6 May 2025

Grafton Downs Limited
Attn: Glenn Wright
PO Box 7652 Wellesley Street
Auckland
Auckland 1141

Dear Glenn,

**Plan Change - Franklin 2 Precinct – Paerata Rise Development, Paerata Road, Paerata**

**(Our Reference: 12914.000.002_134)**

# 1 Introduction

ENGEO Ltd was requested by Grafton Downs Limited to prepare an addendum to the previous Beca report (dated July 2014) to support a private plan change over the land at the Paerata Rise subdivision (known in the Auckland Unitary Plan as the Franklin 2 Precinct).

This addendum report references additional investigations that have been carried out since the Beca report was prepared and addresses specific queries raised by Auckland Council as part of the plan change process. This report should be read in conjunction with the Beca report.

# 2 Proposed Plan Change

In preparation of this report, we have been provided with a drawing titled *Proposed Plan Change Franklin 2 Precinct*, from Boffa Miskell Ltd, dated 26 November 2024. Based on this, we understand that the following plan changes are proposed:

a) Rezone the area adjacent to the **Glenbrook Roundabout** from Residential Mixed Housing Urban to Business Local Centre and one smaller area from Residential Mixed Housing Urban to Open Space Informal Recreation.

b) Rezone a small site in the vicinity of **Sim Road** from Residential Mixed Housing Urban to Business Neighbourhood Centre.

c) Rezone the existing Business Local Centre area located largely in the vicinity of **Wesley College** to Residential Mixed Housing Urban.

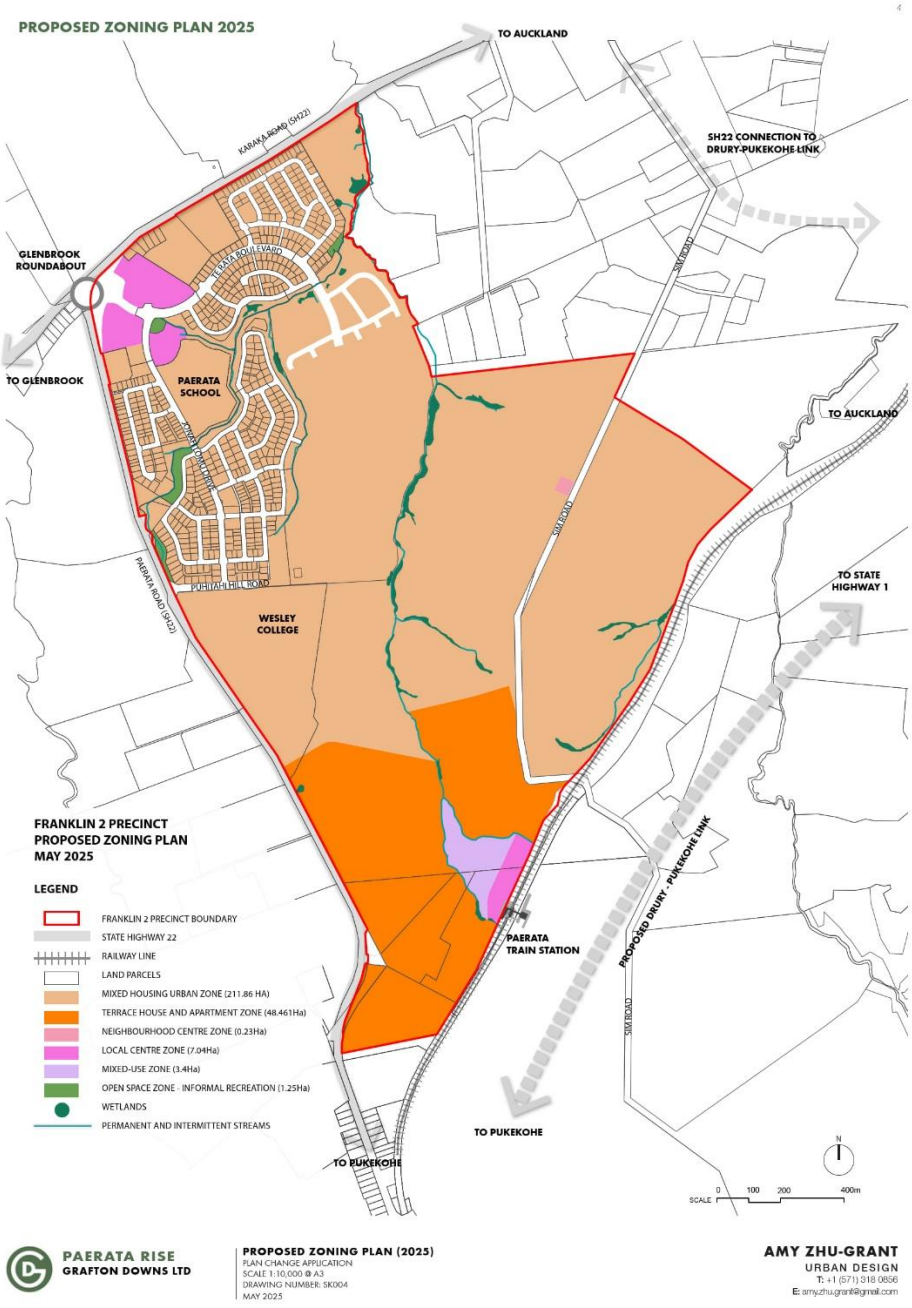
d) Rezone the area adjacent to the **Paerata Rail Station** from Mixed Housing Urban to Business: Local Centre and Business Mixed Use.

e) Rezone the residential area located **South of Wesley College** from Residential Mixed Housing Urban to Residential Terraced Housing and Apartment Buildings.

These proposed plan changes are presented on a map in Figure 1.

The majority of the proposed plan changes, specifically items a) to d) above, will not impact the geotechnical natural hazard risk assessment, as the developments and loadings will be similar from a geotechnical perspective. However, item e above, will have an increase loading, allowing up to six-storey structures to be constructed (compared to two-storey in the current plan use).

**Figure 1: Wider Paerata Rise Subdivision with Locations of Proposed Plan Changes**



# 3 Previous Investigations and Earthworks

A number of investigations and reports have been carried out across the wider Paerata Rise subdivision including the original Beca investigations and subsequent stage specific investigations carried out by ENGEO. The location of these investigations are presented on the investigation location plans attached in Appendix 1 and the accompanying reports include.

- Beca Ltd – Wesley College: Paerata North SHA – Geotechnical Factual Report, dated 11 April 2014
- Beca Ltd – Wesley College: Paerata North SHA - Geotechnical Interpretive Report, dated 4 July 2014
- ENGEO Ltd – Wesley New Town Development – Geotechnical Investigation Report, (ref. 12914.000.000_08) dated 29 June 2016
- ENGEO Ltd - Paerata Rise Phase 2 & 3 Geotechnical Investigation Report, (ref. 12914.000.002_01) dated 6 July 2018
- ENGEO Ltd - Paerata Rise Phase 3B&C Geotechnical Investigation Report, (ref. 12914.000.002_91) dated 30 November 2021
- ENGEO Ltd - Paerata Phase 4A Geotechnical Report, (ref. 12914.000.005_03) dated 27 September 2022

Subdivisional earthworks associated with the above investigations have been and are continuing to be carried out across the wider Paerata Rise subdivision and the following sections also draw on our experience during these earthworks.

# 4 Geological Model

The previous investigations and geological maps indicate three main geological settings across the wider subdivision:

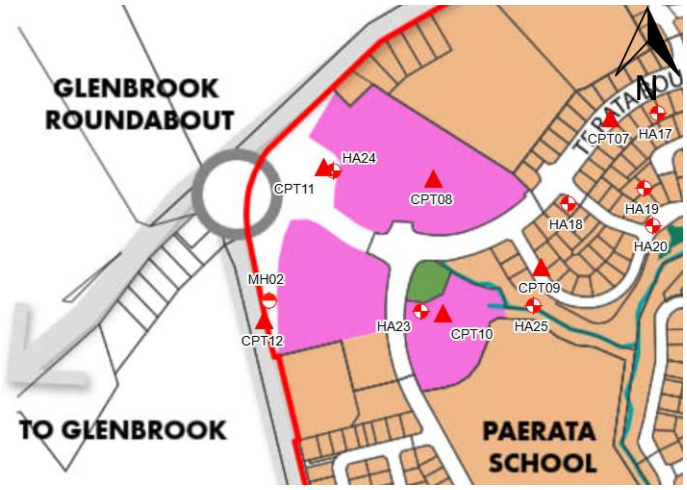
- The majority of the wider subdivision is underlain by Puketoka alluvial deposits which generally comprise reworked volcanic deposits. Based on *in situ* strength tests these deposits are generally very stiff although isolated pockets of peat were identified at depth. In the southernmost portion of the wider subdivision, swamp deposits were encountered which had lower strengths.
- The ground in the higher elevated areas, in the south-eastern part of the wider subdivision, generally comprises very stiff to hard SAVF ash deposits.
- An isolated lobe of South Auckland Volcanic Field Basalt extends into the north-western corner of the wider subdivision. This basalt rock is overlain by ash deposits and underlain by the aforementioned alluvium.

The following sections provide specific commentary on each of the Plan Change areas.

## 4.1 Glenbrook Roundabout

The proposed plan changes in the Glenbrook Roundabout area are presented in Figure 2 along with available geotechnical investigations. Detailed logs are included in the ENGEO 2018 report.

**Figure 2: Previous Investigations and Plan Change Areas Around Glenbrook Roundabout**

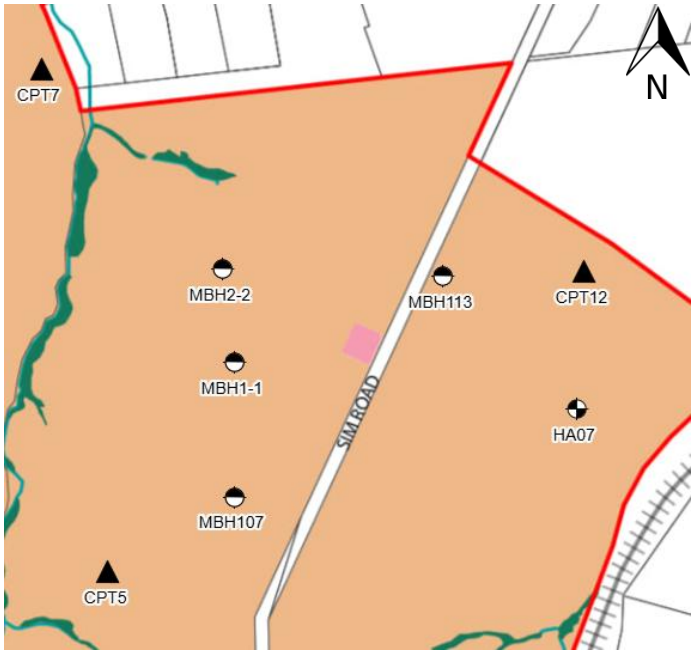



The geology on this area varies, with both Puketoka Alluvium and SAVF deposits encountered near surface to beyond 10 m depth. Both deposits comprise very stiff, clayey silt and silty clay. Groundwater was encountered between 1.5 and 4.1 m bgl.

## 4.2 Sim Road

The proposed plan changes west of Sim Road are presented in Figure 3 along with available geotechnical investigations. Detailed logs are included in the Beca 2014 report.

**Figure 3: Previous Investigations and Plan Change Area Sim Road**

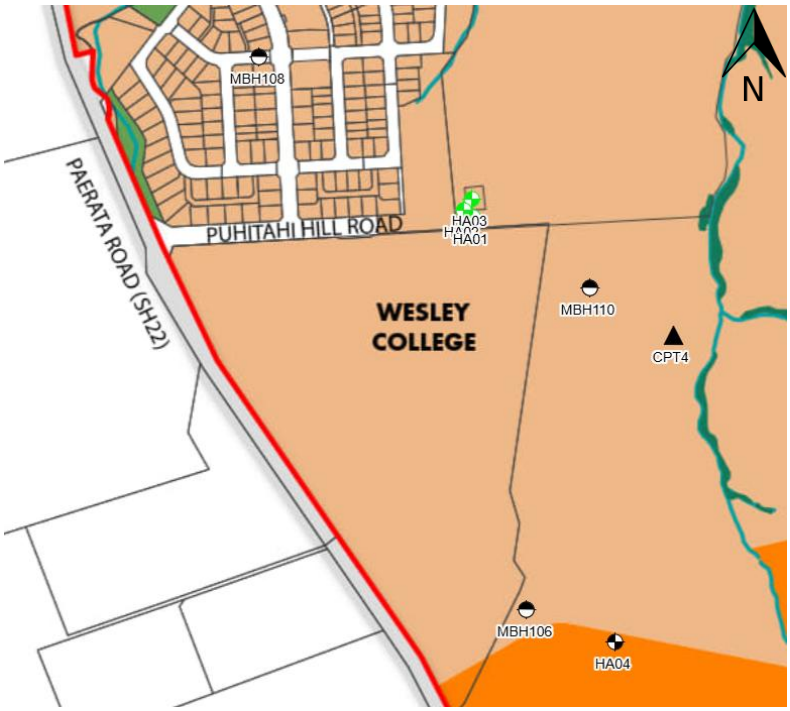


Based on the investigations, this area is underlain by Puketoka alluvium which generally comprised very stiff silt underlain by loose to medium dense sand deposits. Groundwater was encountered between 6.9 and 18.2 m bgl in the area.

## 4.3 Wesley College

The proposed plan changes in the Wesley College area are presented in Figure 4 along with available geotechnical investigations. Detailed logs are included in the Beca 2014 (black) and ENGEO 2017 (green) reports.

**Figure 4: Previous Investigations Around the Plan Change Area in Wesley College Sub-Precinct**

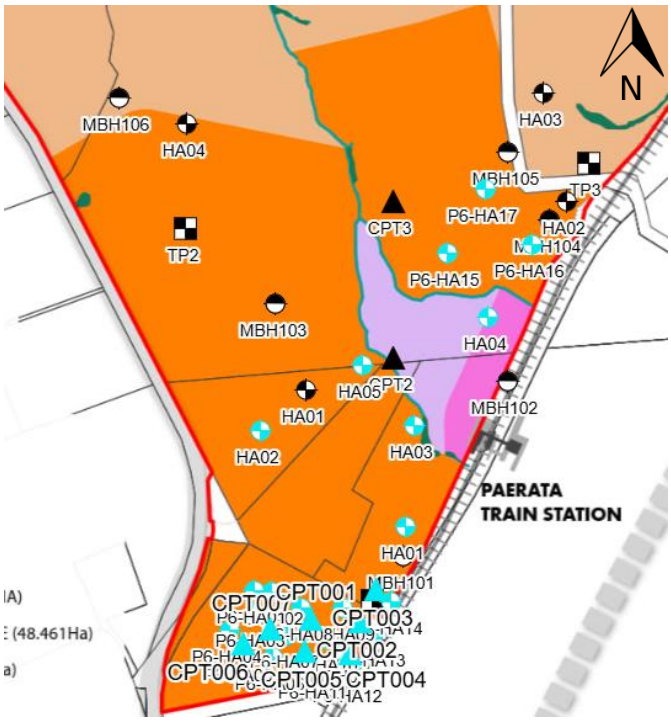



Based on the investigations this area is underlain by Puketoka alluvium which comprises very stiff silt underlain by loose to medium dense sand. Groundwater was encountered between 6.4 and 20.2 m bgl in the area.

## 4.4 Paerata Rail Station and South of Wesley College

The proposed plan changes in the southern portion of the wider subdivision are presented in Figure 5 along with available deep geotechnical investigations. Detailed logs are included in the Beca 2014 (Black) and ENGEO 2022 (Magenta) reports.

**Figure 5: Previous Investigations Within and Surrounding Paerata Rail Station and South of Wesley College Plan Change Areas**




The western half of this area was found to be underlain by stiff to hard, Puketoka alluvial deposits. The eastern half was found to be underlain by stiff to hard SAVF deposits. The lower lying potions at the southern end of the site comprised soft to firm alluvial deposits with peat being encountered at thickness of 1 m to 3 m at depths between 2 m bgl and 5 m bgl.

# 5 Geotechnical Assessment

## 5.1 Liquefaction

Liquefaction assessments have been carried out using existing CPT data (as described in Section 3) that is available in the vicinity of the plan change areas. The location of analysed CPT investigations are presented in Figure 6.

The analysis has been carried out using C-Liq software and a PGA of 0.19 g and a magnitude of 6.5 have been used for the analysis (from MBIE Module 1, Table A1).

The results indicate that **liquefaction does not occur during an SLS event.** Liquefaction occurred at some of the CPT locations analysed and therefore the results from the analysis of the ULS case only are summarised in Table 1 below and all the analysis are included in Appendix 2.

