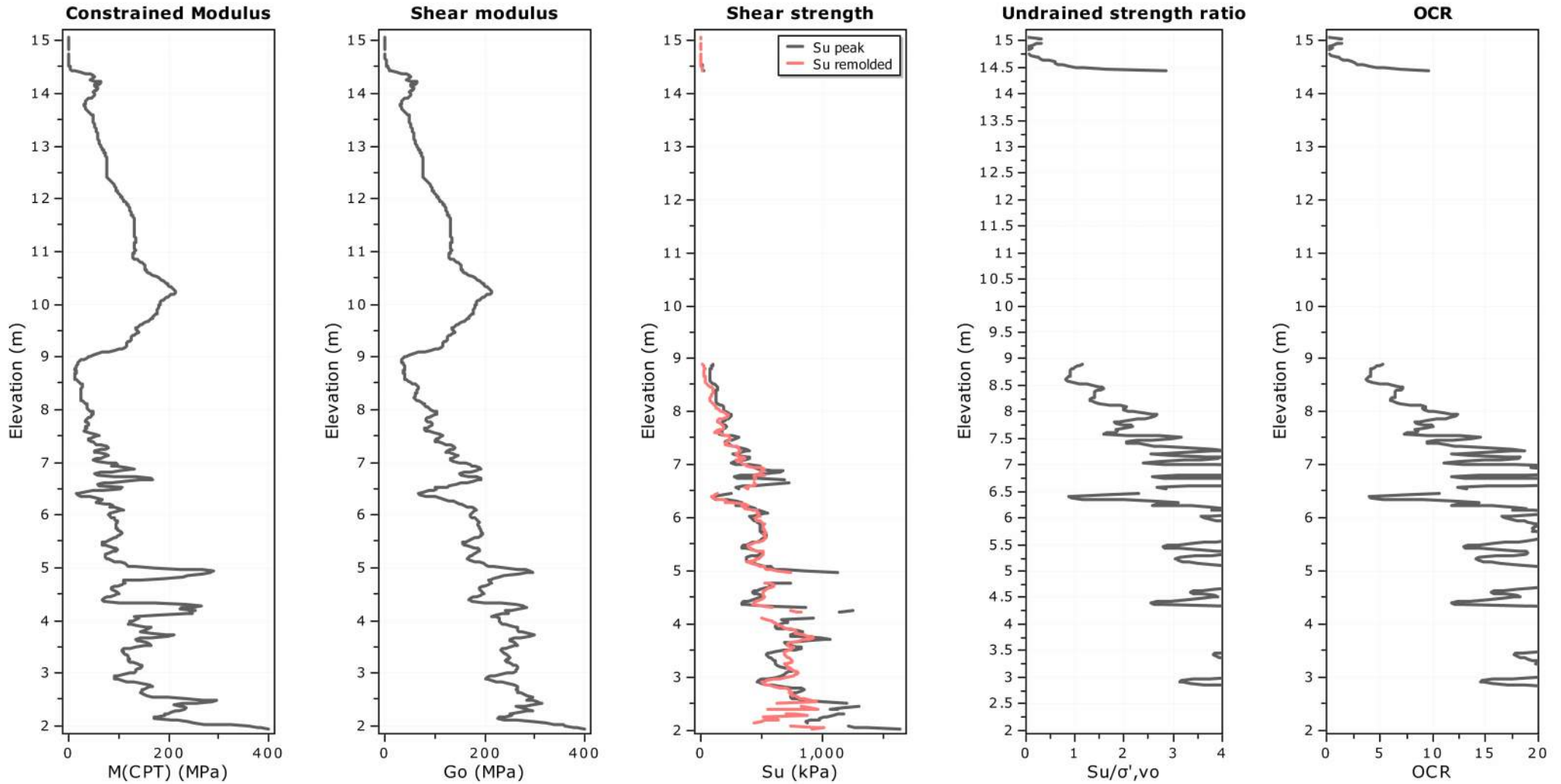
Relative density constant, C_{Dr} : 350.0

Phi: Based on Kulhawy & Mayne (1990)

● — User defined estimation data

Project:

Location:



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)

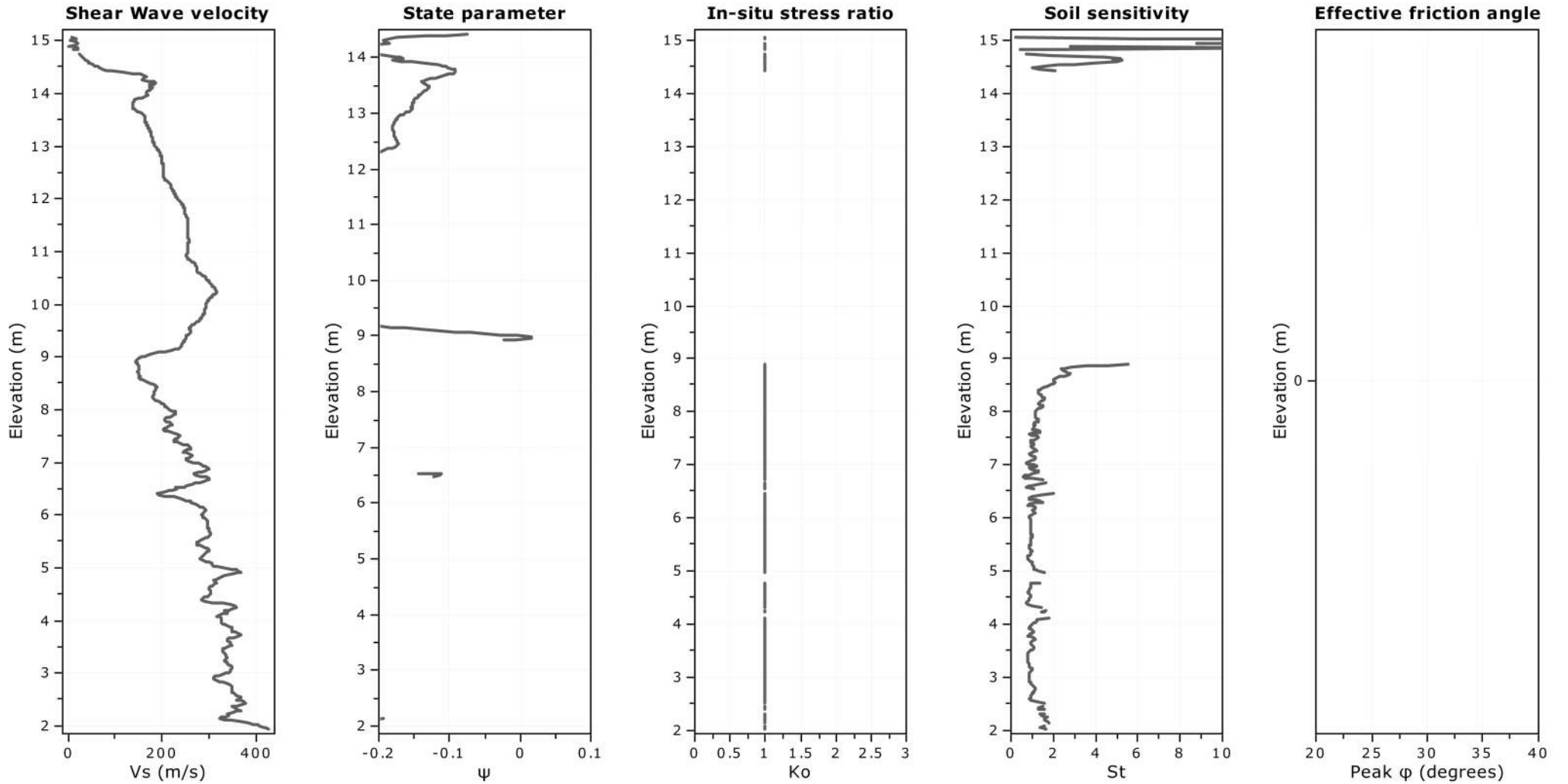
Undrained shear strength cone factor for clays, N_{kt} : 14

OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:
Location:



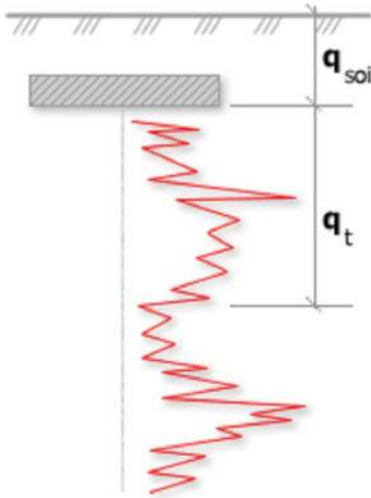
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

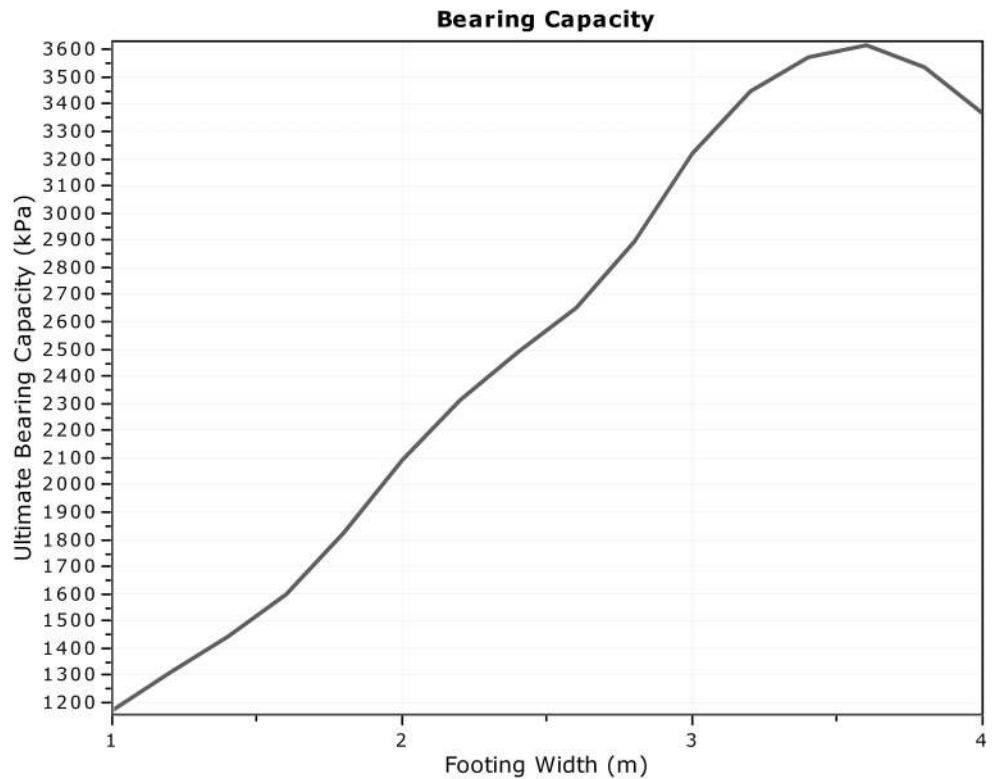
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing

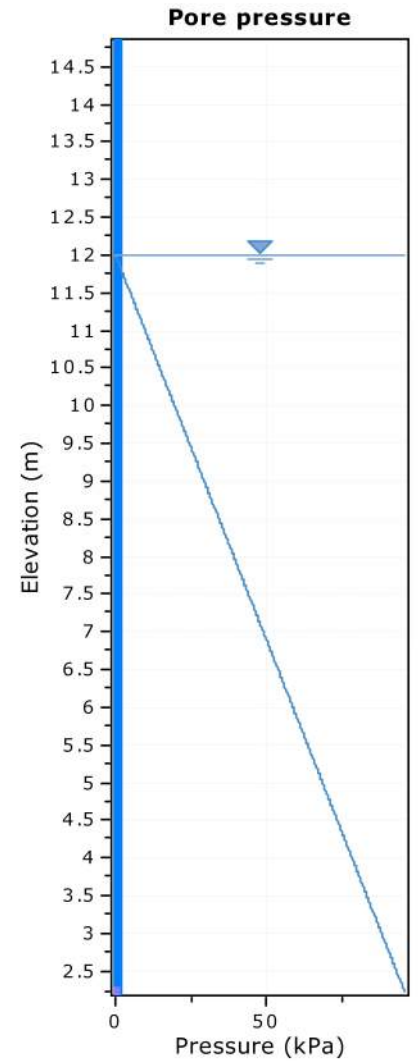
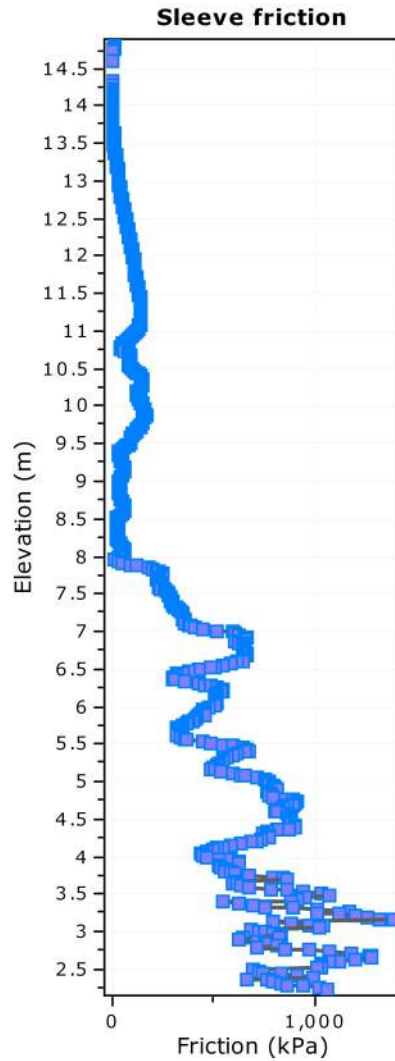
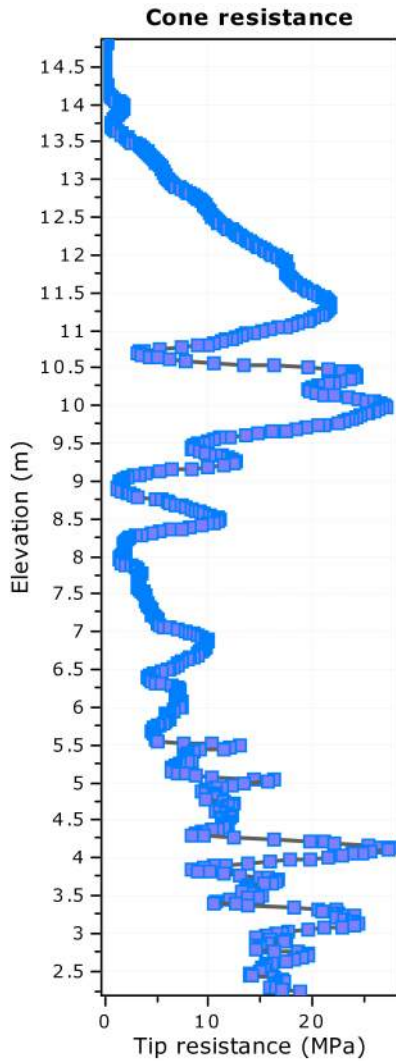


:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	5.81	0.20	9.50	1170.56
2	1.20	0.50	2.30	6.49	0.20	9.50	1307.06
3	1.40	0.50	2.60	7.17	0.20	9.50	1443.95
4	1.60	0.50	2.90	7.96	0.20	9.50	1600.96
5	1.80	0.50	3.20	9.08	0.20	9.50	1826.37
6	2.00	0.50	3.50	10.39	0.20	9.50	2088.44
7	2.20	0.50	3.80	11.52	0.20	9.50	2313.67
8	2.40	0.50	4.10	12.41	0.20	9.50	2492.26
9	2.60	0.50	4.40	13.21	0.20	9.50	2650.89
10	2.80	0.50	4.70	14.43	0.20	9.50	2894.65
11	3.00	0.50	5.00	16.04	0.20	9.50	3217.76
12	3.20	0.50	5.30	17.19	0.20	9.50	3447.25
13	3.40	0.50	5.60	17.82	0.20	9.50	3573.36
14	3.60	0.50	5.90	18.03	0.20	9.50	3616.21
15	3.80	0.50	6.20	17.61	0.20	9.50	3532.02
16	4.00	0.50	6.50	16.80	0.20	9.50	3369.40

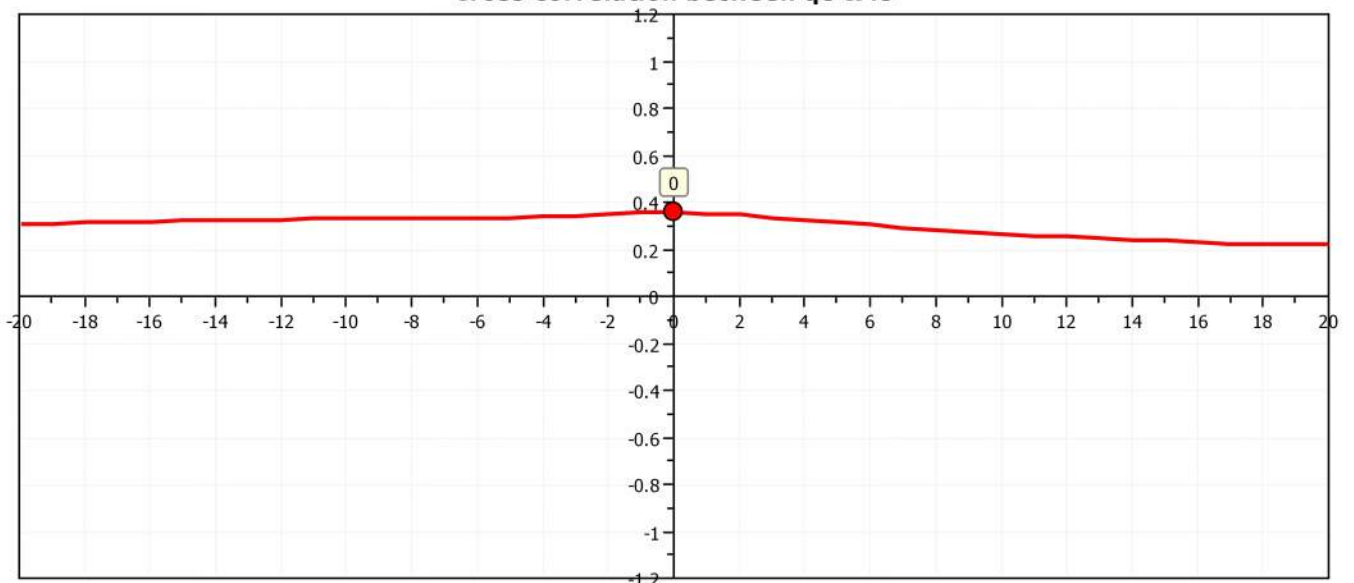
Project:

Location:



The plot below presents the cross correlation coefficient between the raw q_c and f_s values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

Cross correlation between q_c & f_s

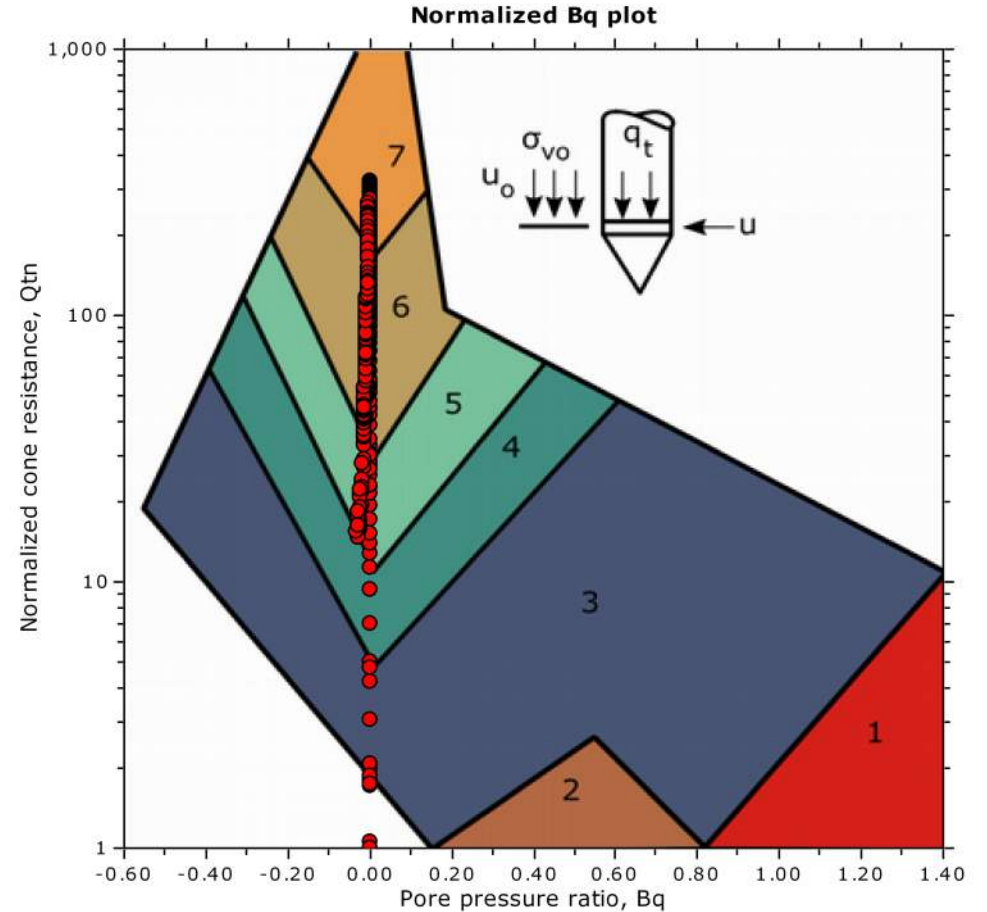
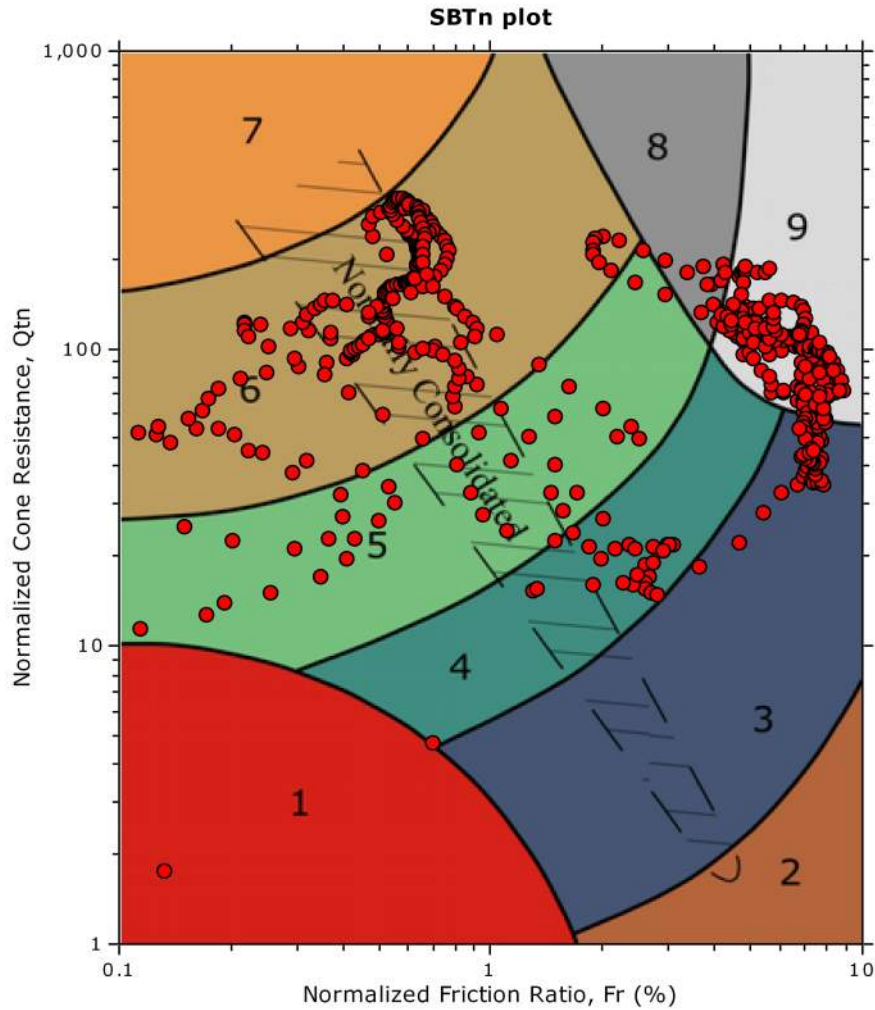




Project:

Location:

SBT - Bq plots (normalized)



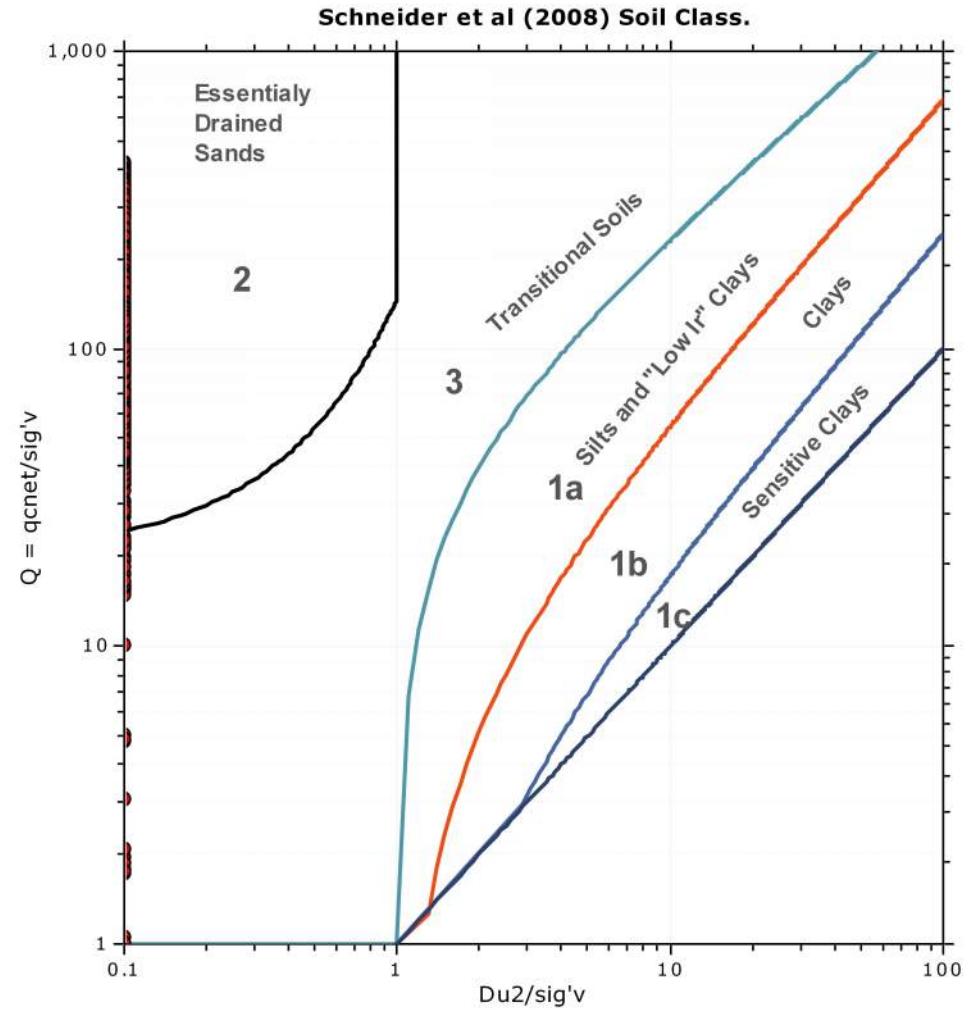
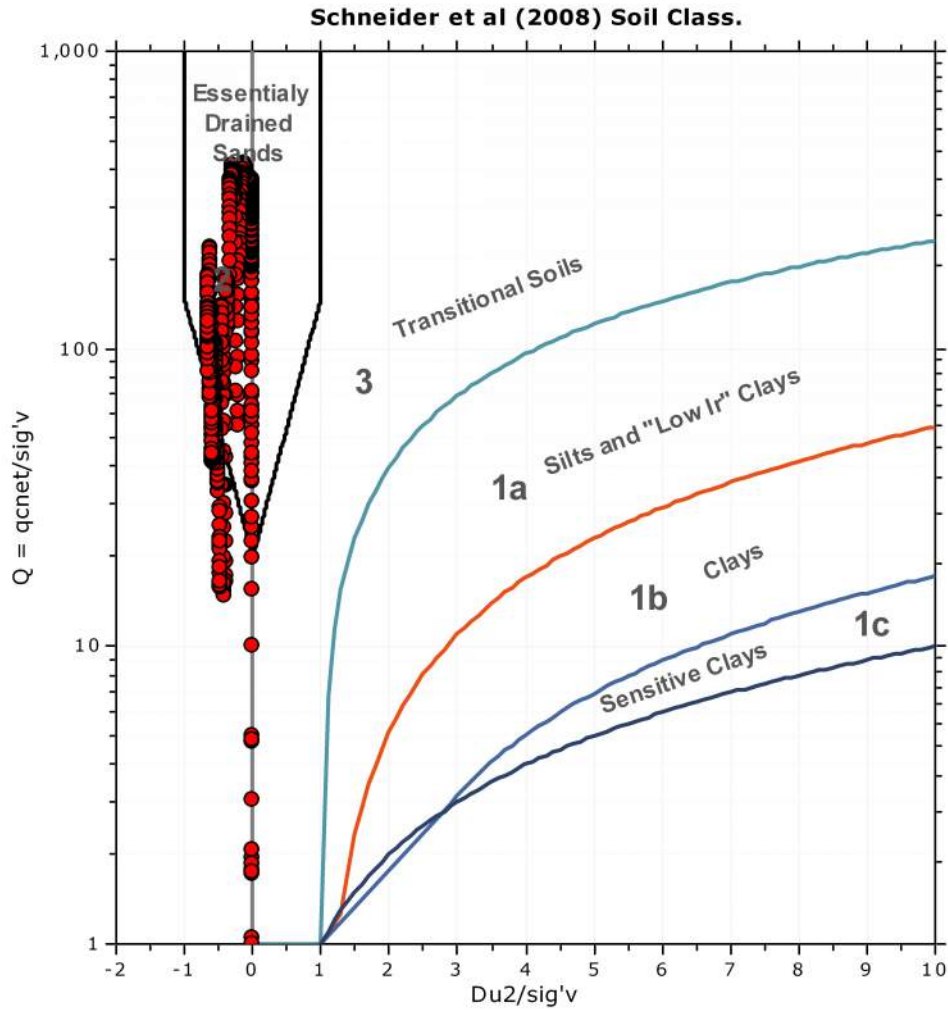
SBTn legend