**Figure 6: Location of Analysed CPT Investigations in the Liquefaction Assessment. To the Left: Glenbrook Roundabout (yellow), Phase 2 East (green) and Phase 3 (blue). To the Right: Paerata Train Station and South of Wesley College.**

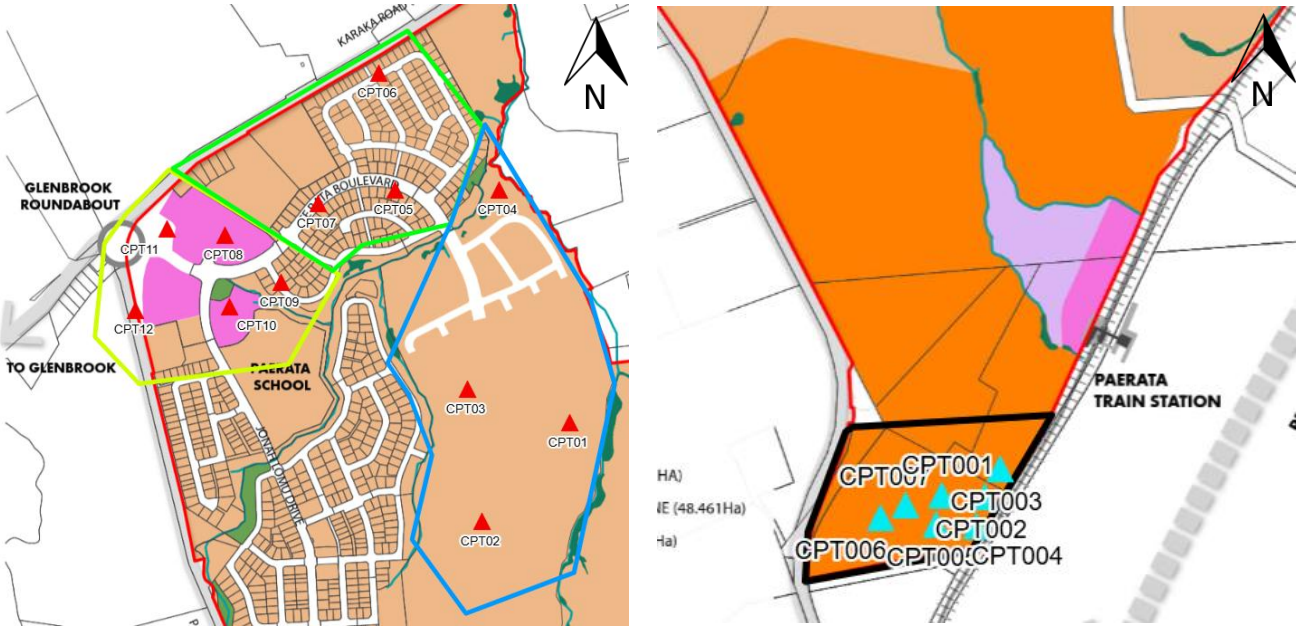


**Table 1: Liquefaction Analysis Results for the ULS Seismic Case**

| CPT | Plan Change Area | Groundwater Table (m bgl) [1] | Total Vertical Liquefaction Settlement (mm) | LPI | LSN | General Performance Level (MBIE) [2] |
|---|---|---|---|---|---|---|
| CPT08 | Glenbrook Roundabout | 1 | 77 | 4 | 16 | L2 |
| CPT09 | | 1.5 | 6 | 0 | 1 | L0 |
| CPT10 | | 4 | 0 | 0 | 0 | L0 |
| CPT11 | | 3 | 6 | 0 | 1 | L0 |
| CPT12 | | 1.5 | 16 | 0 | 4 | L0 |
| CPT001 | Paerata Train Station and South of Wesley College | 1.5 | 87 | 1 | 6 | L1 |
| CPT002 | | 0.5 | 277 | 10 | 34 | L3 |
| CPT003 | | 1.5 | 101 | 5 | 21 | L2 |
| CPT004 | | 1.5 | 176 | 6 | 3 | L2 |
| CPT005 | | 1 | 261 | 10 | 11 | L3 |
| CPT006 | | 4.0 | 104 | 2 | 0 | L2 |
| CPT007 | | 2.5 | 211 | 4 | 4 | L2 |
| CPT05 | Phase 2 East | 1 | 51 | 3 | 9 | L2 |
| CPT06 | | 1 | 141 | 6 | 20 | L3 |
| CPT07 | | 2 | 32 | 0 | 5 | L1 |
| CPT01 | Phase 3 | 1 | 129 | 4 | 26 | L3 |
| CPT02 | | 0.5 | 75 | 3 | 16 | L2 |
| CPT03 | | 1 | 130 | 5 | 33 | L3 |
| CPT04 | | 2.5 | 51 | 1 | 11 | L2 |

Notes

1. Groundwater table estimated from dip test in the closest borehole investigation point
2. Based on LPI, LSN, portion of the deposits liquefying and crust

The calculated liquefaction falls within categories L0 to L3 (Insignificant to High), in accordance with Table 5.1 of MBIE Module 3. The characteristics of the liquefaction range from “no liquefaction” in L0 (Insignificant) through to “moderate-to-large differential movements, and settlement of the ground in the order of 100 mm to 200 mm” in L3 (High).

As noted above, liquefaction will not occur in an SLS event, however in some areas significant settlements could occur during a ULS event. We consider that this liquefaction risk could be significantly reduced and/or mitigated by earthworks design during resource consent stage and / or building and foundation design during building consent stage. We would therefore recommend that liquefaction is further addressed during resource and building consent stages (potentially with additional investigations where appropriate).

## 5.2 Consolidation Settlement

Based on the investigation results, most of the wider subdivision is underlain by stiff to hard soils at shallow depths. This indicates that, generally, the soil is not very compressible and that shallow foundations should be feasible for most planned developments. However, where apartment buildings are proposed piled foundations may be necessary. Specific foundation recommendations for each lot will be provided at Geotechnical Completion Report stage.

In the southern lower lying areas, where soft to firm alluvial deposits were encountered, significant fill has already been placed to create a crust over the alluvial deposits. To mitigate long term settlement risks, settlement monitoring of this fill (and any other fill in other areas of soft to firm alluvial deposits) should be carried out until settlements attenuate.

## 5.3 Stability

Across the majority of the Plan Change areas the existing topography is gently sloping and the proposed earthworks will likely further reduce slope angles, so the risk of global instability is considered low. However, any existing slopes adjacent to streams that are to remain should be assessed for slope stability and may require grading, mechanically stabilised earth embankments or retaining structures to achieve adequate factors of safety.

Further, a natural slope in the vicinity of Paerata Train Station and South of Wesley College plan change area was found to not have adequate factors of safety (in the Beca 2014 report). The location of this slope is presented as a hatched area just northeast of the plan change area Figure 7. Specific stability analysis of this slope and remedial options (earthworks and / or ground improvements) will need to be addressed as part of the resource consent for subdivision in this area.


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**Figure 7: Identified Area of Land Instability**

## 5.4 Auckland Anniversary Floods

During the Auckland anniversary 2022 severe rainfall and winds were experienced in the Auckland region, this affected a vast number of locations resulting in landslides and floods. ENGEO was engaged with the Paerata Rise subdivision prior to, during and following these events. Site visits were undertaken both before and after the event and to the best of our knowledge, no significant land instability was observed.

## 5.5 Expansive Soil

Based on the previous investigations and the lab testing across the wider site, the soil expansivity class is inferred to typically fall within expansivity class M (Moderate) to H1 (High). As is typical for subdivisions, confirmation of the site class (AS2870) will be provided at Geotechnical Completion Report stage through post-earthworks laboratory testing.

The expansive soil risk can be mitigated through foundation design as is typical on the majority of subdivisions through the Auckland region.

## 5.6 Groundwater

Based on the previous investigations, the groundwater levels vary significantly both within the respective plan change areas and across the whole site. We would therefore recommend it be conservatively assumed that the groundwater is shallow across the whole site (1 – 1.5 m bgl).

## 6 Risk Matrix

| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| Glenbrook Roundabout | Liquefaction and Lateral Spreading | | X | | | Based on revised liquefaction analysis in this letter, we consider that the risk for liquefaction and lateral spread in this area is generally low, although CPT08 (northeast portion of the area) did indicate slightly higher risk.<br>Since liquefaction is inferred to only occur during an ULS seismic event, the requirement for the buildings is to withstand the ULS event without collapsing. This can be mitigated through earthworks (i.e. creating a raft of non-liquefiable soils), design of the structure and / or foundation selection. | Low |
| | Consolidation Settlement | X | | | | Based on strength data from investigations in this area, the proposed structures should generally be able to be founded on shallow foundations. Specific foundation recommendations for each lot should be provided at Geotechnical Completion Report stage. | Low |
| | Expansive Soils | | | X | | Based on laboratory testing, near surface soils will be expansive (likely moderate to high). The future risk to foundation dwellings can be mitigated by specific design of foundations. | Low |
| | Slope Instability | X | | | | This zone is generally near level with very stiff soils. Therefore, slope instability is not considered a significant risk. | Low |
| | Material Reuse | | X | | | Site won volcanic ash soils may be considered appropriate for reuse as engineered fill, however considerable care should be undertaken as the surficial volcanic ashes are expected to be highly sensitive and can easily soften when overworked. Major earthworks should be avoided during winter months or during periods of high rainfall. | Low |

| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| | Groundwater | X | | | | Groundwater is anticipated to be approximately 1 – 4 m below existing ground level within this zone. Given no significant earthworks or basement excavations, this is considered to be a low risk. If deep cuts or excavations are proposed further assessments of groundwater should be undertaken to support relevant consents. | Low |
| | Flooding | X | | | | Although the Auckland Council GIS shows multiple flood plains and overland flow paths across this area, works on site have already been carried out to lift the flood prone areas and divert the overland flow paths away from proposed building platforms. | Low |
| Sim Road | Liquefaction and Lateral Spreading | | X | | | Based on the liquefaction analysis in this letter, and the nearest available investigations, we consider that the risk for liquefaction and lateral spread in this area is moderate.<br>Since liquefaction is inferred to only occur during an ULS seismic event, the requirement for the buildings is to withstand the ULS event without collapsing. This can be mitigated through subdivisional earthworks (i.e. creating a raft of non-liquefiable soils), design of the structure and / or foundation selection.<br>Due to the limited investigation in this area we would recommend that further investigation and a liquefaction assessment is carried out during the design for the Resource Consent stage. | Low |
| | Consolidation Settlement | | X | | | Based on strength data from investigations in this area, the proposed structures should generally be able to be founded on shallow foundations. If lower strength materials are encountered, then reduced bearing capacities could be designed for. Specific foundation recommendations for each lot should be provided at Geotechnical Completion Report stage. | Low |


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| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| | Expansive Soils | | | X | | Based on laboratory testing, near surface soils will be expansive (likely moderate to high). The future risk to foundation dwellings can be mitigated by specific design of foundations. | Low |
| | Slope Instability | X | | | | Existing slopes were noted to be gently sloping. The risk of land instability in this gently sloping ground is considered to be low, however this situation should be reevaluated when civil plans become available. Where any steep slopes are proposed as part of the earthworks these should be assessed and may require grading, mechanically stabilised earth embankments or retaining structures to achieve adequate factors of safety. | Low |
| | Material Reuse | | X | | | Site won volcanic ash soils may be considered appropriate for reuse as engineered fill, however considerable care should be undertaken as the surficial volcanic ashes are expected to be highly sensitive and can easily soften when overworked. Major earthworks should be avoided during winter months or during periods of high rainfall. | Low |
| | Groundwater | X | | | | Groundwater is anticipated to be approximately 6.0 m below existing ground level within this area. It is anticipated that cuts within this area will be above groundwater. If deep cuts or excavations are proposed further assessments of groundwater should be undertaken to support relevant consents. | Low |
| | Flooding | X | | | | This area is not mapped as flood prone or as a flood plain and there are no identified overland flow paths crossing this area. | Low |


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| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| Wesley College | Liquefaction and Lateral Spreading | | X | | | Based on the liquefaction analysis in this letter, on the nearest available investigations, we consider that the risk for liquefaction and lateral spread in this area is moderate.<br>Since liquefaction is inferred to only occur during an ULS seismic event, the requirement for the buildings is to withstand the ULS event without collapsing. This can be mitigated through subdivisional earthworks (i.e. creating a raft of non-liquefiable soils), design of the structure and / or foundation selection.<br>Due to the limited investigation in this area we would recommend that further investigation and a liquefaction assessment is carried out during the design for the Resource Consent stage. | Low |
| | Consolidation Settlement | | X | | | In the absence of nearby investigations, the risk for consolidation settlement has been assessed to be moderate. Based on-site wide investigations, the proposed structures should generally be able to be founded on shallow foundations (although reduced bearing capacities may apply if lower strength materials are encountered). Specific foundation recommendations for each lot should be provided at Geotechnical Completion Report stage. | Low |
| | Expansive Soils | | | X | | Based on laboratory testing, near surface soils will be expansive (likely moderate to high). The future risk to foundation dwellings can be mitigated by specific design of foundations. | Low |
| | Slope Instability | X | | | | Existing slopes were noted to be near level to gently sloping. The risk of land instability in this gently sloping ground is considered to be low, however this situation should be reevaluated when civil plans become available. Where any steep slopes are proposed as part of the earthworks these should be assessed and may require grading, mechanically stabilised earth embankments or retaining structures to achieve adequate factors of safety. | Low |

| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| | Material Reuse | | X | | | If site won volcanic ash soils are to be used as engineered fill, considerable care should be undertaken as the surficial volcanic ashes are expected to be highly sensitive and can easily soften when overworked. Major earthworks should be avoided during winter months or during periods of high rainfall. | Low |
| | Groundwater | | X | | | In the absence of any near-by investigations the groundwater table should be assumed to be shallow at around 1 m bgl. We would recommend that further investigation should be carried out to assess groundwater levels to support relevant consents. | Low |
| | Flooding | X | | | | Given the area is small and not mapped as flood prone nor crossed by any overland flow paths the flooding risk is considered low in this area. | Low |
| Paerata Rail Station and South of Wesley College | Liquefaction and Lateral Spreading | | | X | | Based on the liquefaction analysis in this letter, we consider that the risk for liquefaction and lateral spread in this area is moderate to high.<br>However, since liquefaction is inferred to only occur during an ULS seismic event, the requirement for the buildings is to withstand the ULS event without collapsing. This can be mitigated through subdivisional earthworks (i.e. creating a raft of non-liquefiable soils), design of the structure and / or foundation selection.<br>The residual risk is therefore considered low; however, this must be detailed during detailed design. | Low |
| | Consolidation Settlement | | | X | | Settlements of soft soils under deep fills have been assessed to have a high risk. To mitigate these long-term settlement risks, settlement monitoring of deep fills (and any fill over areas of soft to firm alluvial deposits) should be carried out until settlements attenuate. | Low |


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| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| | | | | | | Provided the above occurs, lightweight residential dwellings (i.e. standalone dwellings and townhouses) should generally be able to be founded on shallow foundations (although reduced bearing capacities may apply if lower strength materials are encountered).<br>It is anticipated that specific design of foundations will be required for apartment buildings during the Building Consent stage. Depending on soil conditions and building loads these structures may require piling. Specific foundation recommendations for each lot should be provided at Geotechnical Completion Report stage. | |
| | Expansive Soils | | | X | | Based on laboratory testing, near surface soils will be expansive (likely moderate to high). The future risk to foundation dwellings can be mitigated by specific design of foundations. | Low |
| | Slope Instability | | | X | | Given the strength of the shallow soil and the site topography, the risk of global instability is considered generally low in this area. However, a natural slope has been found to have elevated risk of land instability (refer to Beca report 2014), located just northeast of this area. This issue needs to be addressed and mitigated during detailed design, however, it is considered that this can be mitigated with a number of effective measures, for example earthworks to either increase toe support, regrade the slope, or reduce the slope height.<br>The proposed plan change is considered to not have an adverse effect on stability of this slope. | Low |
| | Material Reuse | X | | | | Where pockets of organic materials are present in the cut areas these would not be suitable for reuse and should be separated out and added to topsoil stockpiles or removed from site. | Low |


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| Plan Change Area | Hazard | Risk Level | | | | Comment | Residual Risk (following mitigation) |
|---|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | | |
| | Groundwater | | | X | | Groundwater is anticipated to be approximately 1 – 4 m below existing ground level within this area.<br>If significant excavations are proposed, these may intersect groundwater and may require specific measures, such as sump and pumping, sheet piling etc, to facilitate works.<br>This should be assessed to support relevant consents. | Low |
| | Flooding | | | X | | This area is crossed by multiple flood plains and overland flow paths. As such, the flooding risk has been interpreted to be high. Significant earthworks and recontouring of the land will be carried out as part of the subdivisional works. Provided these works are designed to mitigate the flooding risk then we consider this will reduce the residual risk to low. | Low |

# 7 Discussion and Future Work

We consider that the level of previous investigations completed on the site (as described in Section 6) to be sufficient to support this application for the proposed private plan changes for 'Franklin 2 Precinct'. The land is considered suitable for the proposed rezoning and subsequent development subject to effective management of the geotechnical risk items identified in this report.

The geotechnical risks identified above can be managed appropriately through specific engineering design, earthworks controls and monitoring and specific foundation design such that residual risks are reduced to tolerable levels. Further detailed assessment and reporting should be undertaken to support landform design and a future application for resource consent as identified in the risk assessment above.

# 8 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Grafton Downs Limited, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

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

iv. This Limitation should be read in conjunction with the Engineering NZ / ACENZ Standard Terms of Engagement.

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We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on (09) 972 2205 if you require any further information.