- | | | |
|--|---|---|
| ■ 1. Sensitive fine grained | ■ 4. Clayey silt to silty clay | ■ 7. Gravelly 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 |

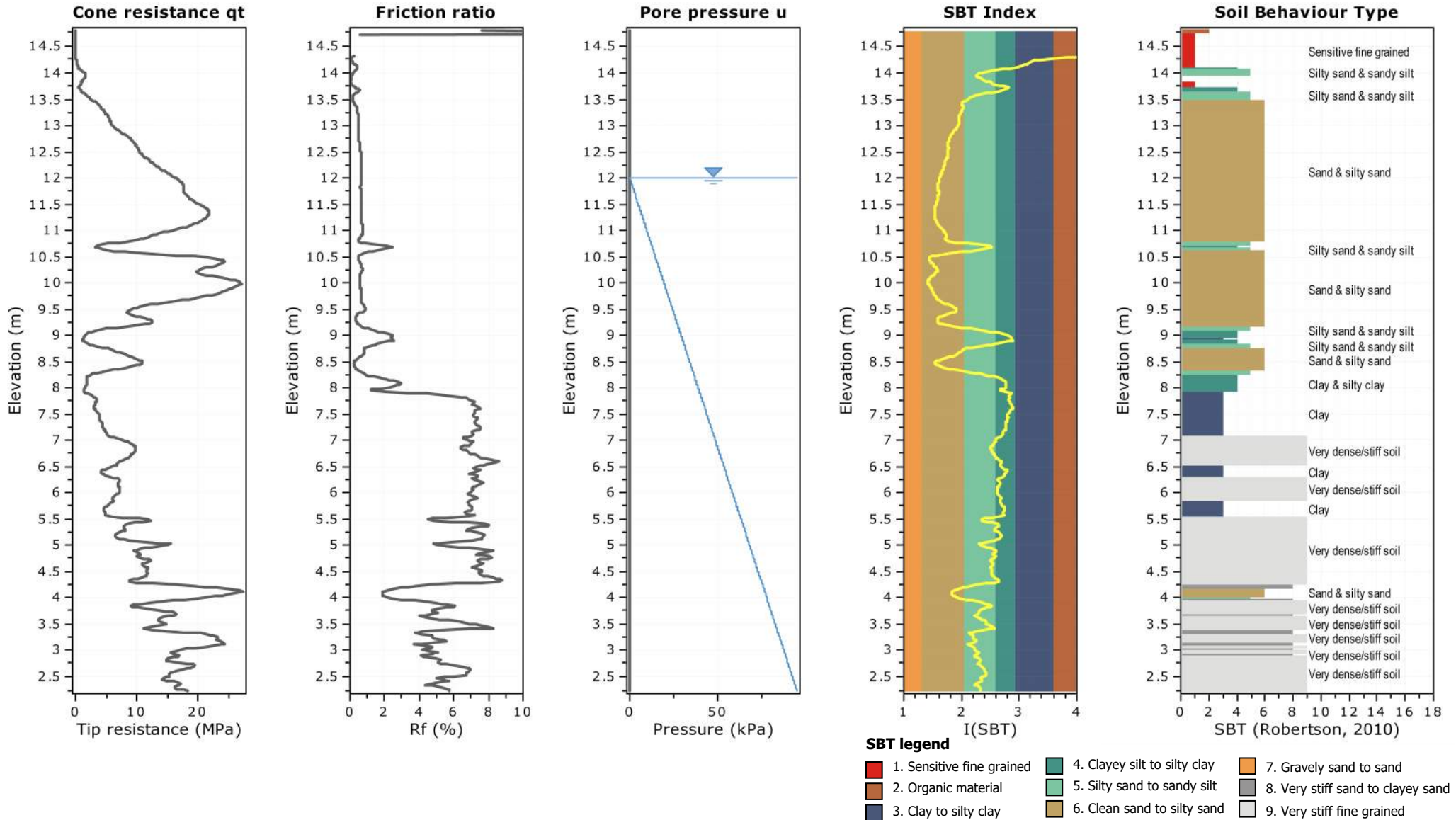
Project:

Location:

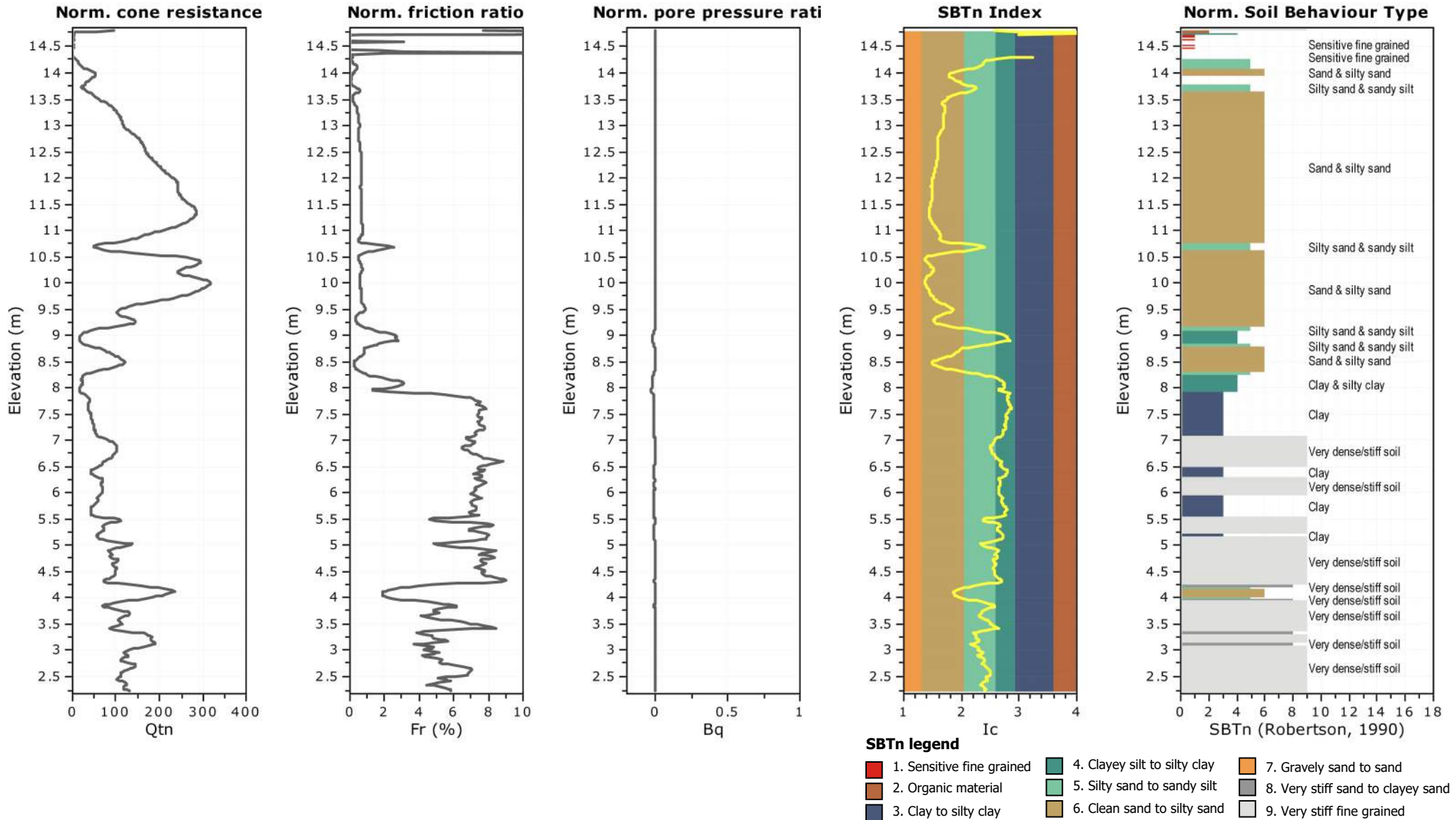
Bq plots (Schneider)



Project:
Location:

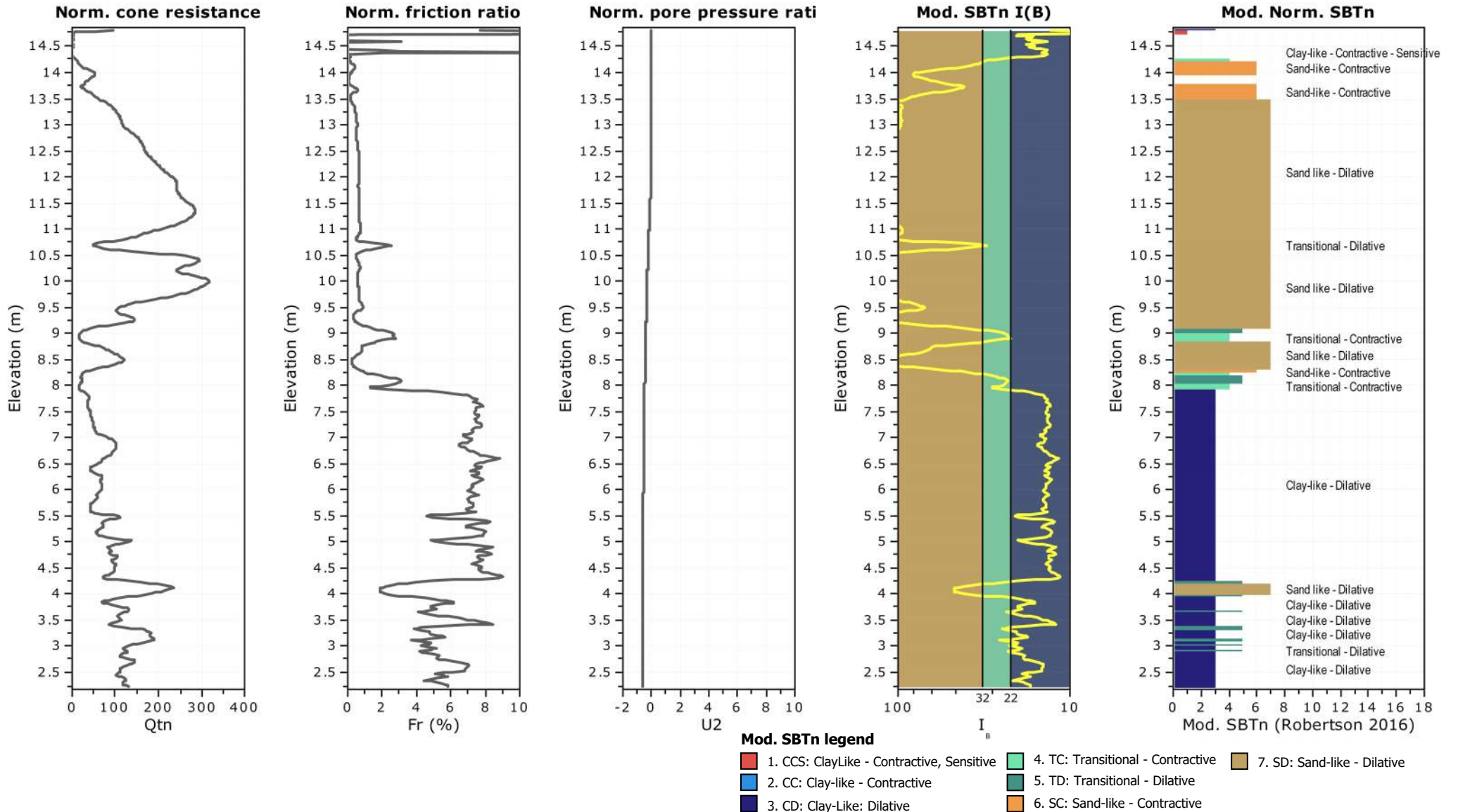


Project:
Location:



Project:

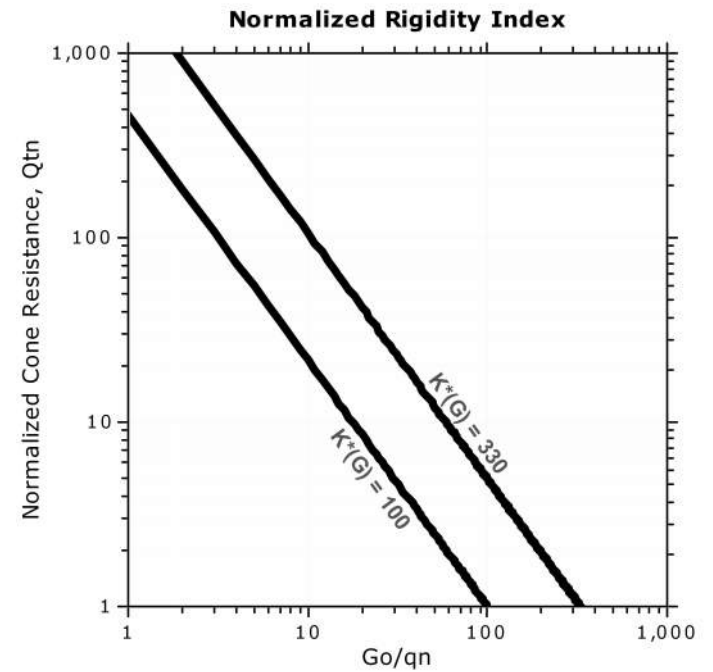
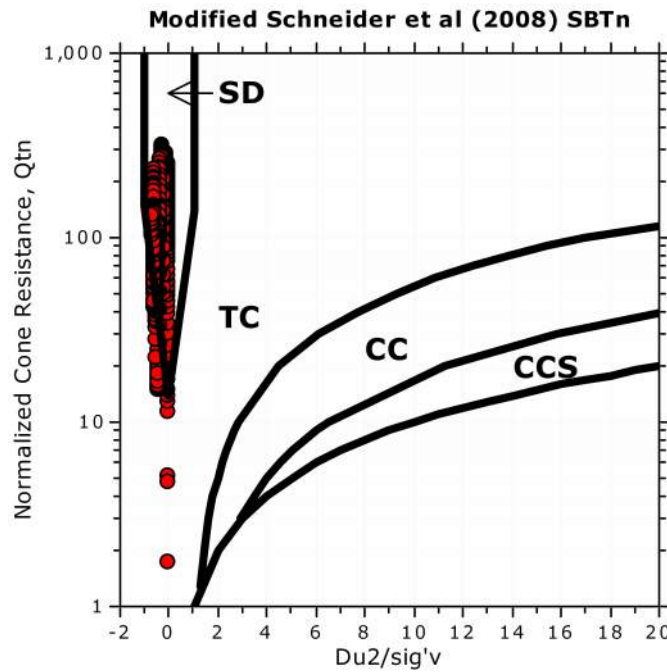
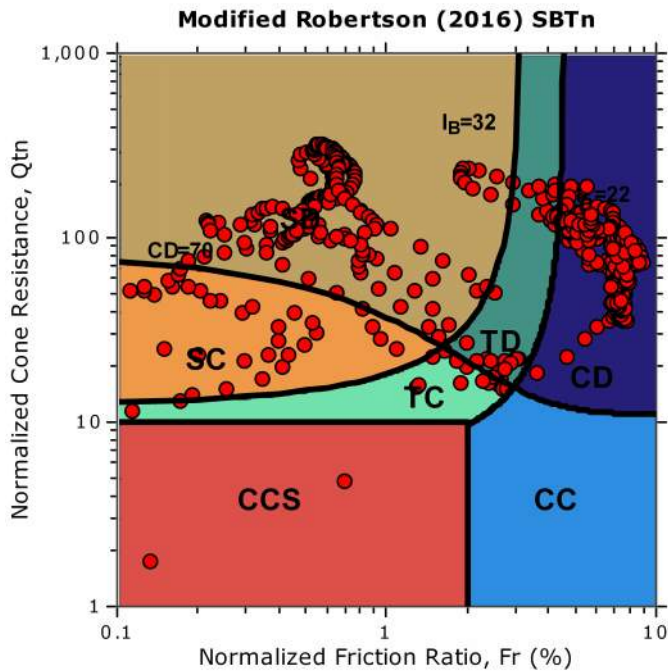
Location:



Project:

Location:

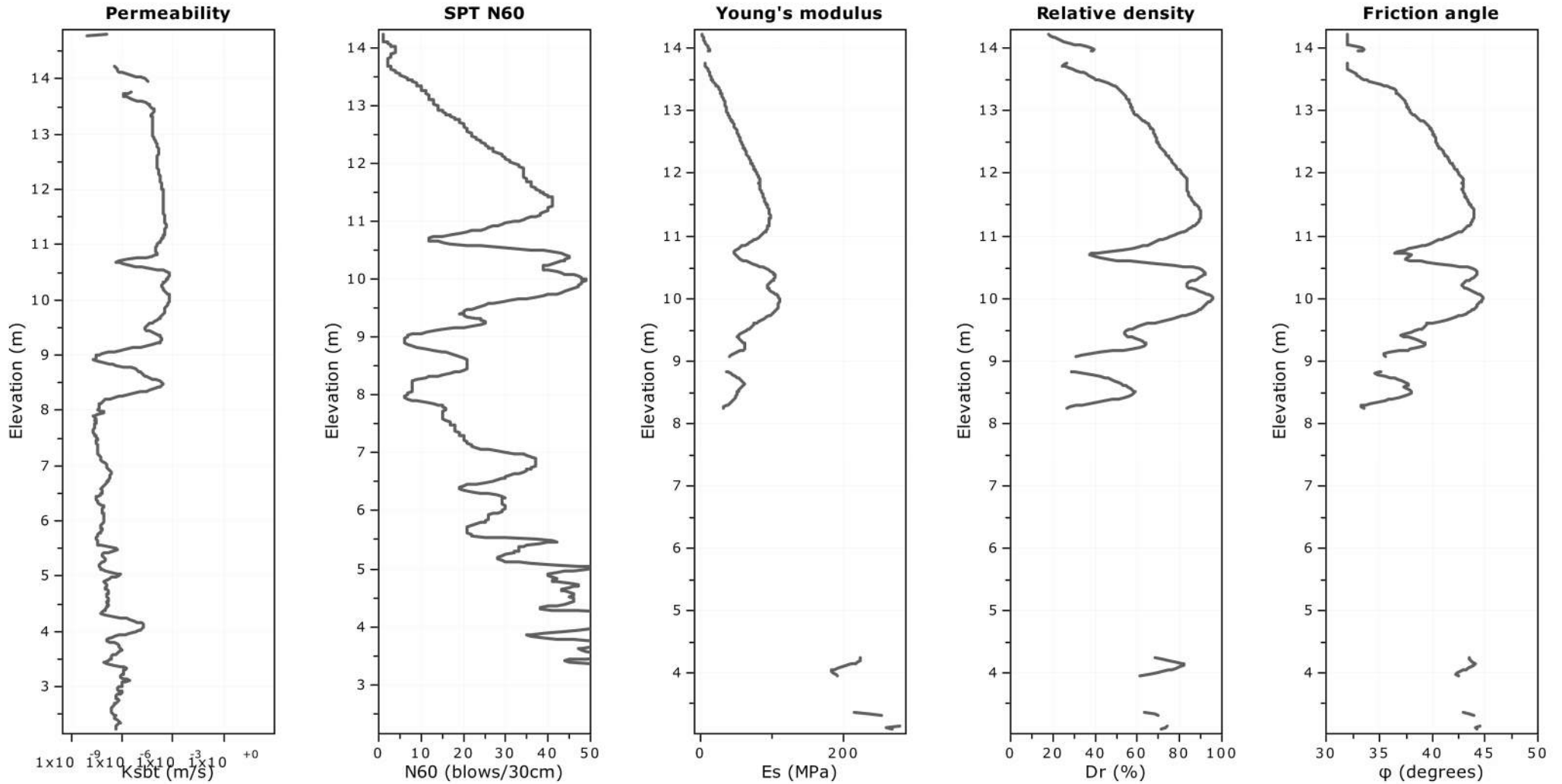
Updated SBTn plots



- 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)

Project:
Location:



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)