Report prepared by

**Alex Keijzer**

Geotechnical Engineer

Report reviewed by

**Dustin Tookey, CMEngNZ (CPEng)**

Associate Geotechnical Engineer

**Attachments:**

Investigation Plan

Liquefaction Analysis


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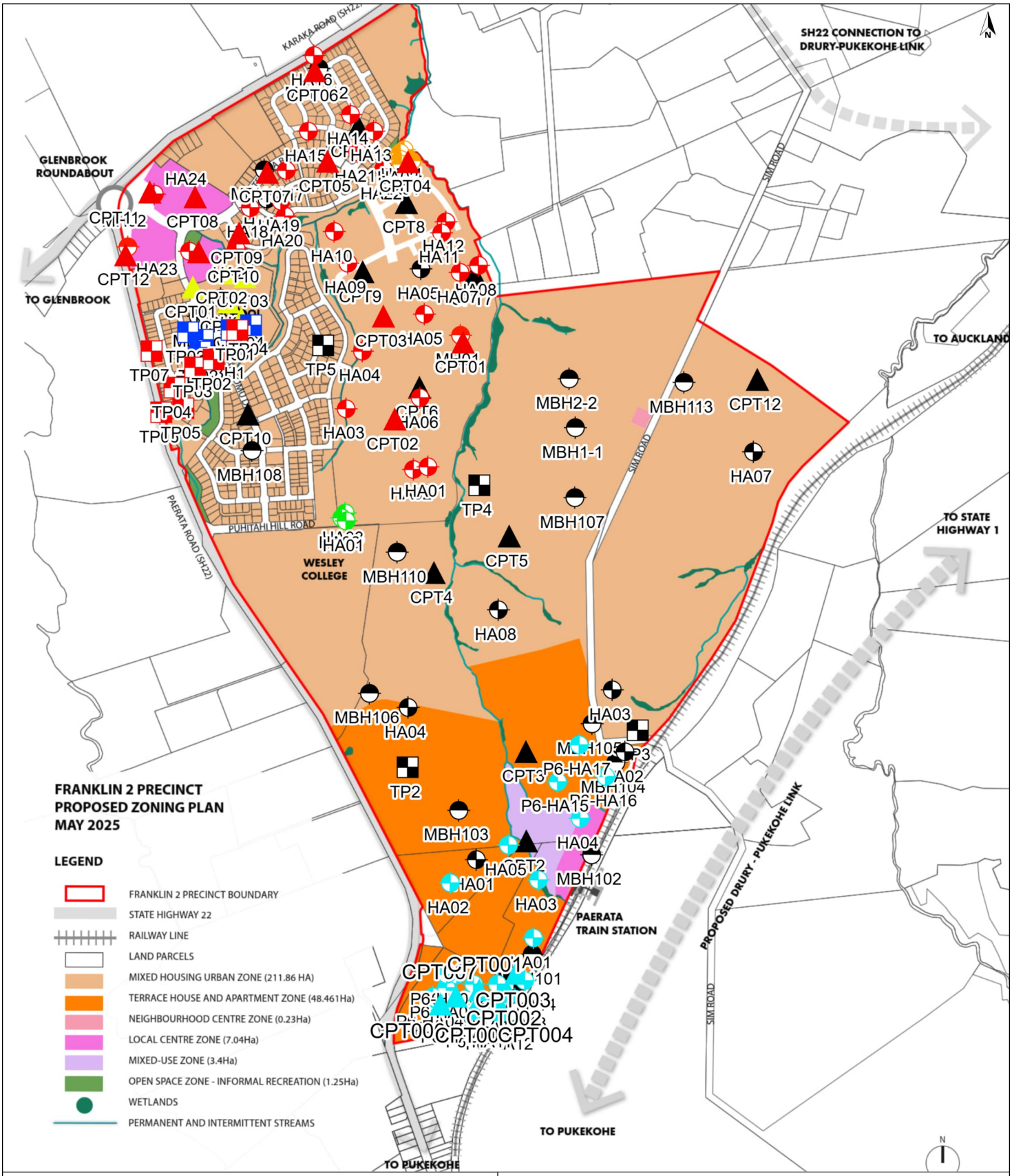
# APPENDIX 1

Investigation Location Plans




**Legend**

- CPT (ENGEO, 2018)
- CPT (ENGEO, 2022)
- Machine Borehole (ENGEO, 2022)
- Hand Auger (ENGEO, 2022)
- Machine Borehole (ENGEO, 2018)
- Hand Auger (ENGEO, 2017)
- Test Pit (ENGEO, 2018)
- Test Pit (ENGEO, 2017)
- Machine Borehole (ENGEO, 2016)
- Hand Auger (ENGEO, 2016)
- Hand Auger (ENGEO, 2018)
- CPT (Beca, 2016)
- Hand Auger (Beca, 2014)
- Test Pit (Beca, 2014)
- Machine Borehole (Beca, 2014)
- CPT (Beca, 2014)
- Plan Change 2025-05

0 250 m 500 m

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ENGEO

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| | | |
|---|---|---|
| Title: Investigation Location Plan | | |
| Client: Grafton Downs Ltd | | Size: A4 |
| Project: Paerata Rise - Plan Change Stage 9-12 | Drawn: AK | Figure No.: 2 |
| Date: 05-05-2025 | Checked: DT | |
| Proj No: 12914.000.006 | Scale: 1:14500 | Version: Final |

# APPENDIX 2:

Liquefaction Analysis

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

# LIQUEFACTION ANALYSIS REPORT

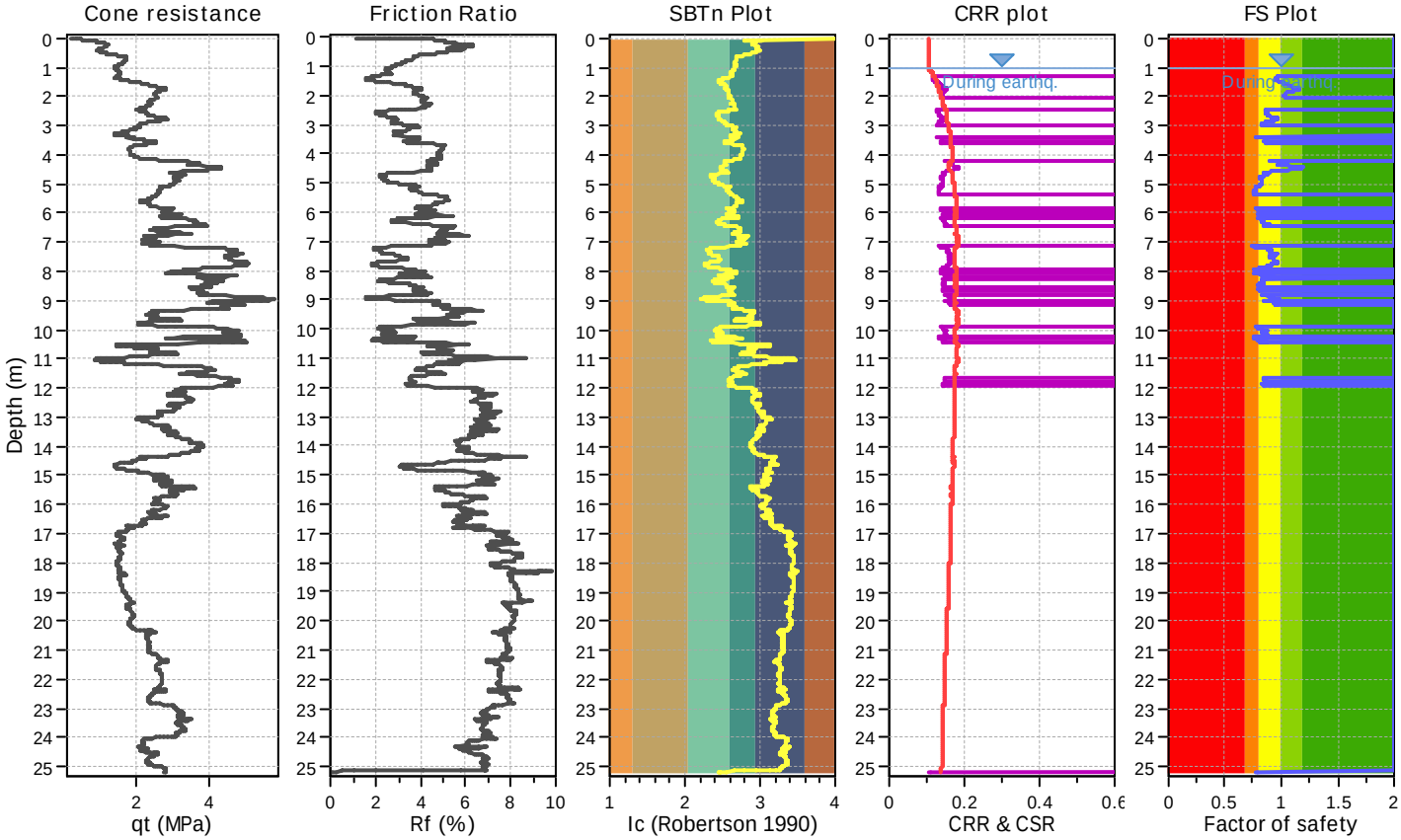
Project title :

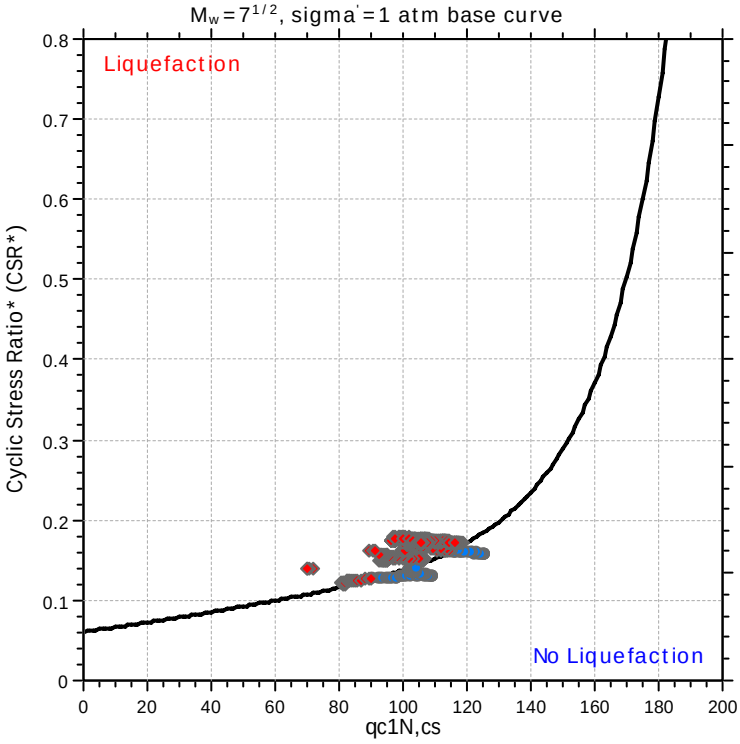
Location :

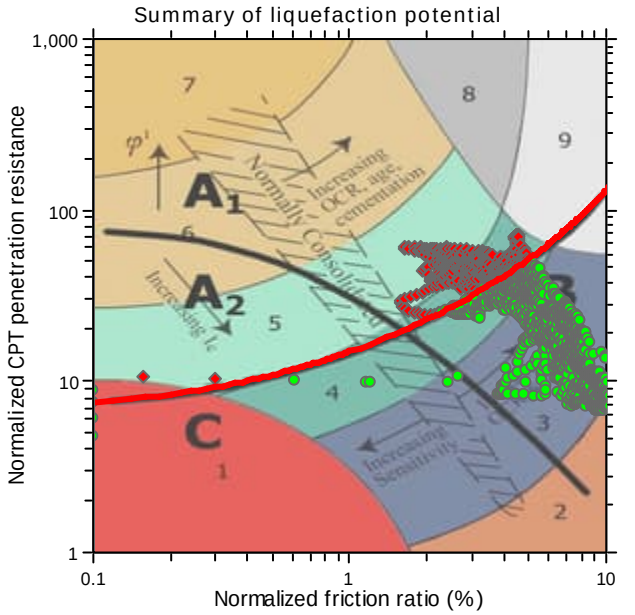
CPT file : CPT01-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

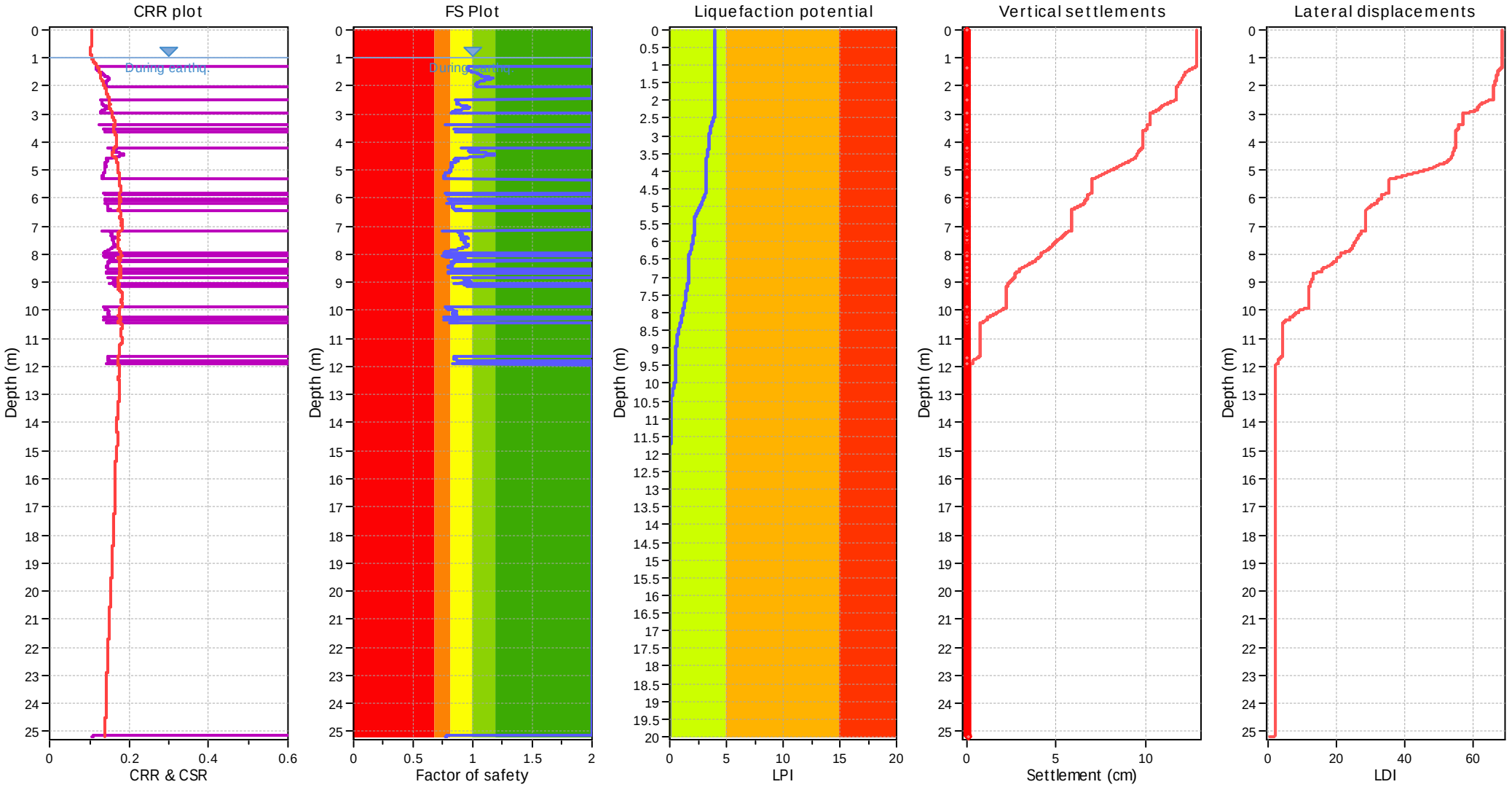



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

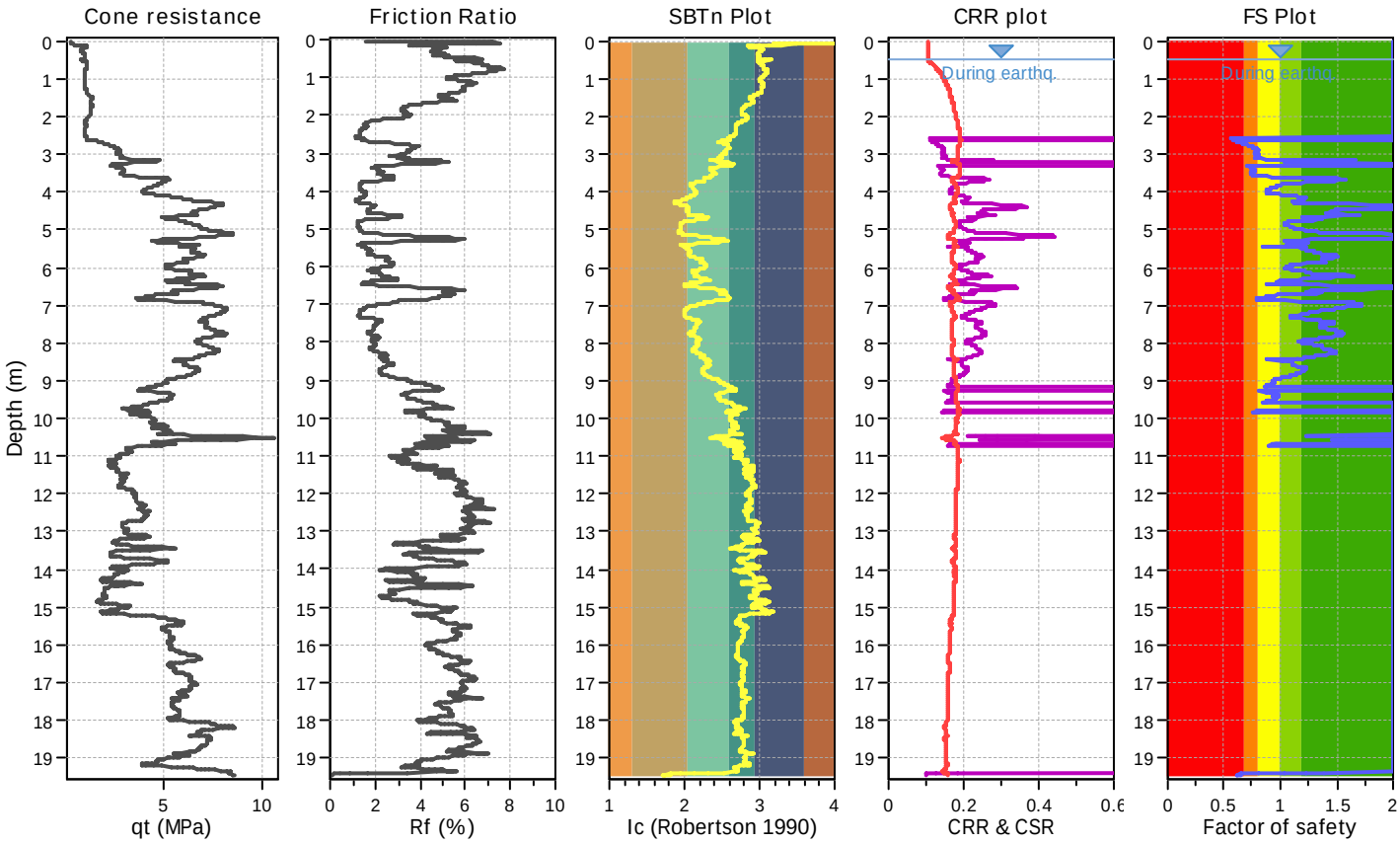
Project title :

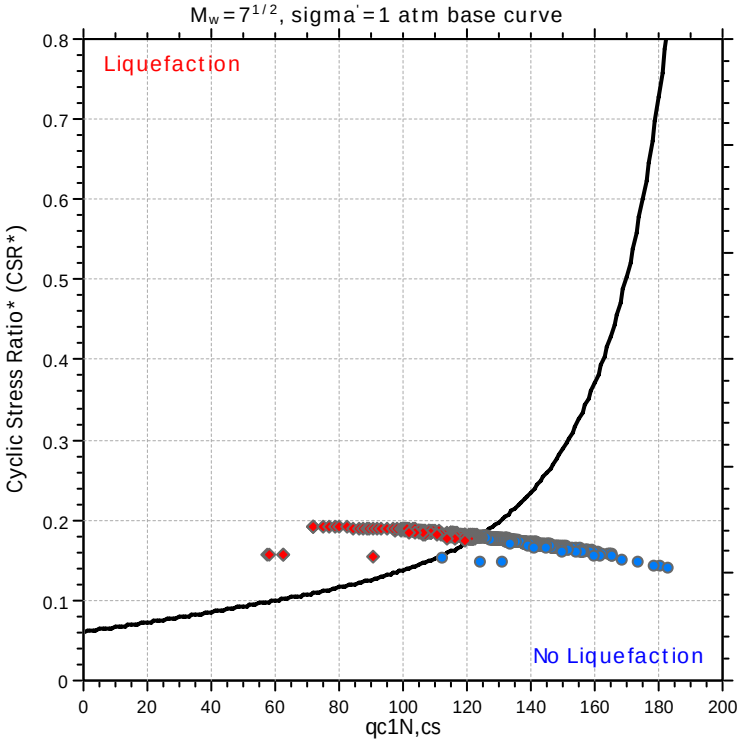
Location :