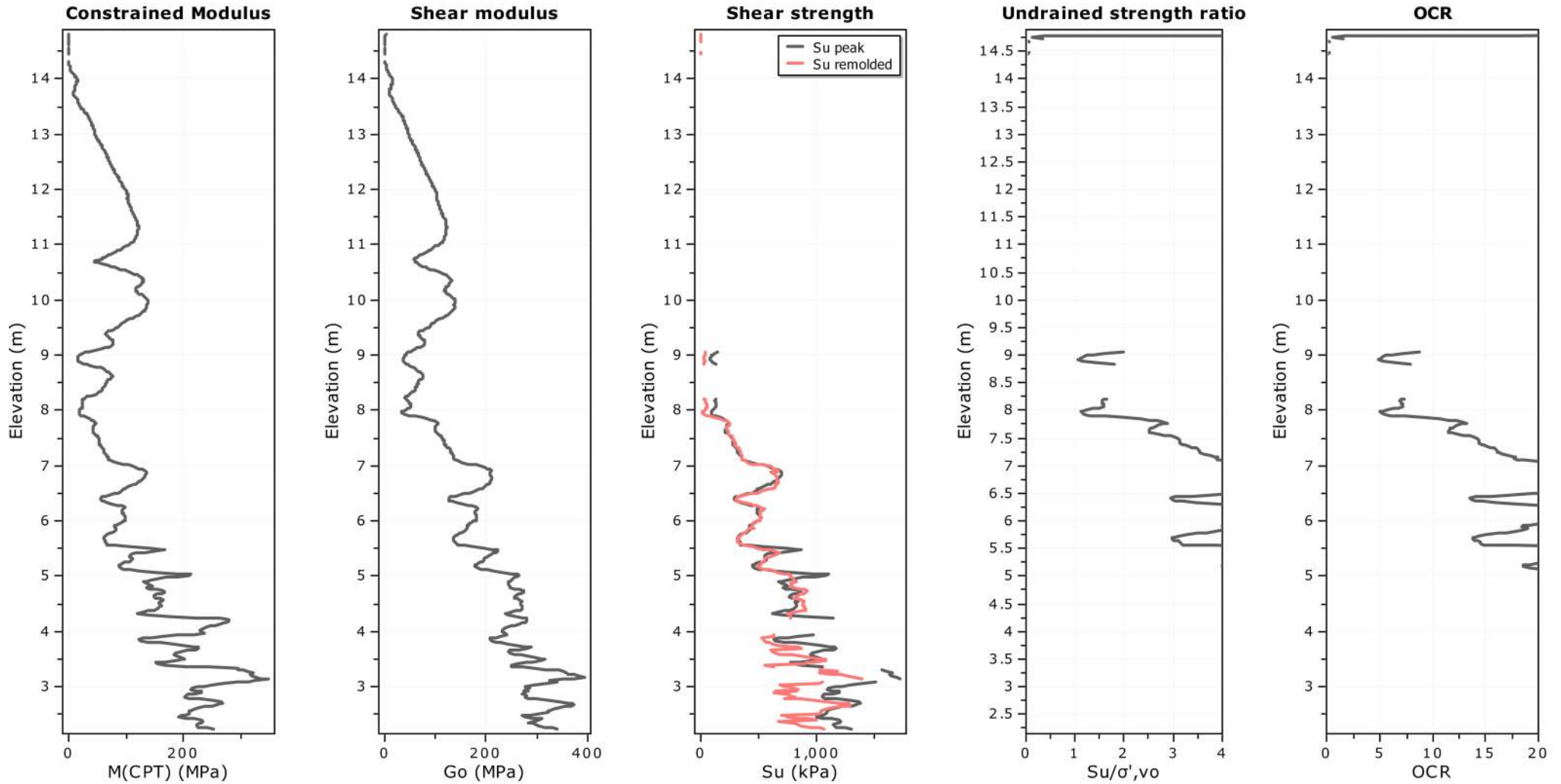
Relative density constant, C_{Dr} : 350.0

Phi: Based on Kulhawy & Mayne (1990)

● — User defined estimation data

Project:

Location:



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)

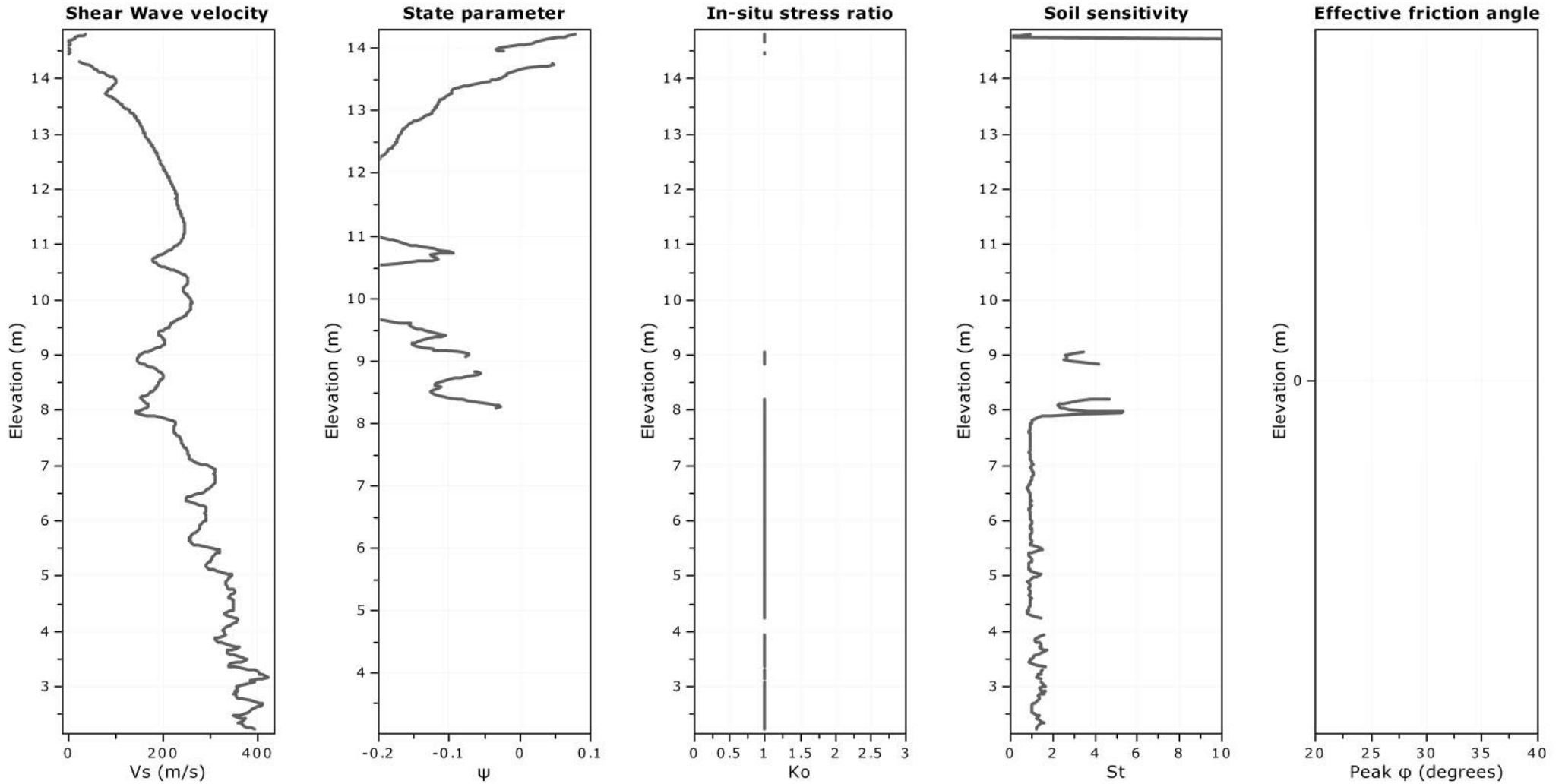
Undrained shear strength cone factor for clays, N_{kt} : 14

OCR factor for clays, N_{kt} : 0.33

● User defined estimation data

● Flat Dilatometer Test data

Project:
Location:



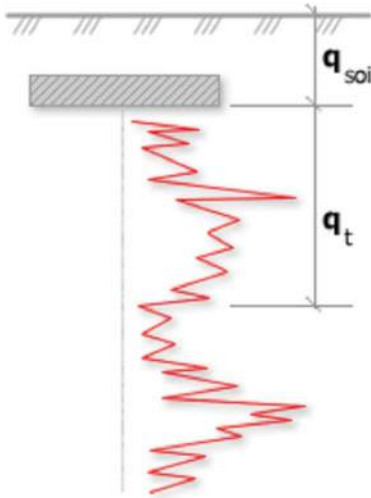
Calculation parameters

Soil Sensitivity factor, N_s : 7.00

—●— User defined estimation data

Project:

Location:



Bearing Capacity calculation is performed based on the formula:

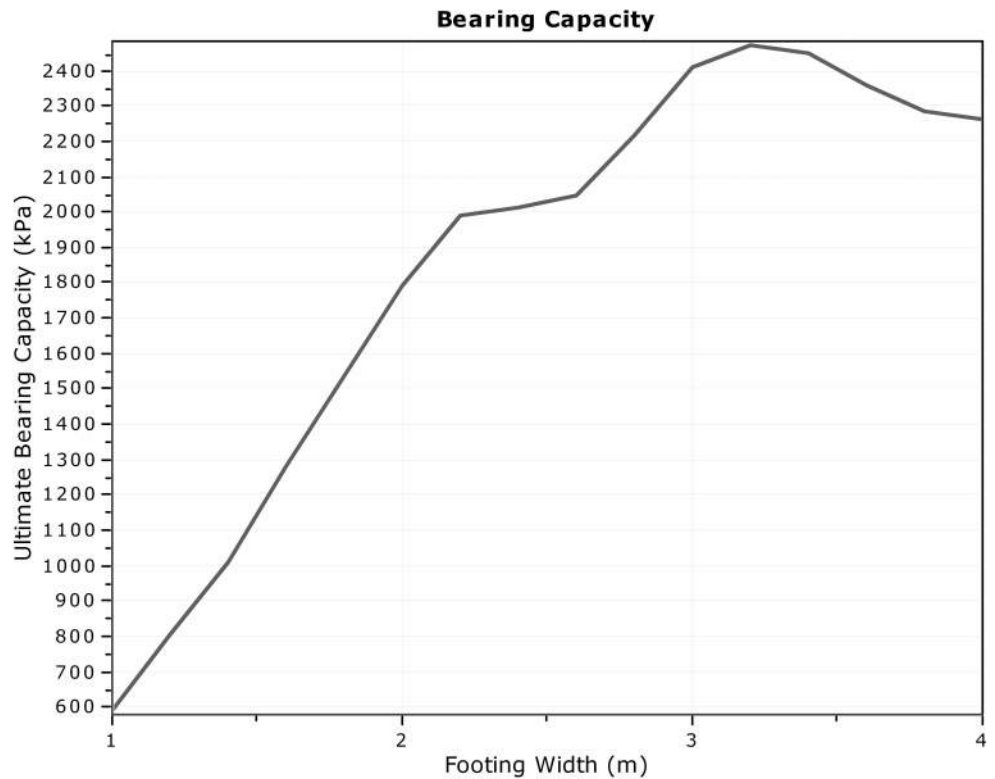
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:

R_k : Bearing capacity factor

q_t : Average corrected cone resistance over calculation depth

q_{soil} : Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	2.90	0.20	9.50	589.72
2	1.20	0.50	2.30	3.99	0.20	9.50	806.98
3	1.40	0.50	2.60	5.01	0.20	9.50	1011.67
4	1.60	0.50	2.90	6.37	0.20	9.50	1283.16
5	1.80	0.50	3.20	7.63	0.20	9.50	1535.73
6	2.00	0.50	3.50	8.91	0.20	9.50	1792.18
7	2.20	0.50	3.80	9.91	0.20	9.50	1992.31
8	2.40	0.50	4.10	10.01	0.20	9.50	2012.06
9	2.60	0.50	4.40	10.20	0.20	9.50	2048.91
10	2.80	0.50	4.70	11.03	0.20	9.50	2214.77
11	3.00	0.50	5.00	11.99	0.20	9.50	2408.46
12	3.20	0.50	5.30	12.31	0.20	9.50	2471.20
13	3.40	0.50	5.60	12.19	0.20	9.50	2448.20
14	3.60	0.50	5.90	11.75	0.20	9.50	2359.27
15	3.80	0.50	6.20	11.37	0.20	9.50	2282.97
16	4.00	0.50	6.50	11.26	0.20	9.50	2261.04

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) ::

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

where g_w = water unit weight

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

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

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

:: N_{SP}T (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, E_s (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, D_r (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}} \quad (\text{applicable only to SBT}_n: 5, 6, 7 \text{ and } 8 \text{ or } I_c < I_{c_cutoff})$$

:: State Parameter, ψ ::

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

:: Drained Friction Angle, ϕ (°) ::

$$\phi = 29.5^\circ \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c_cutoff}$)

:: 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 $I_c \geq 2.20$
 $M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

:: Small strain shear Modulus, G_0 (MPa) ::

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

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

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

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

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

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

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

:: Remolded undrained shear strength, $S_u(\text{rem})$ (kPa) ::

$$S_{u(\text{rem})} = f_s \quad (\text{applicable only to SBT}_n: 1, 2, 3, 4 \text{ and } 9 \text{ or } I_c > I_{c_cutoff})$$

:: Overconsolidation Ratio, OCR ::

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

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

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

:: In situ Stress Ratio, K_0 ::

$$K_0 = (1 - \sin \phi') \cdot OCR^{\sin \phi'}$$

(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 $I_c > I_{c_cutoff}$)

:: Peak Friction Angle, ϕ' (°) ::

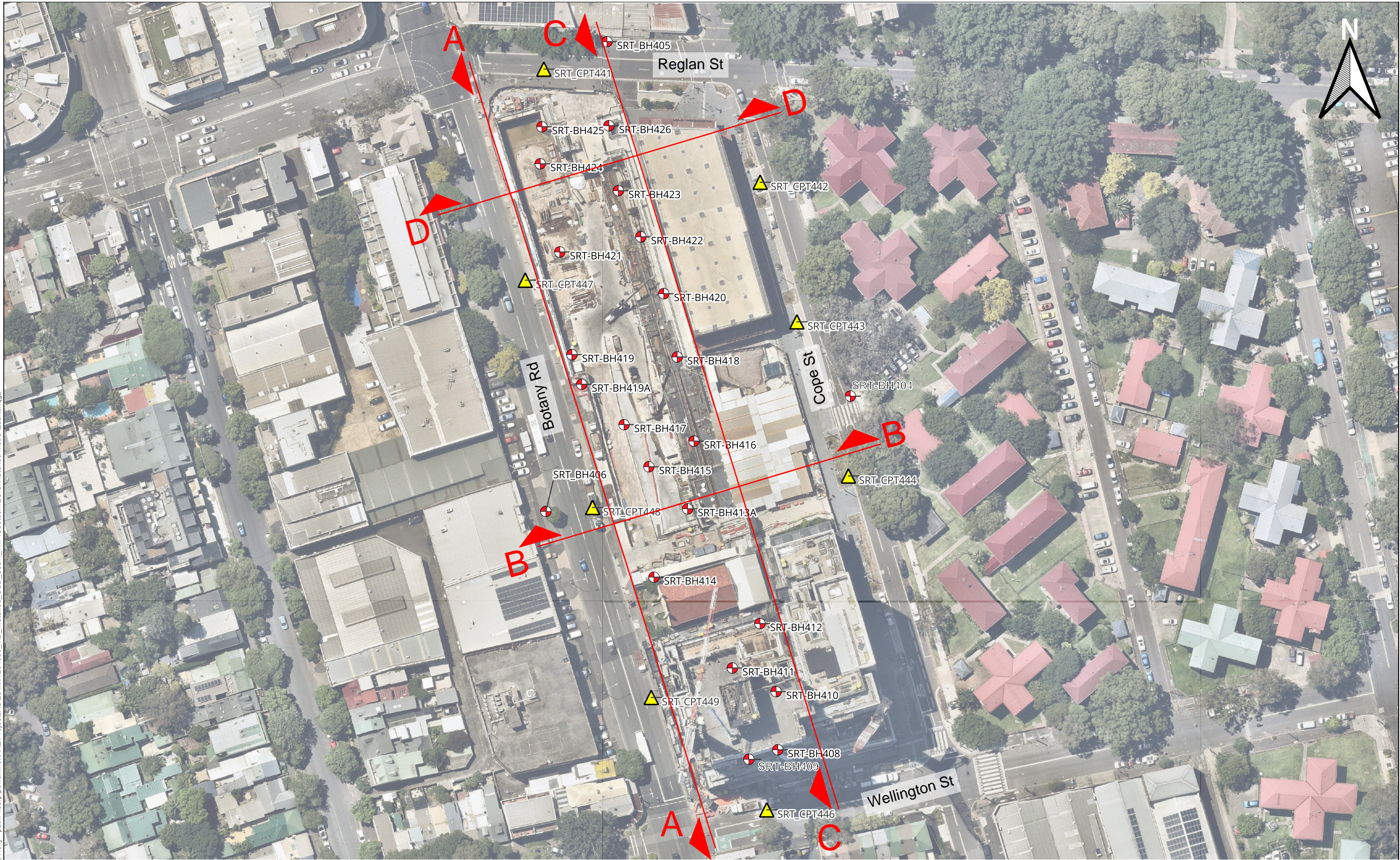
$$\phi' = 29.5^\circ \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(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)