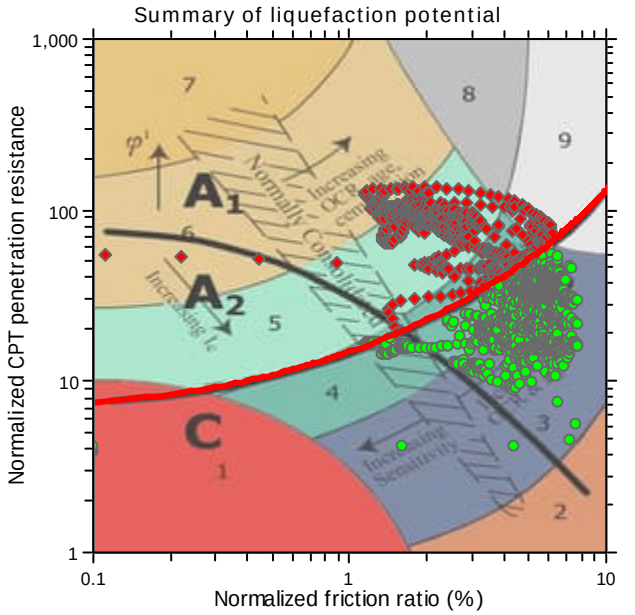
CPT file : CPT02-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 0.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 0.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

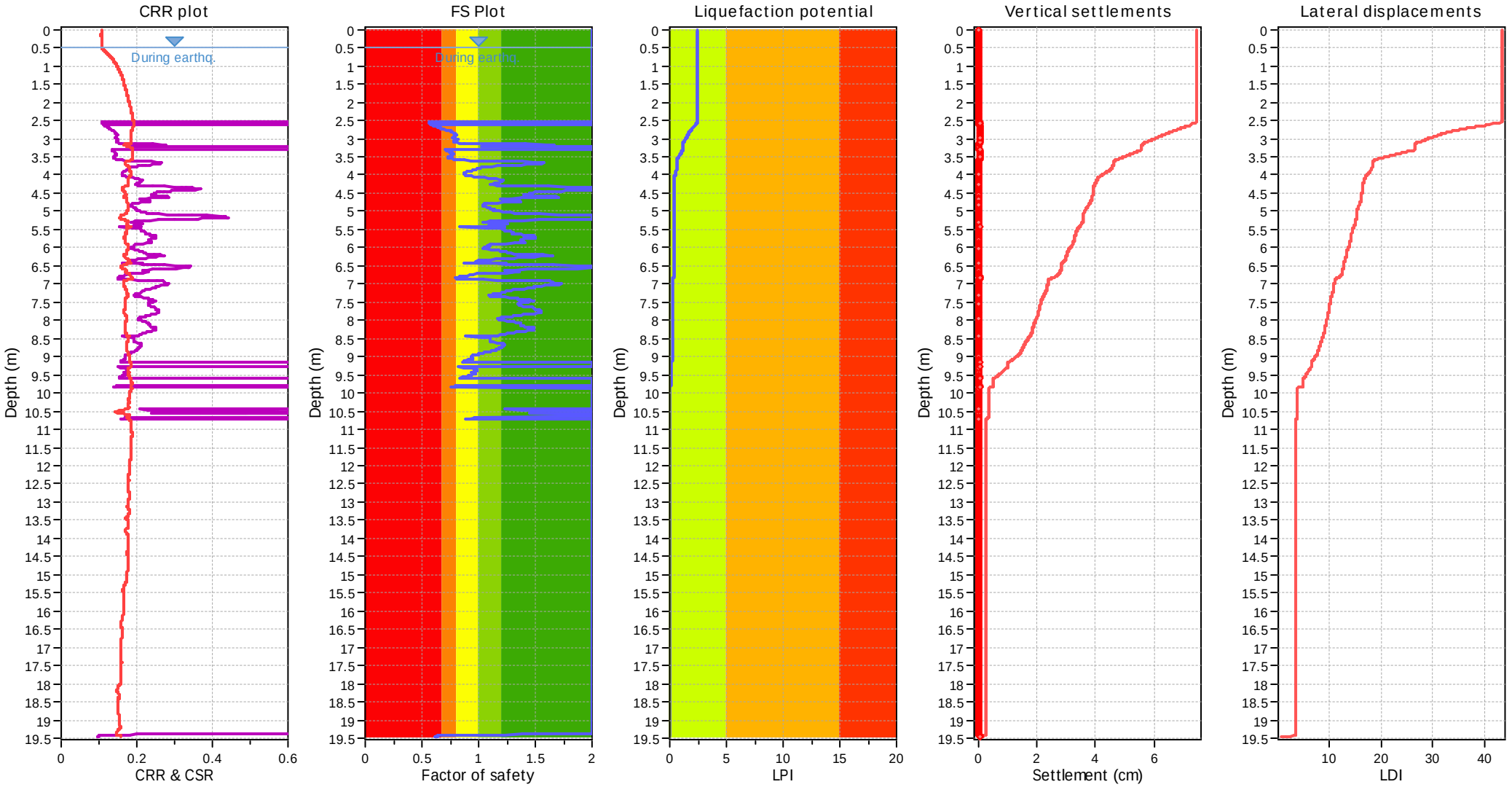



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 0.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 0.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

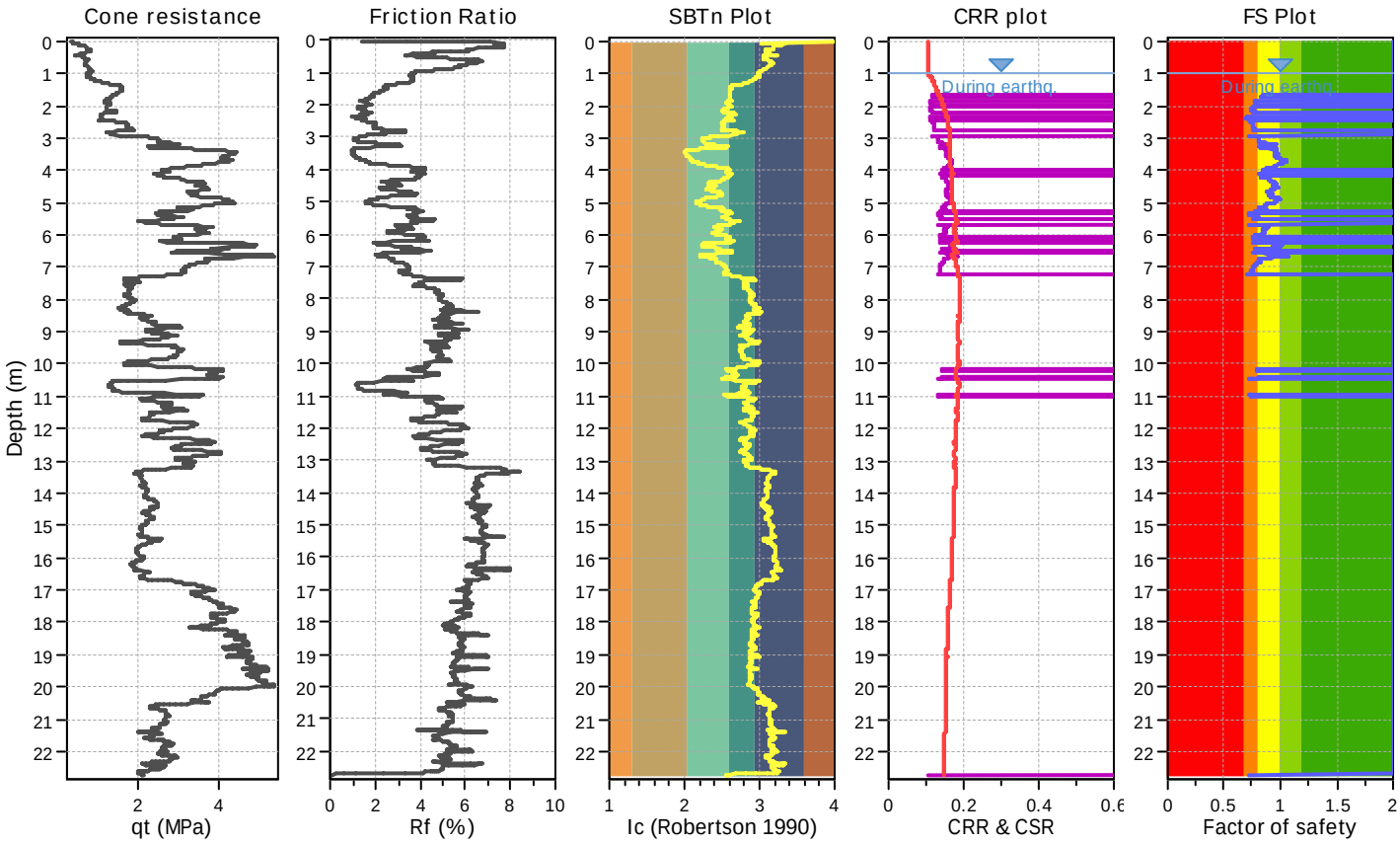
Project title :

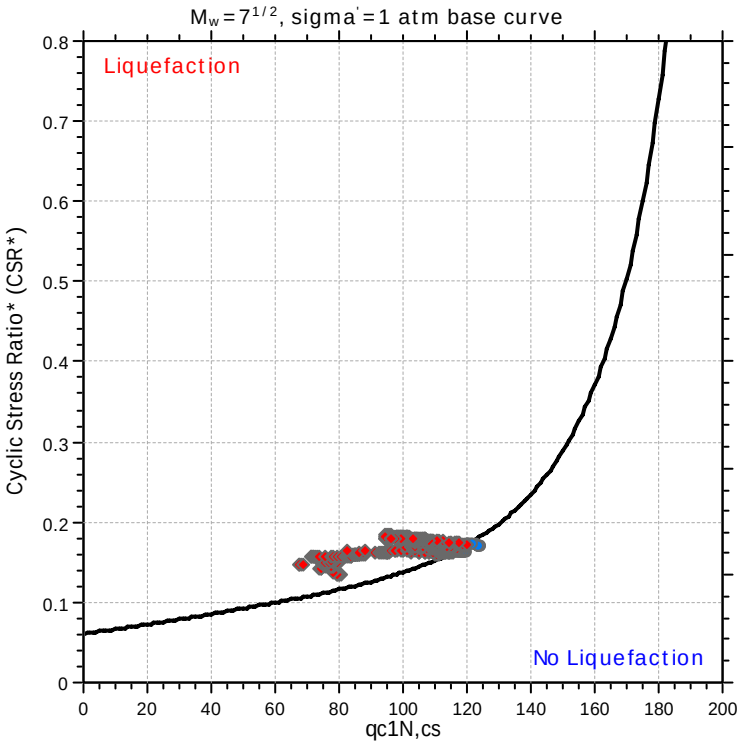
Location :

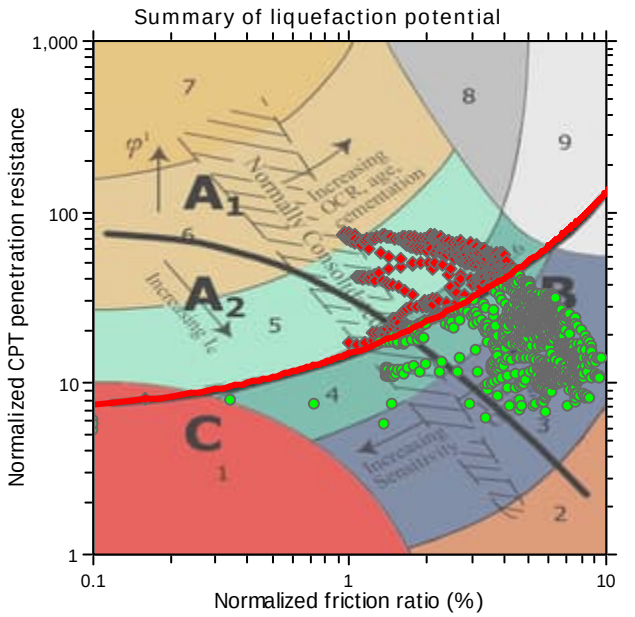
CPT file : CPT03-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

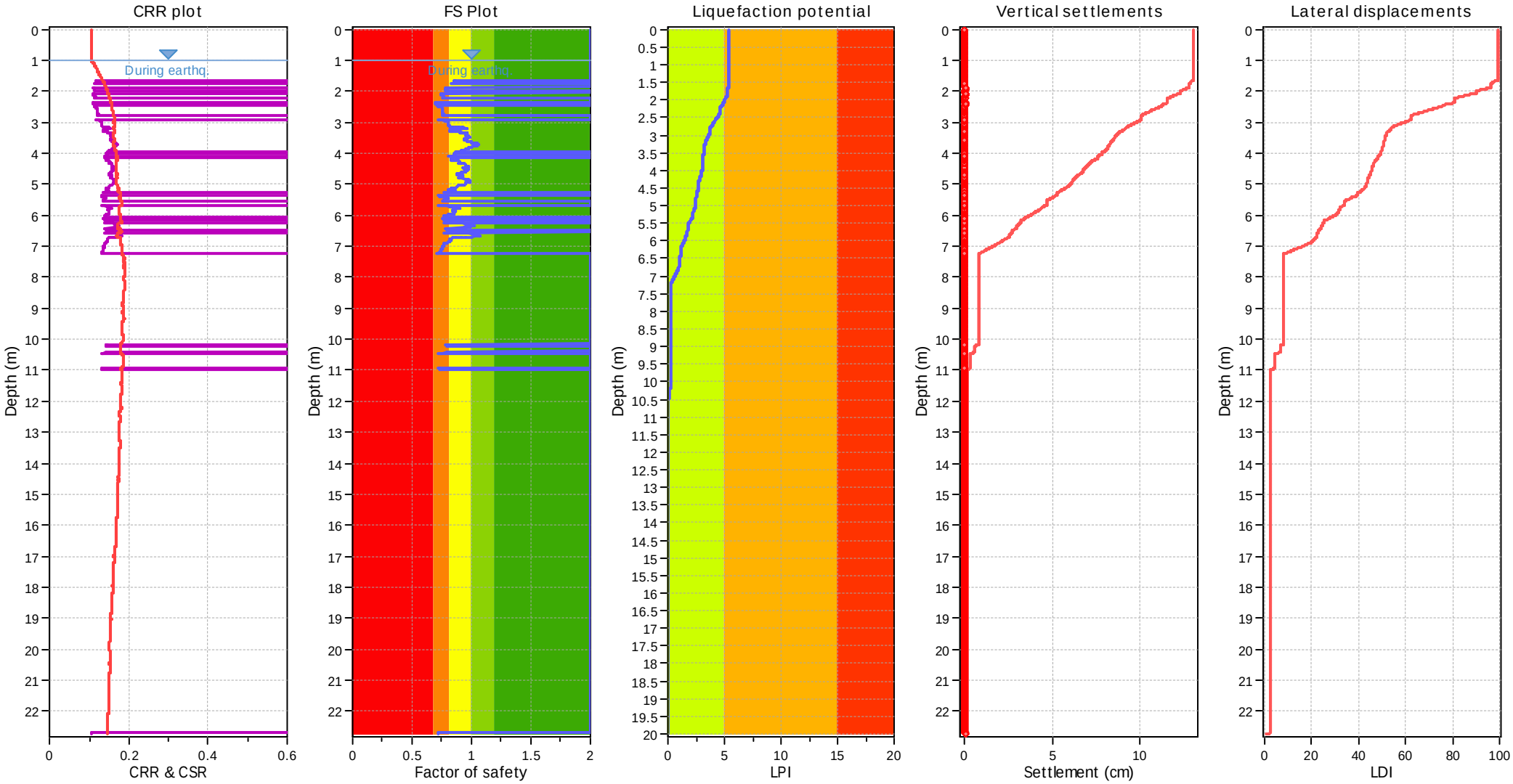



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

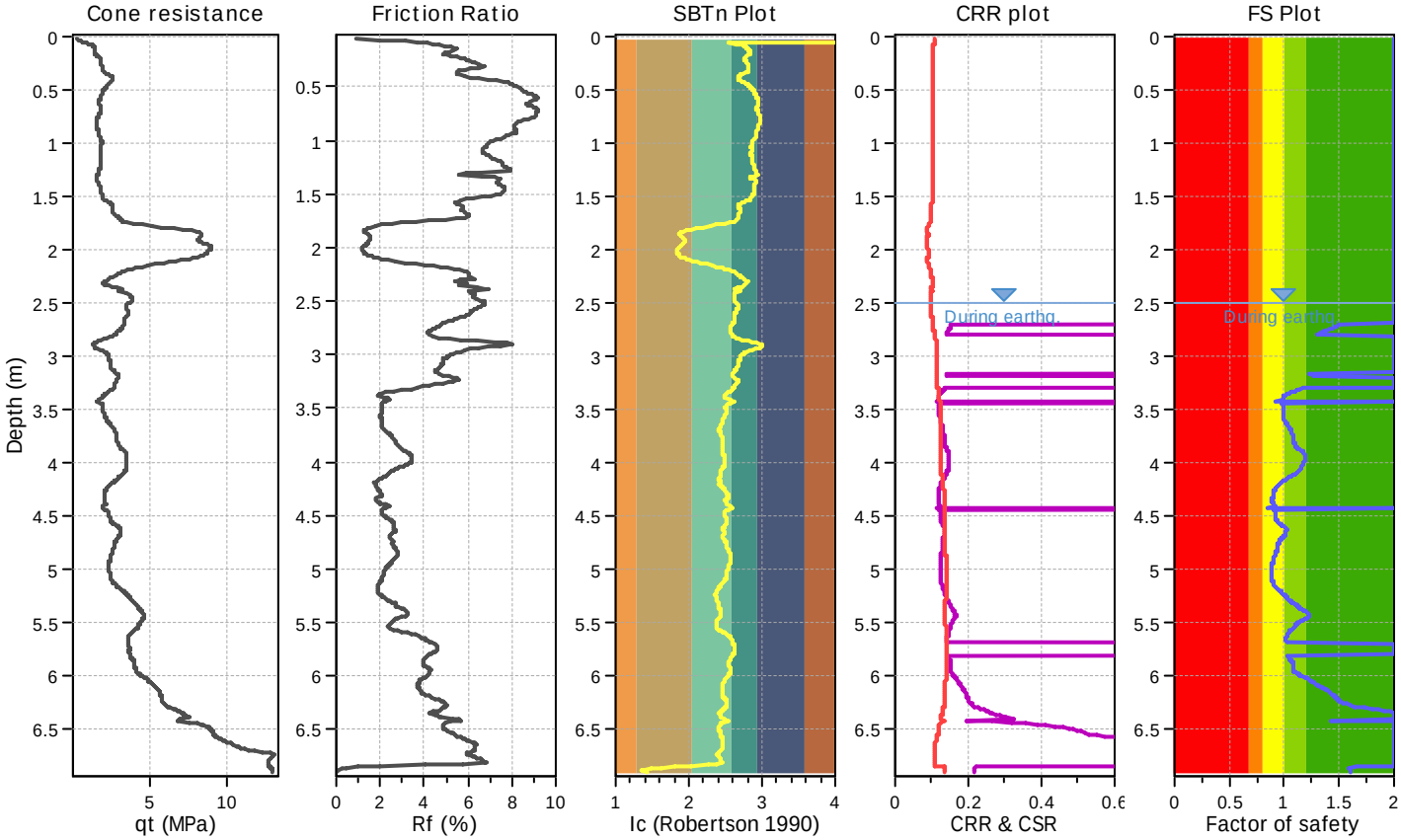
Project title :

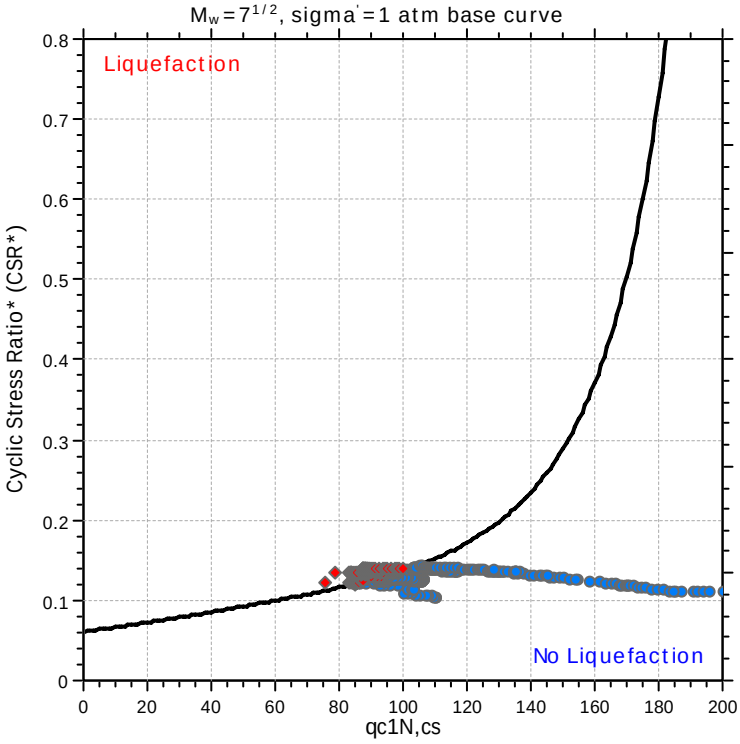
Location :

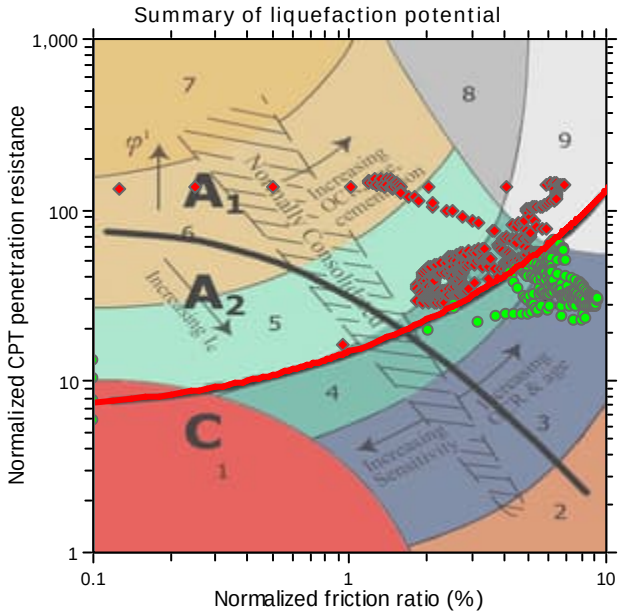
CPT file : CPT04-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 2.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 2.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

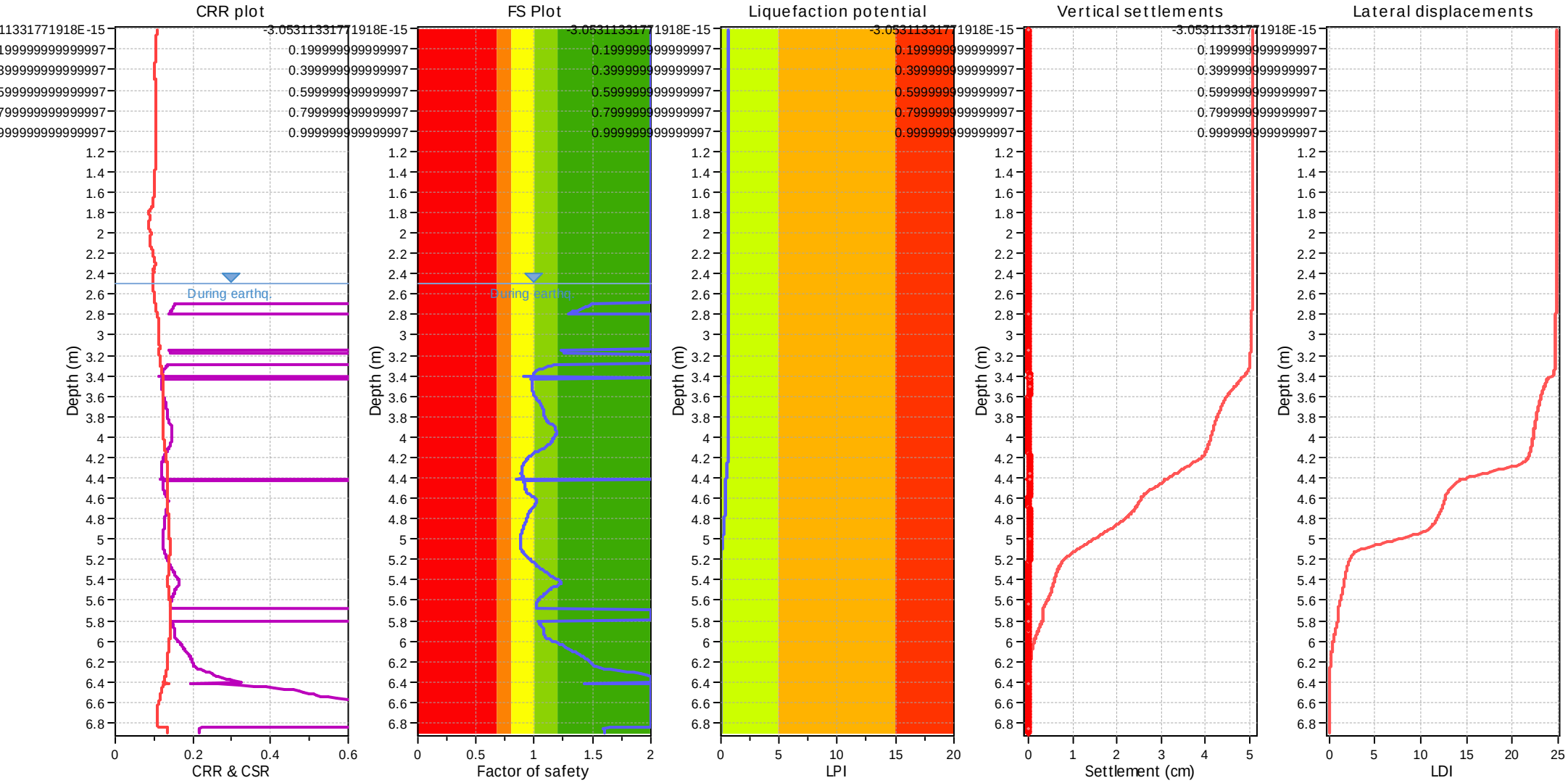



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 2.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 2.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

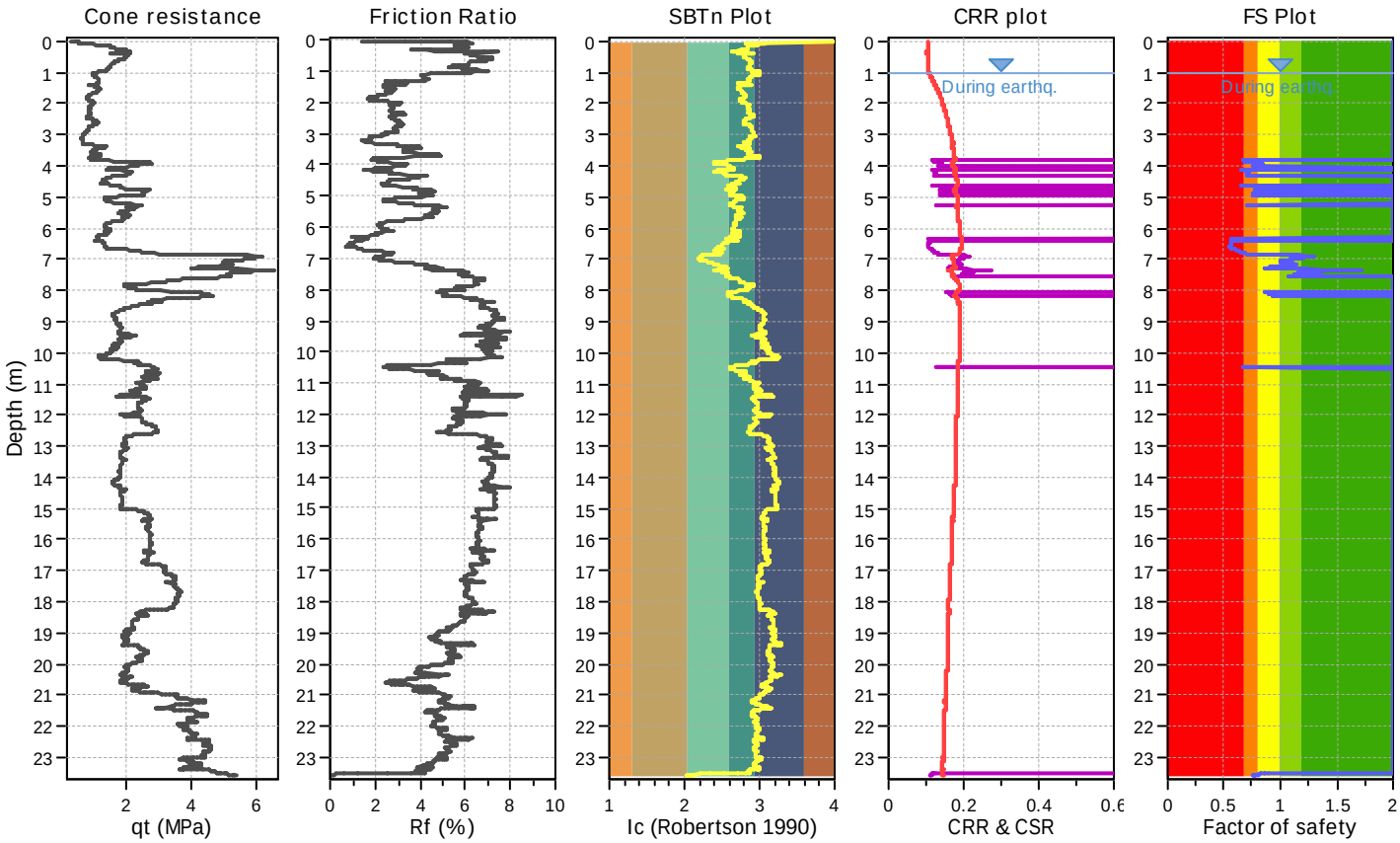
Project title :

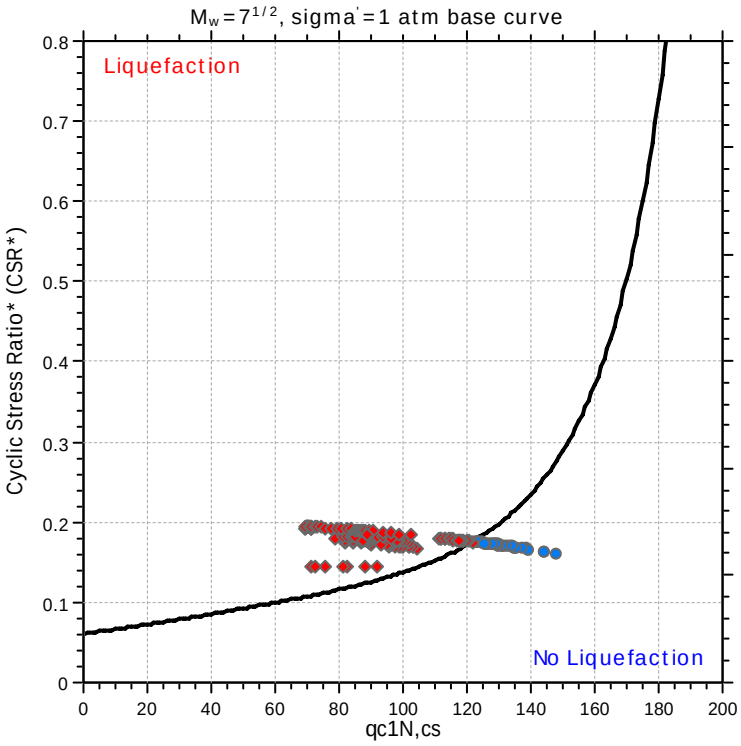
Location :

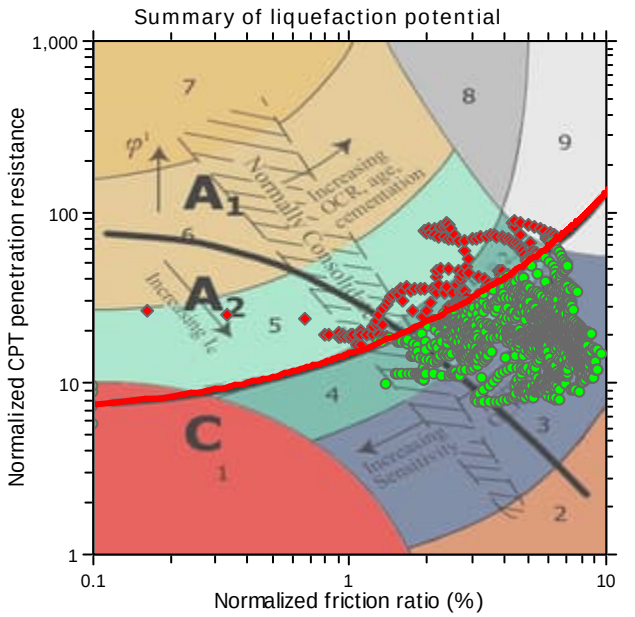
CPT file : CPT05-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