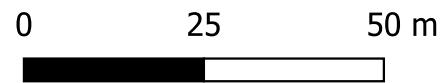
Appendix C – Geological Cross Sections



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Legend

- ▲ CPT Locations
- Borehole Locations



CLIENT
WLD

CONSULTANT



YYYY-MM-DD	2025-03-18
DESIGNED	HG
PREPARED	HG
REVIEWED	SZ
APPROVED	SZ

PROJECT
Waterloo Metro Quarter - Waterloo OSD Northern and Southern Precinct

TITLE
Site Investigation Plan

PROJECT NO
PS20230426

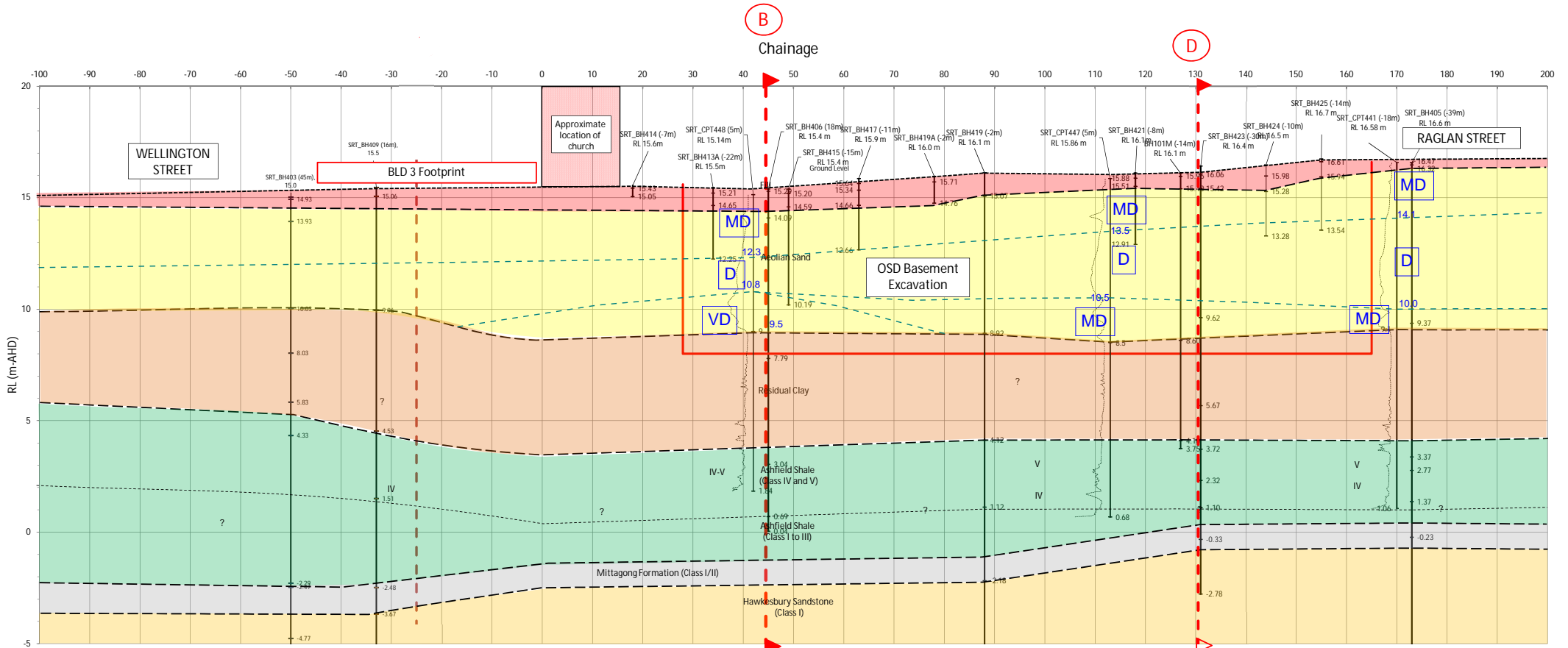
FIGURE
1 of 1

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← Sydenham

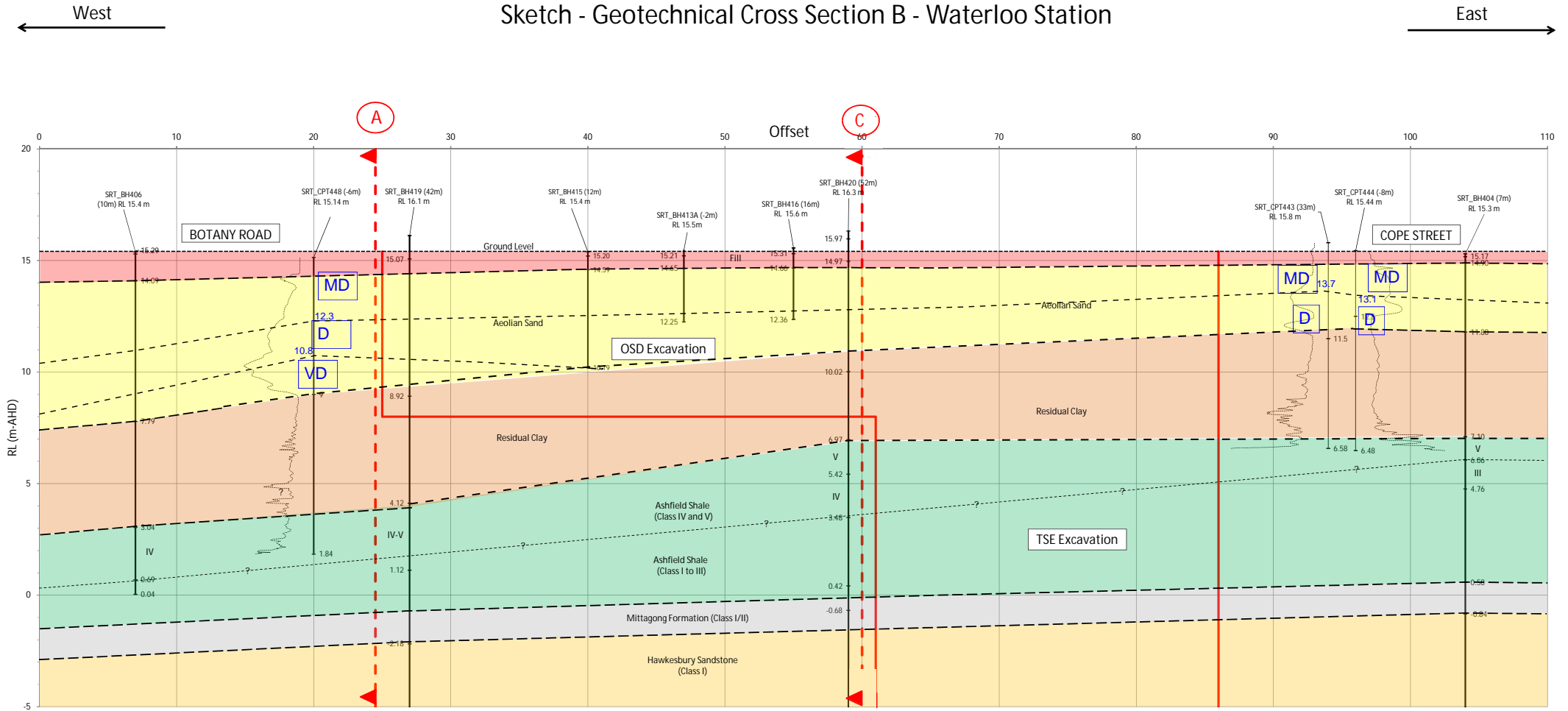
Sketch - Geotechnical Long Section A - Waterloo Station

→ Central



LEGEND FOR AEOLIN SAND Density
MD - Medium Dense
D - Dense
VD - Very Dense

Sketch - Geotechnical Cross Section B - Waterloo Station



LEGEND FOR AEOLIN SAND Density

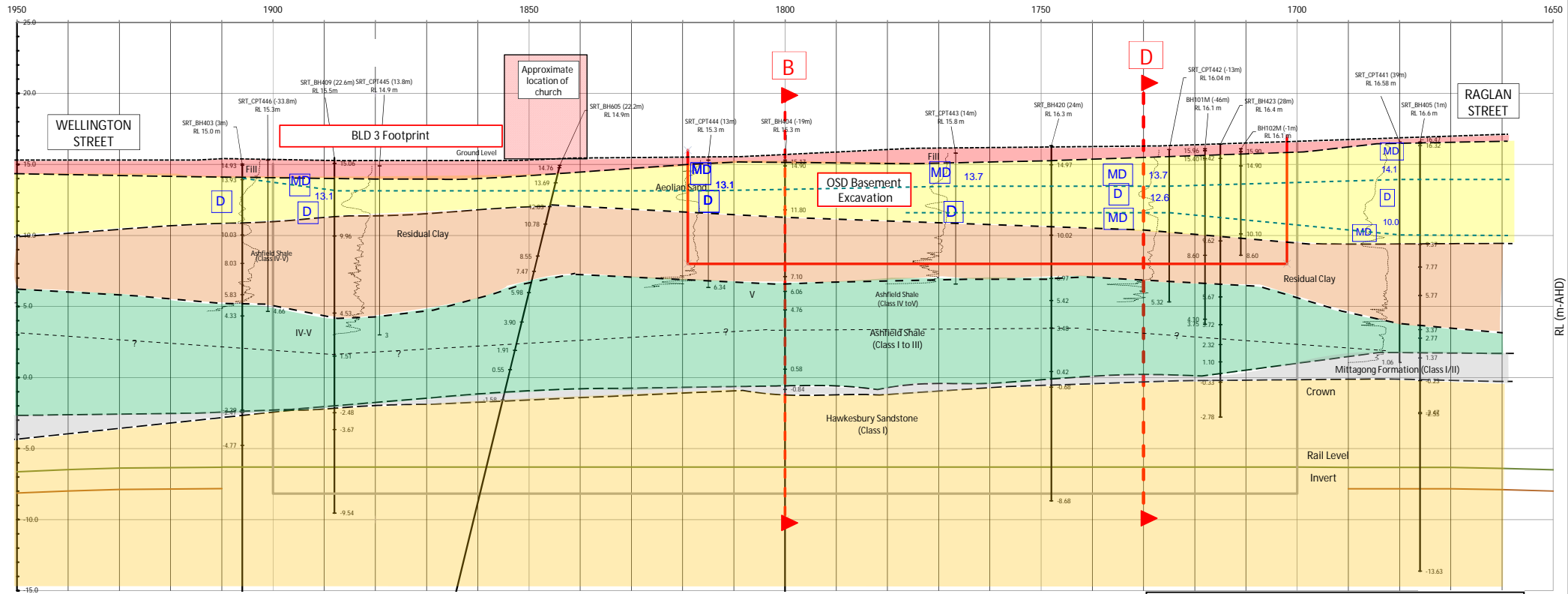
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Sydenham ←

Sketch - Geotechnical long section C - Waterloo Station

→ Central

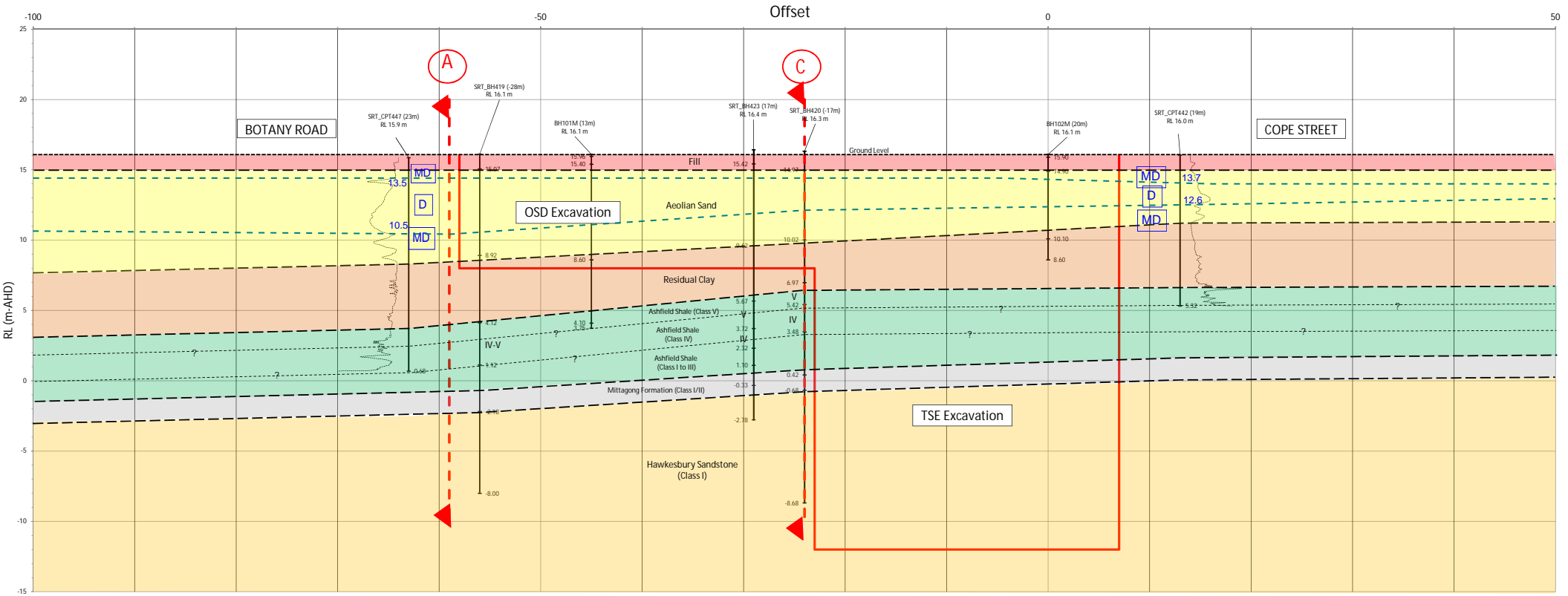
Chainage



LEGEND FOR AEOLIN SAND Density
MD - Medium Dense
D - Dense
VD - Very Dense

Sketch - Geotechnical cross section D - Waterloo Station

← West
→ East



LEGEND FOR AEOLIN SAND Density

- MD - Medium Dense
- D - Dense
- VD - Very Dense