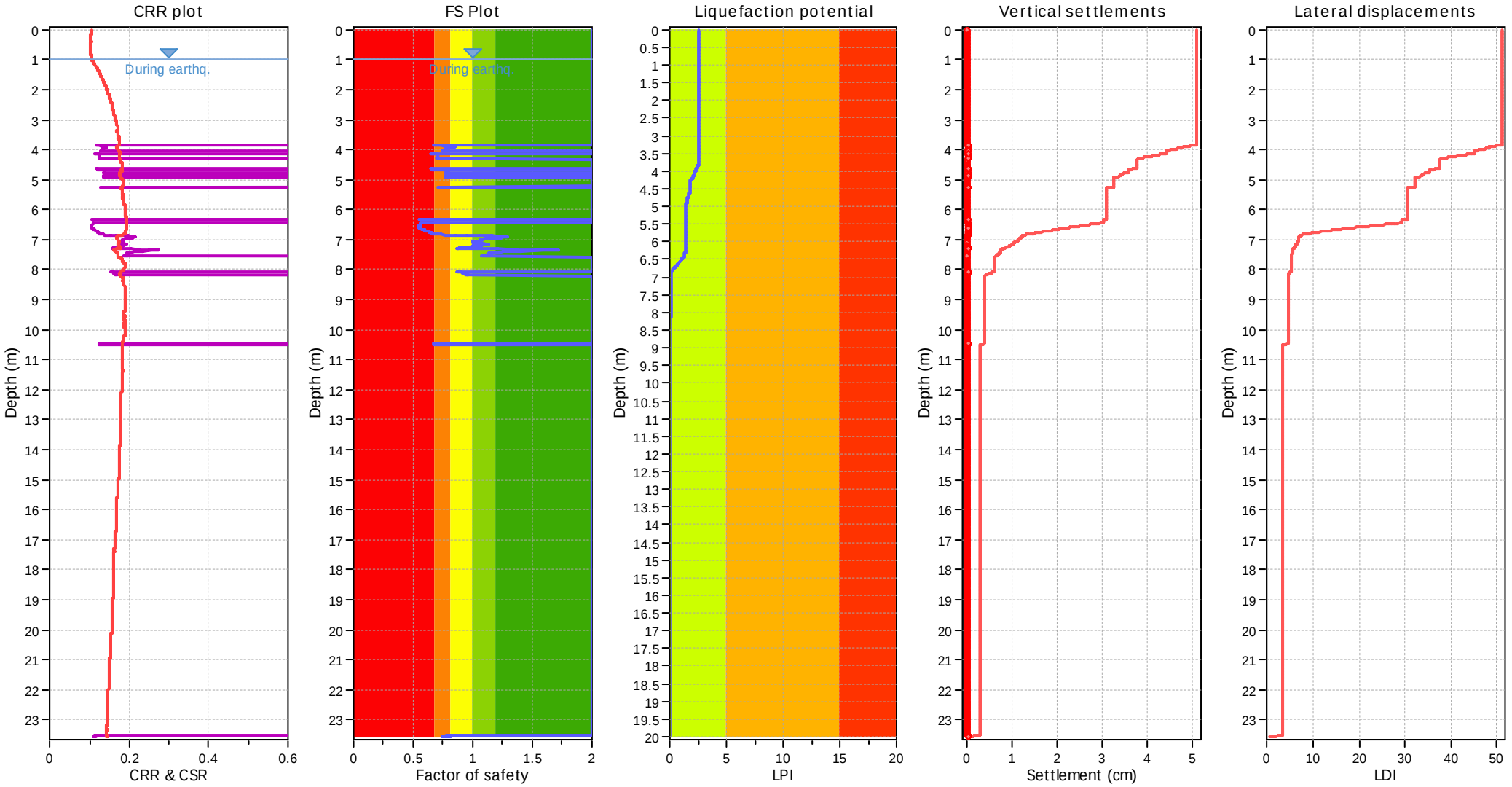



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

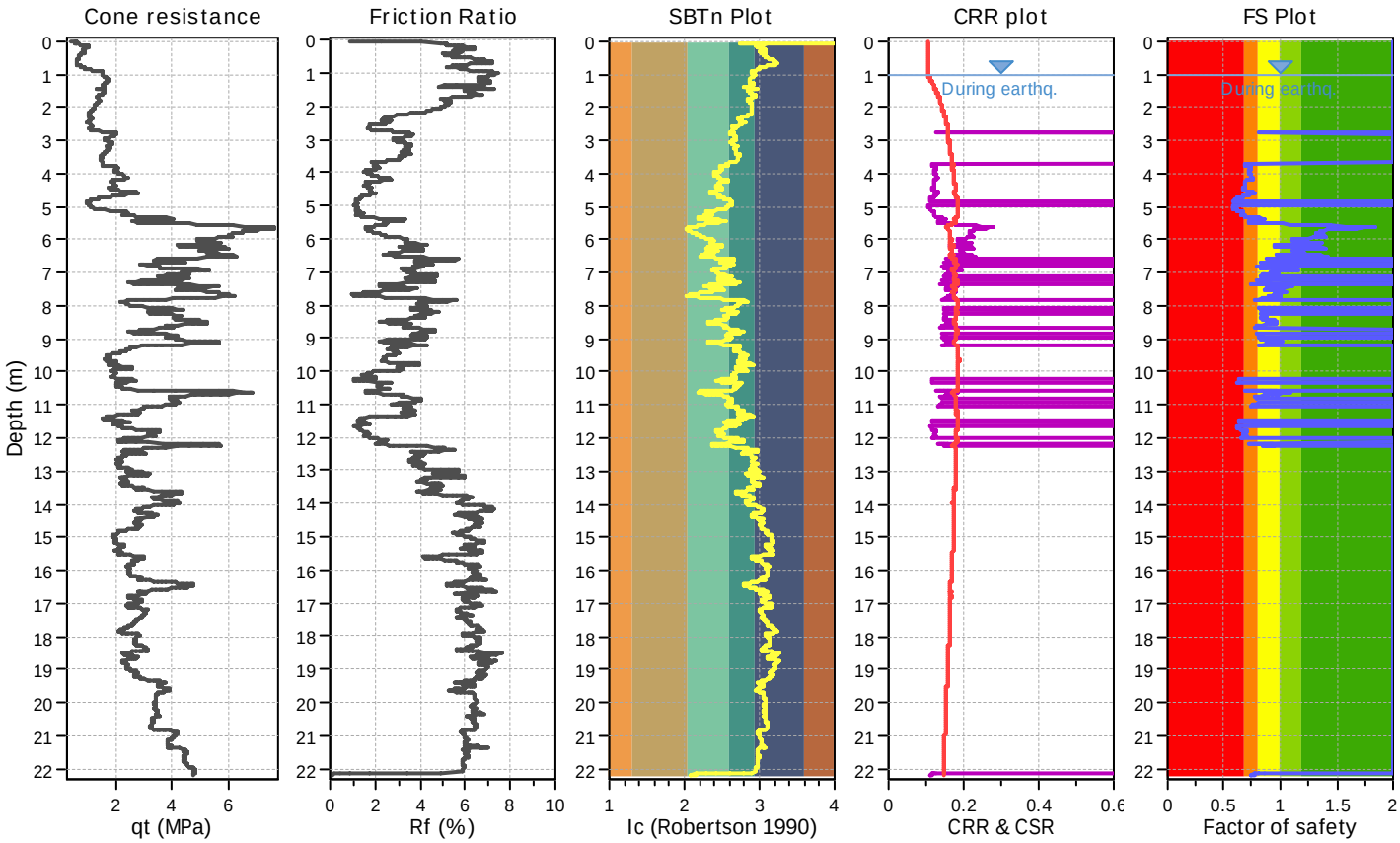
Project title :

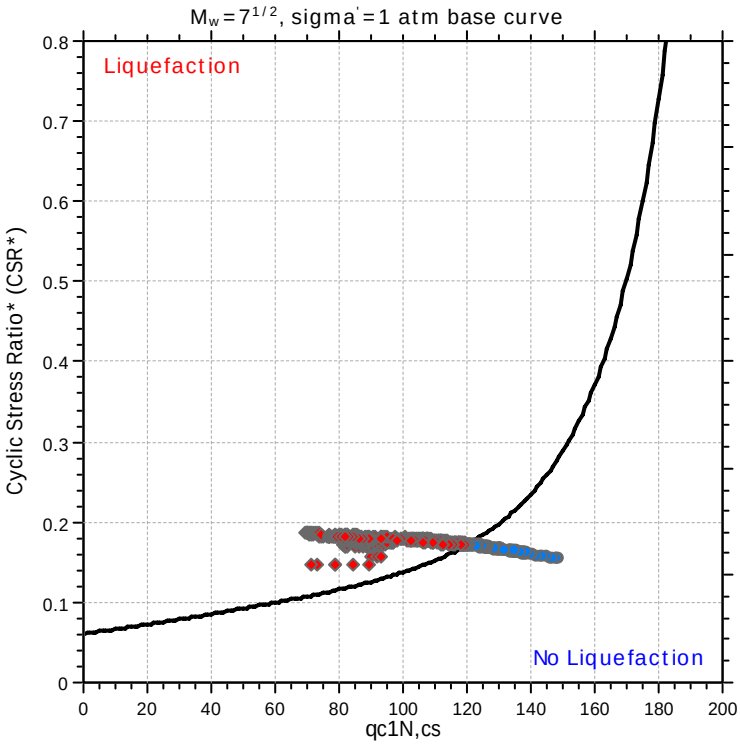
Location :

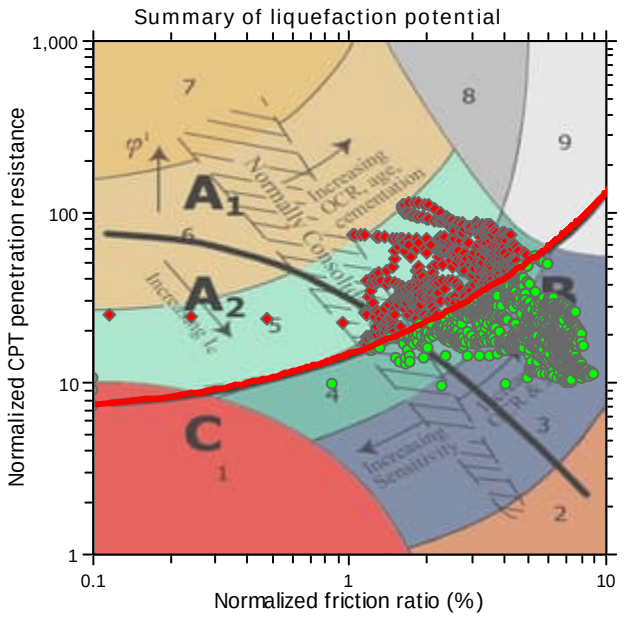
CPT file : CPT06-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

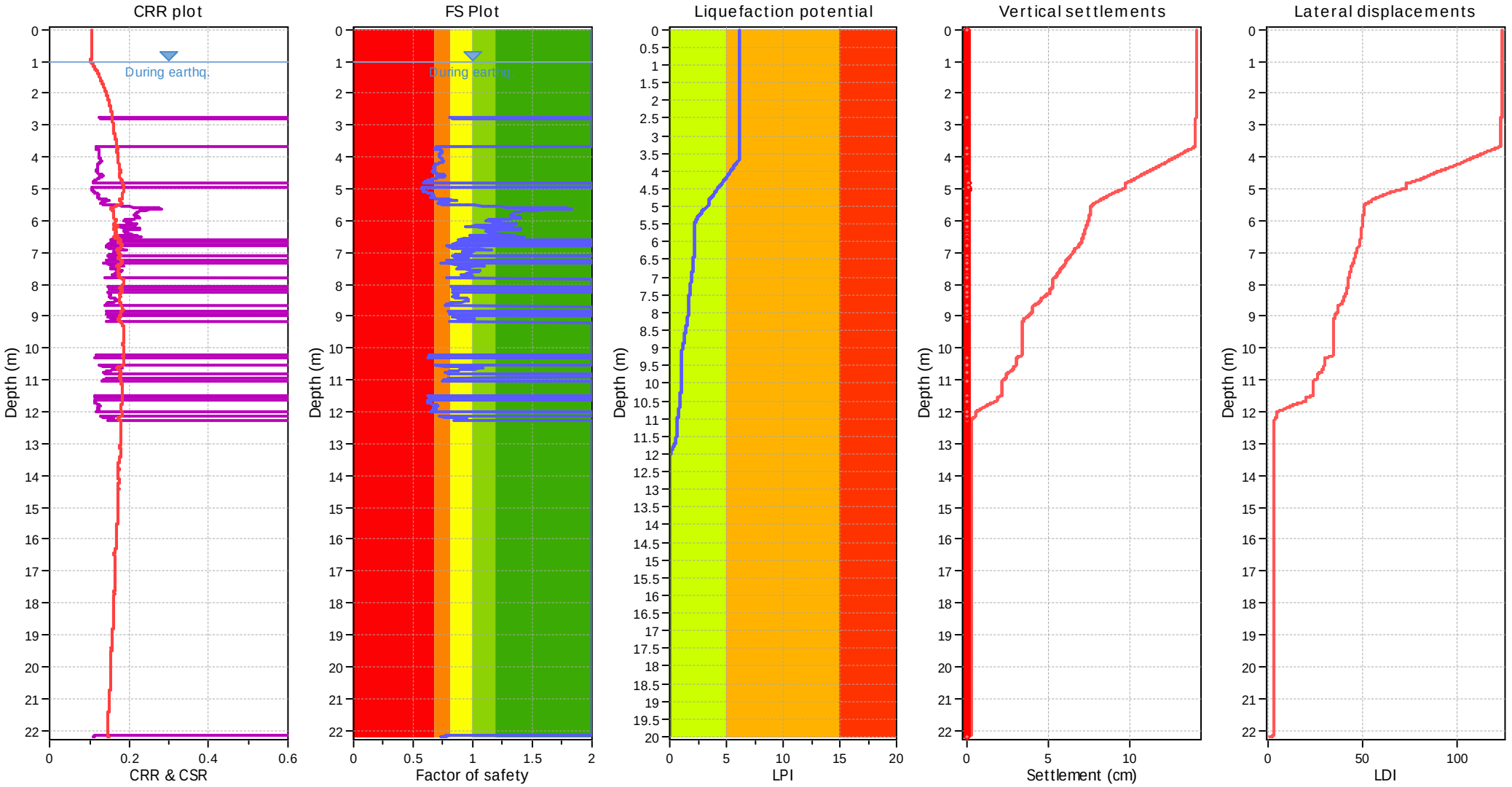



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

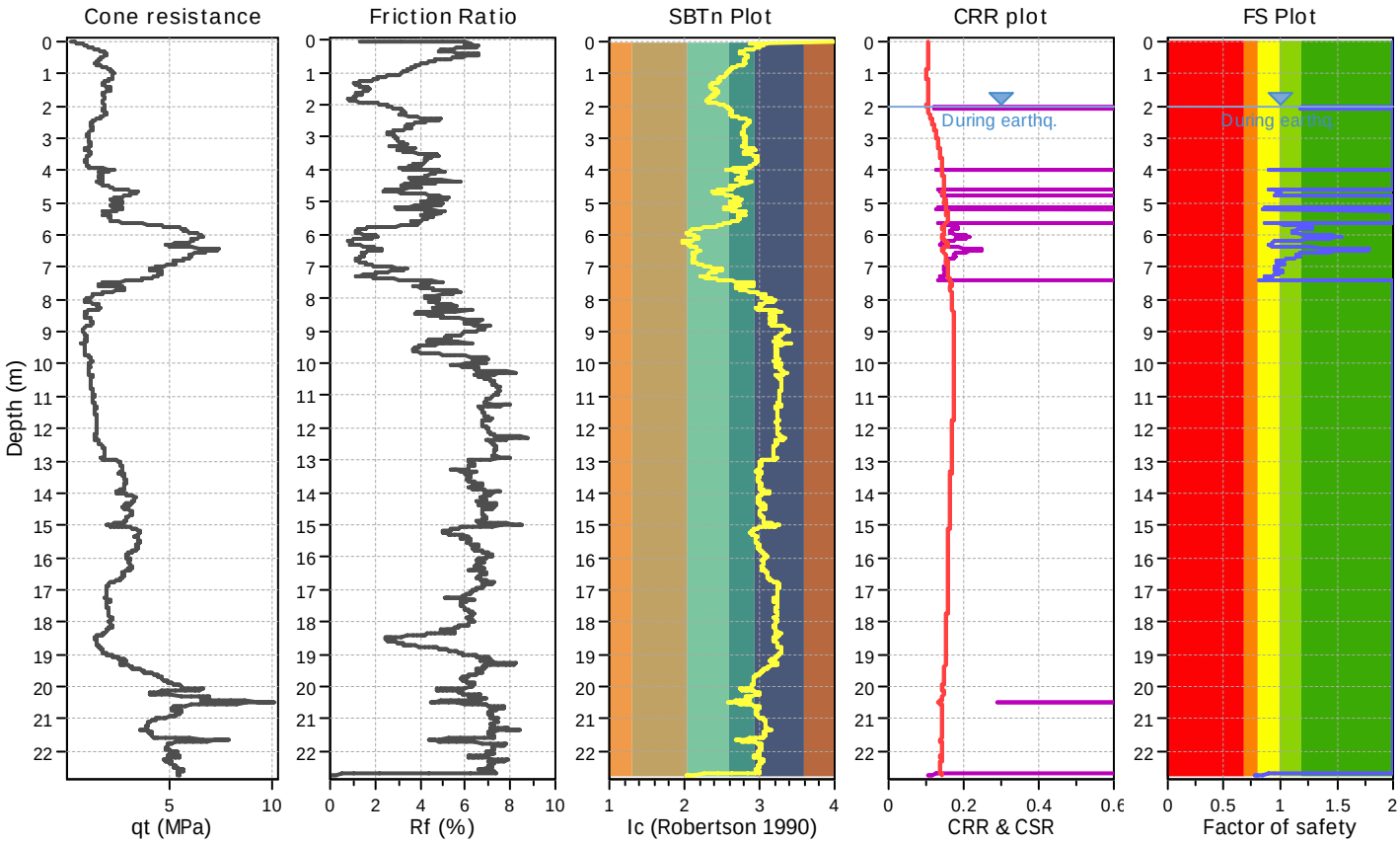
Project title :

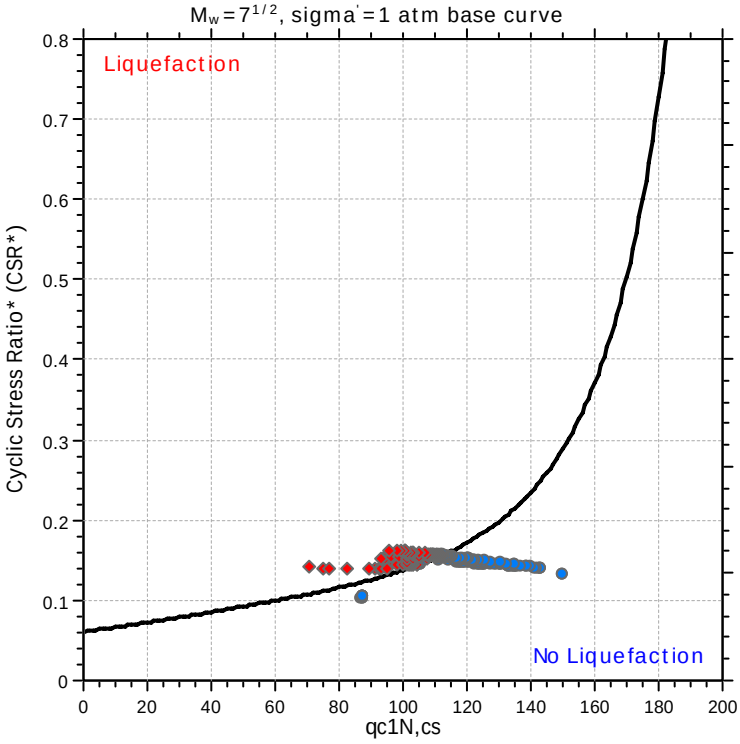
Location :

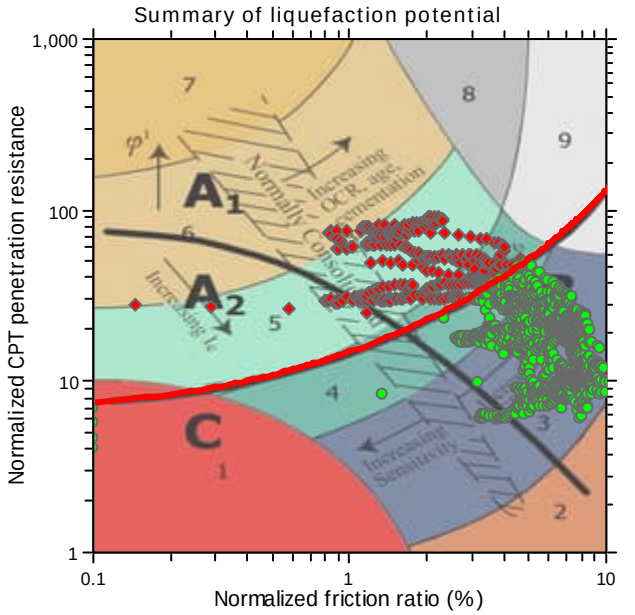
CPT file : CPT07-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 2.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 2.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

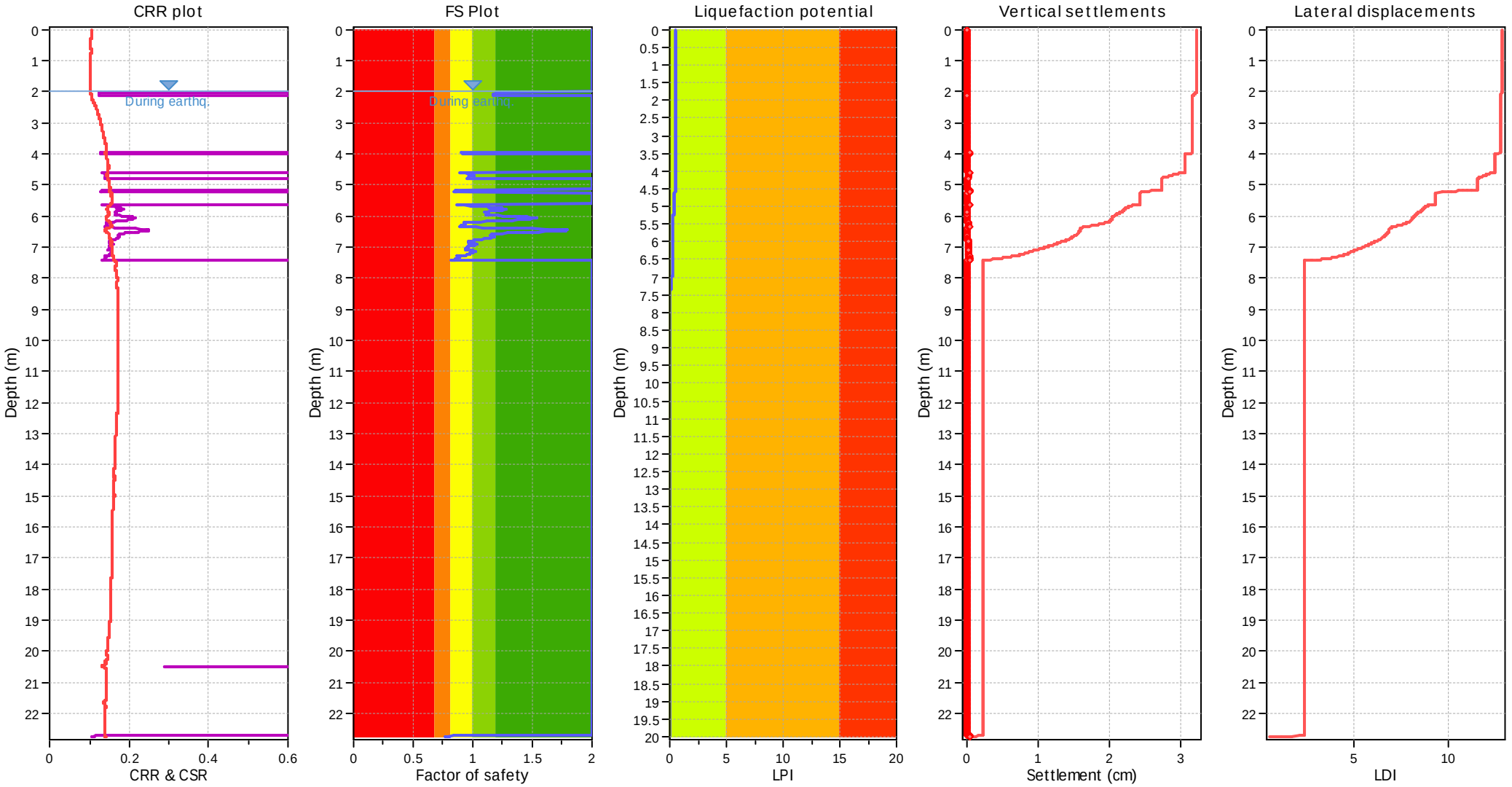



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 2.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 2.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

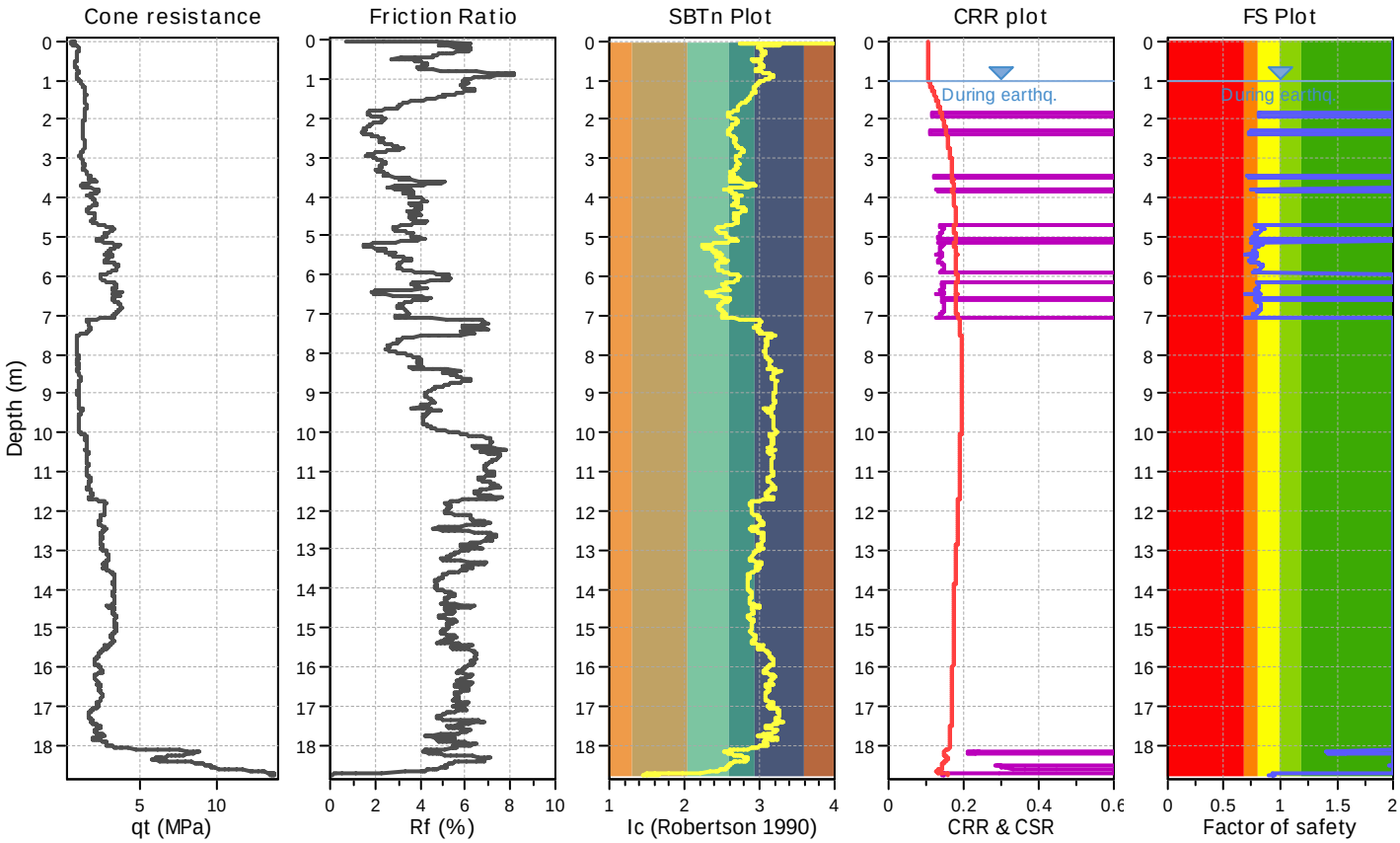
Project title :

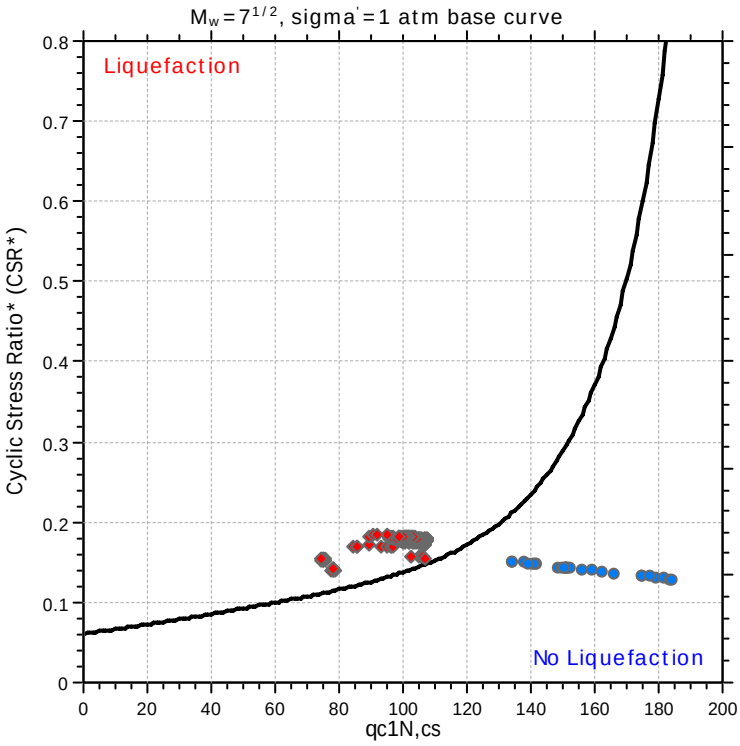
Location :

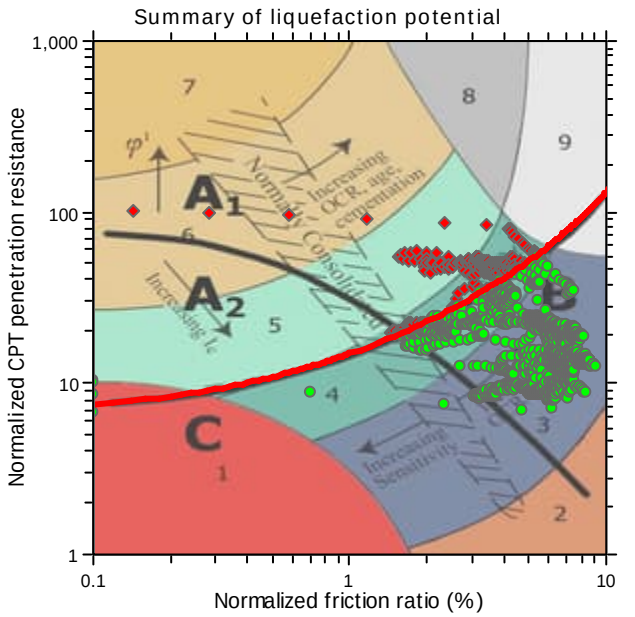
CPT file : CPT08-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

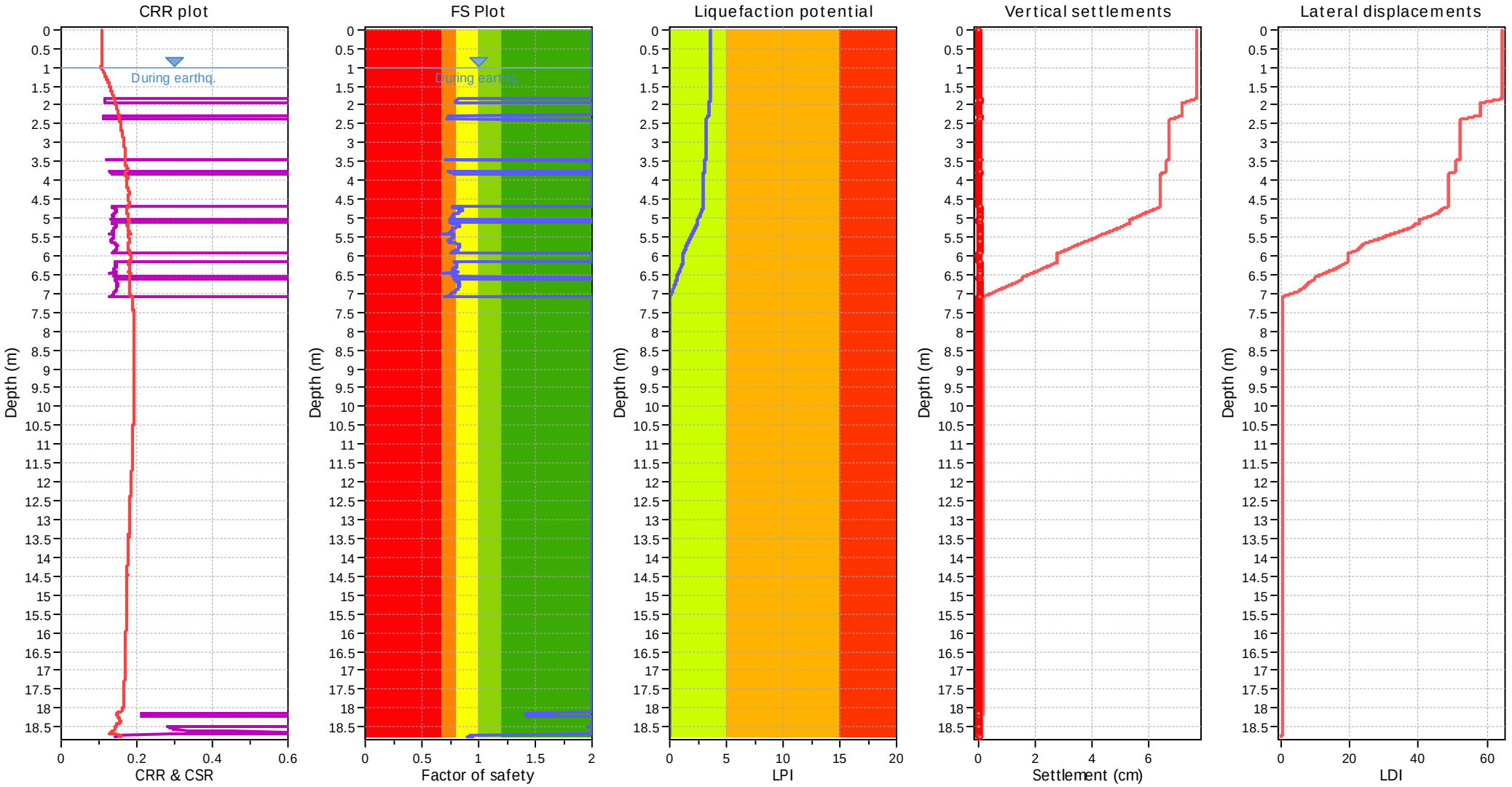



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

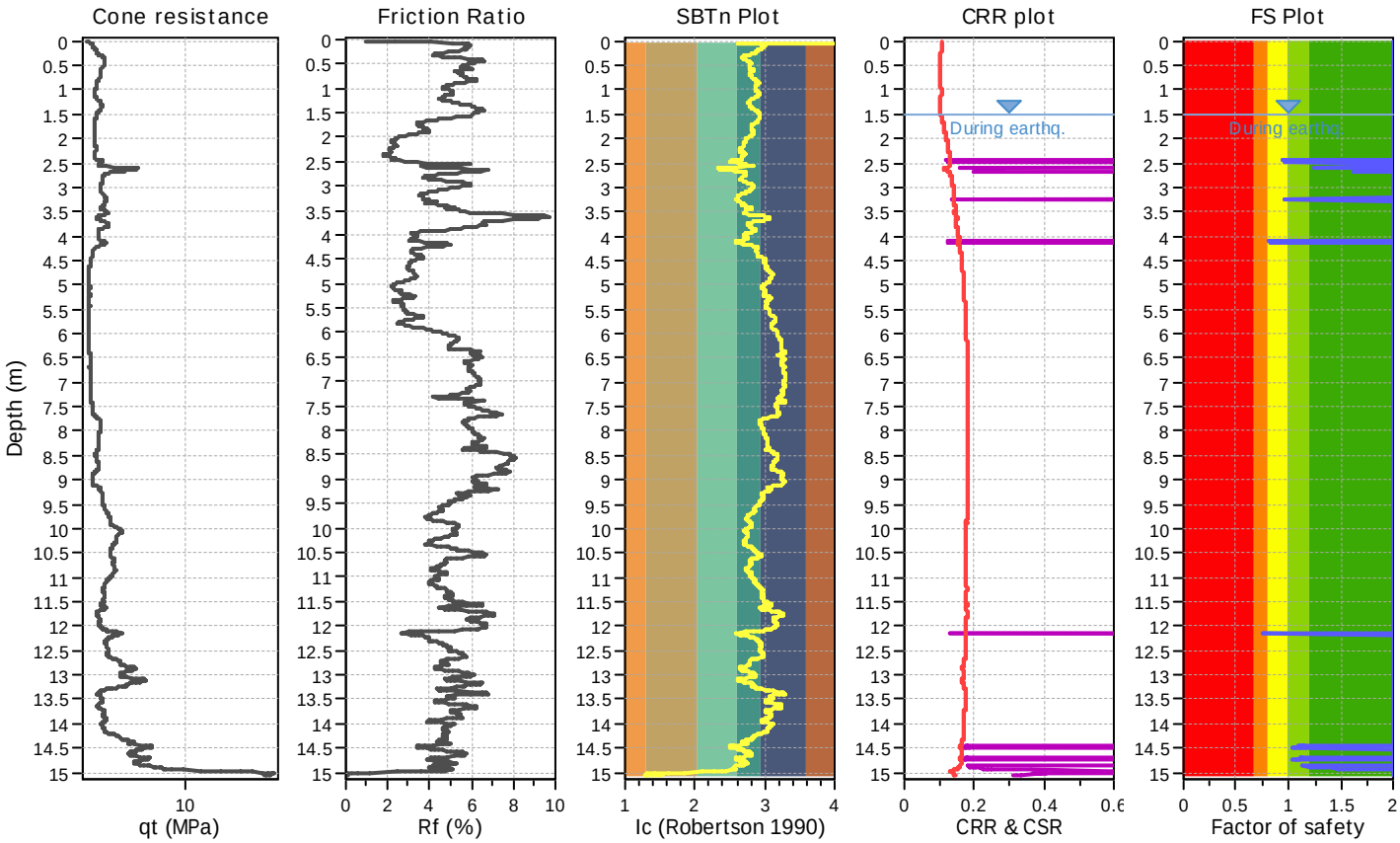
Project title :

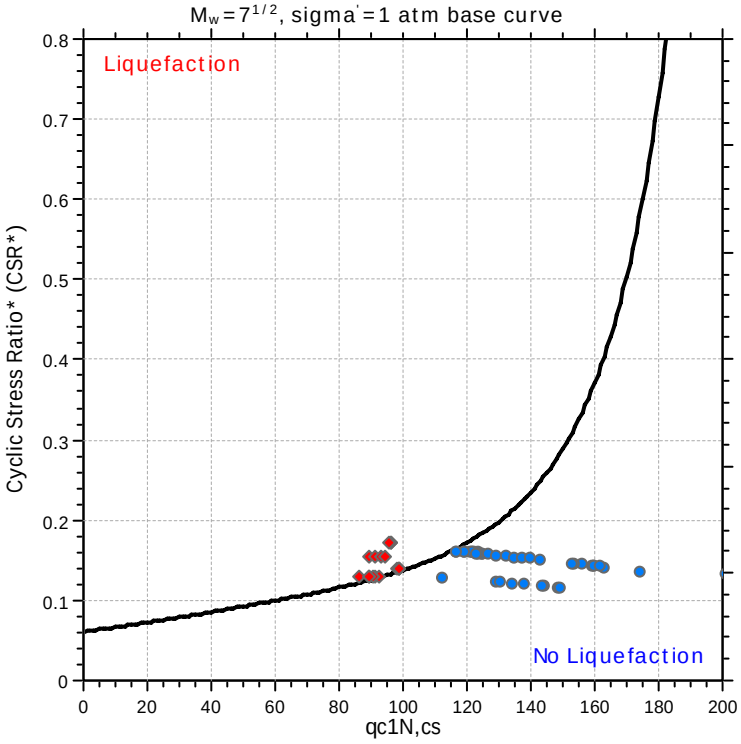
Location :

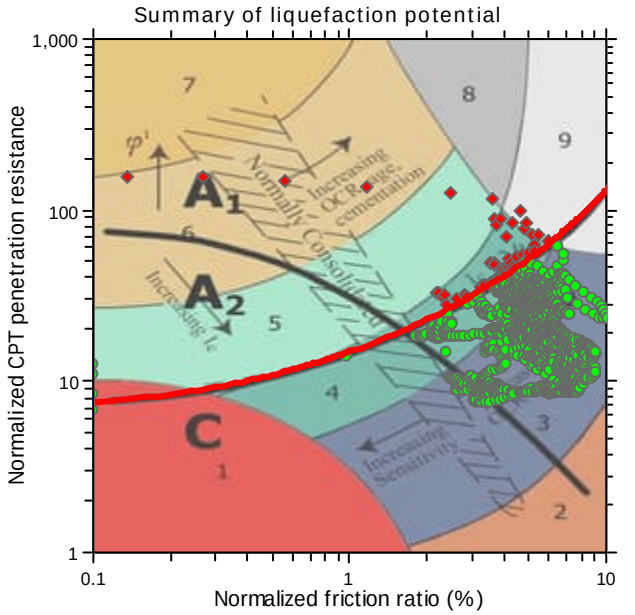
CPT file : CPT09-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

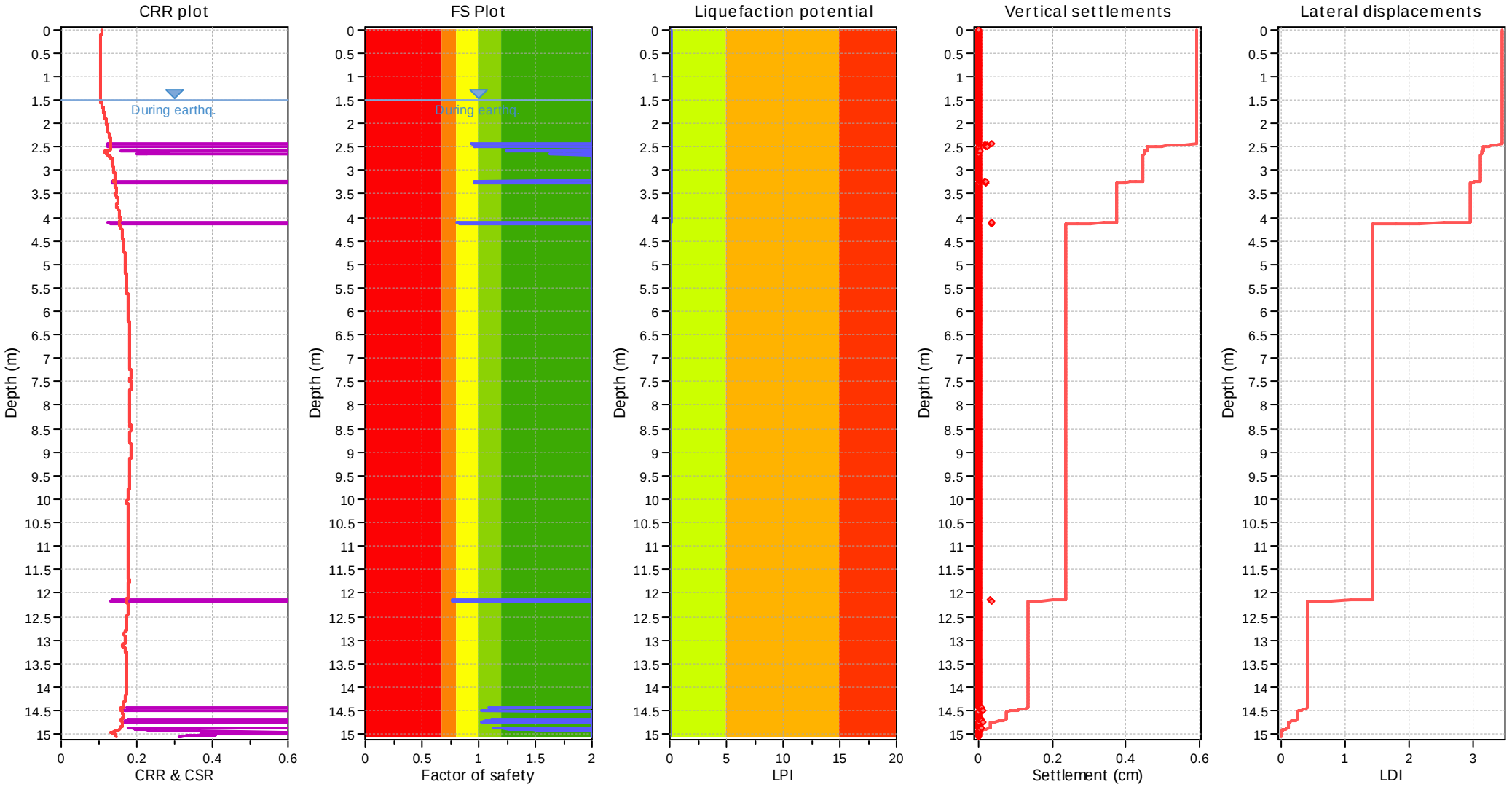



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

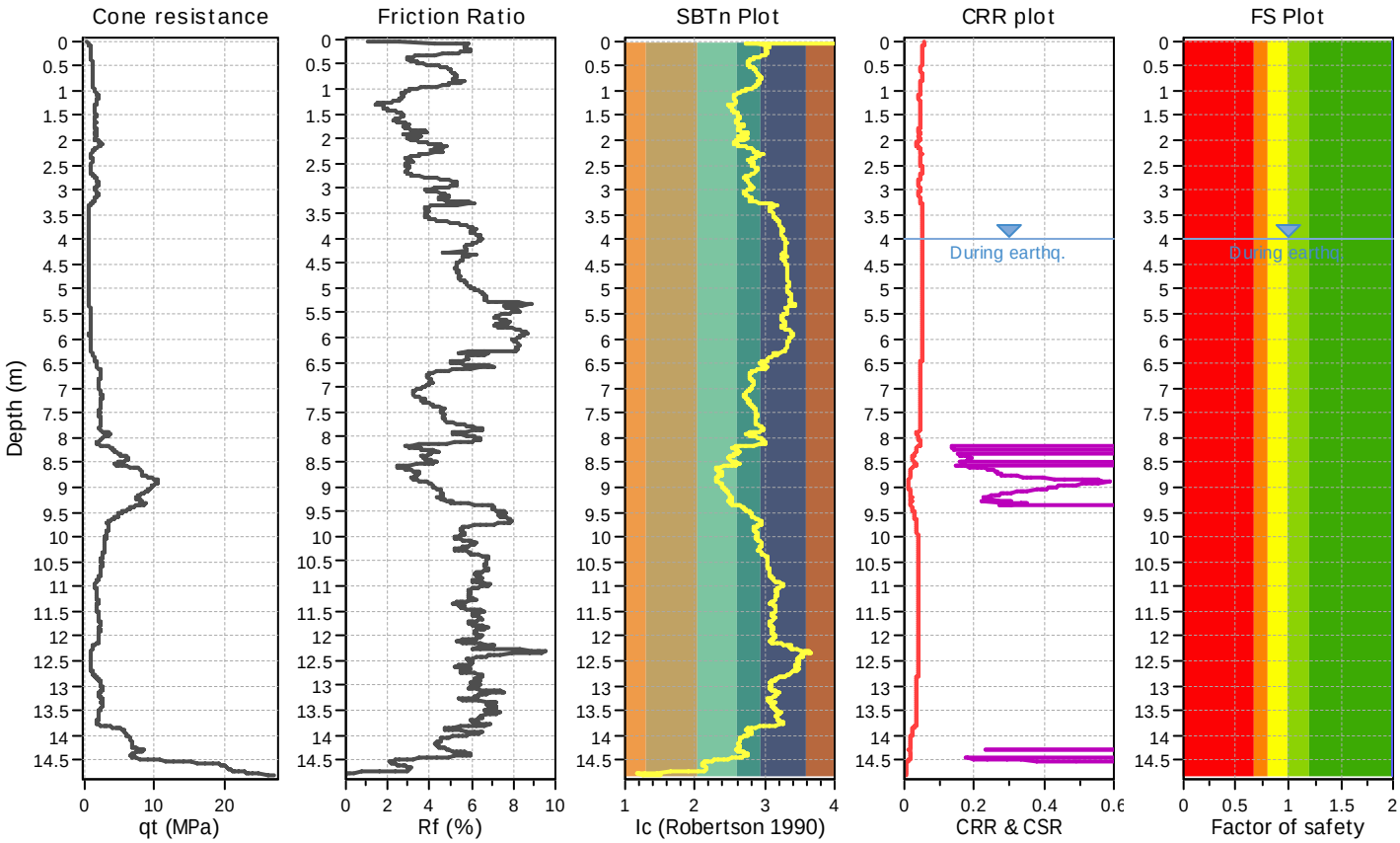
Project title :

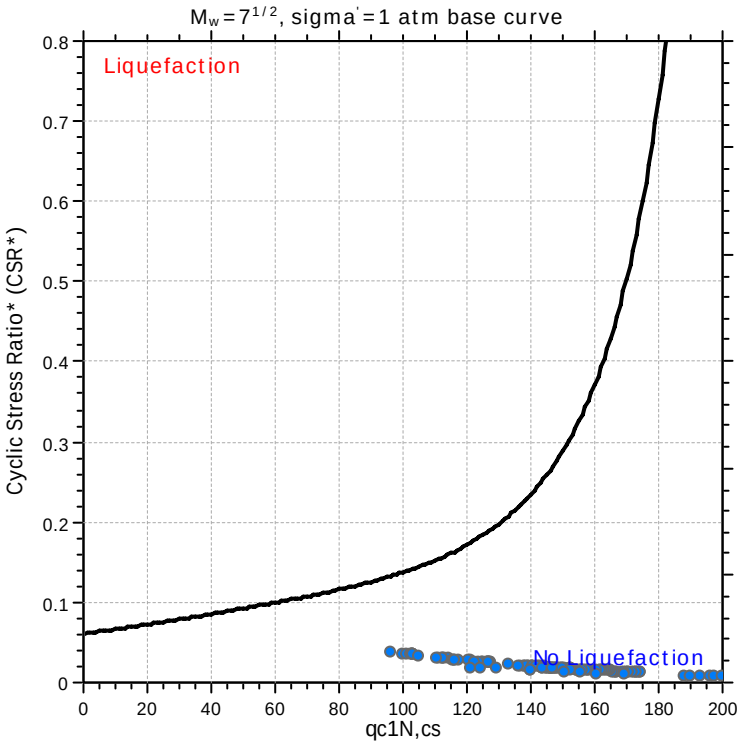
Location :

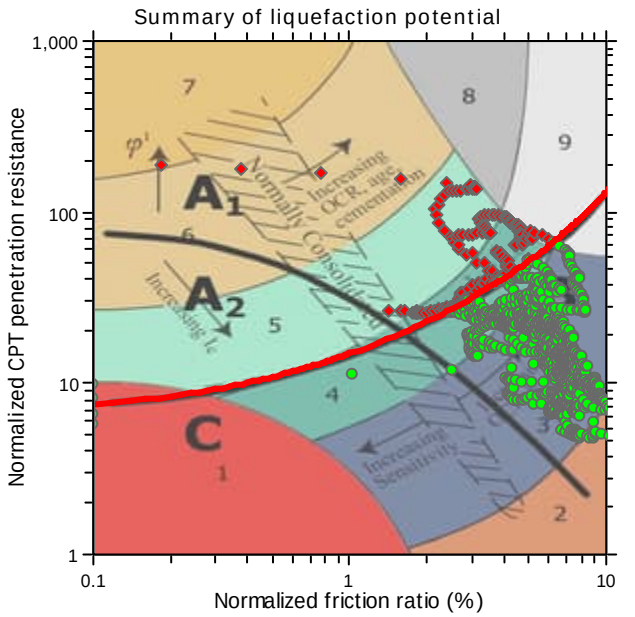
CPT file : CPT10-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 4.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 4.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 0.00 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

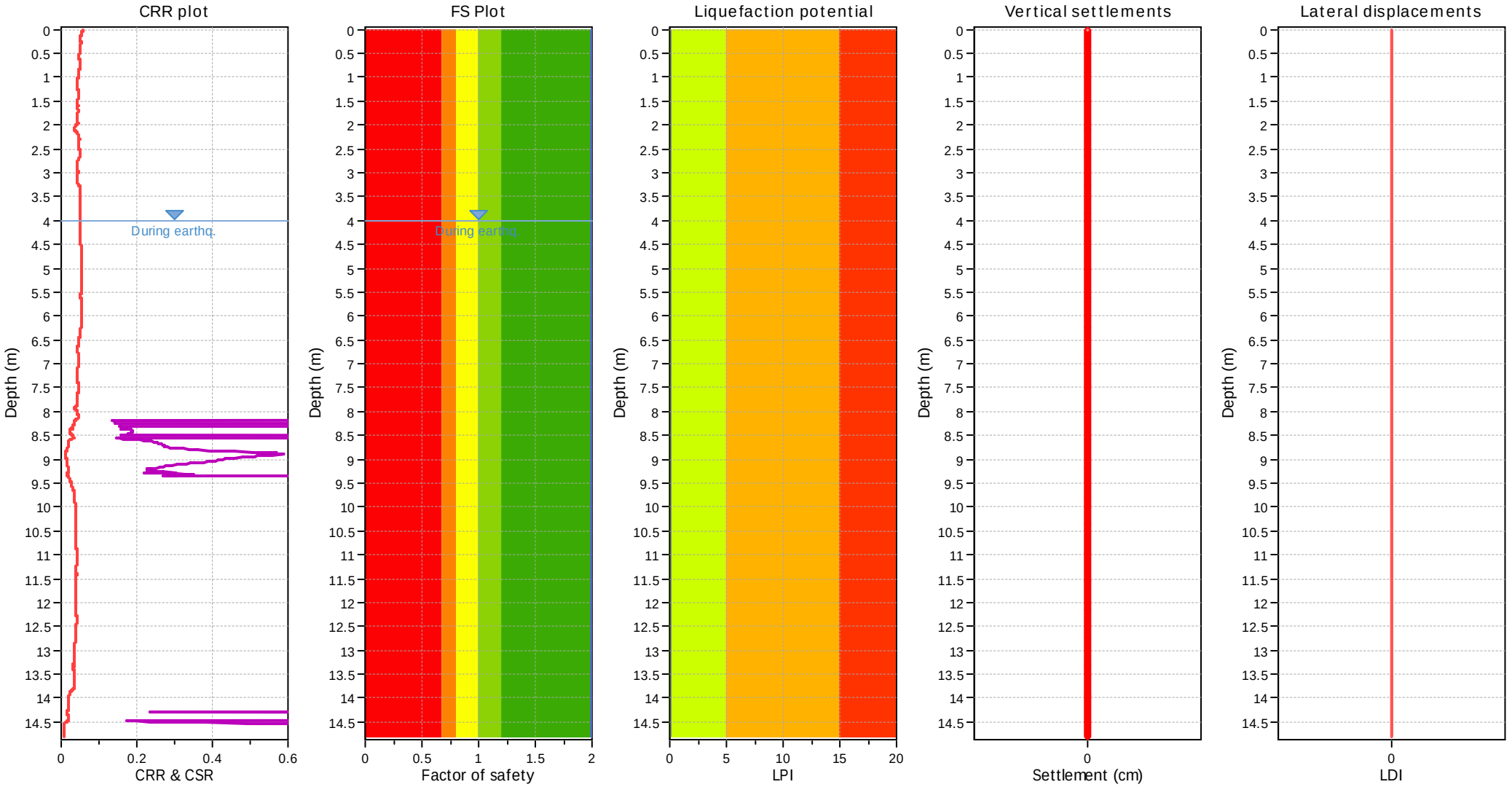



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 4.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 0.00 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 4.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

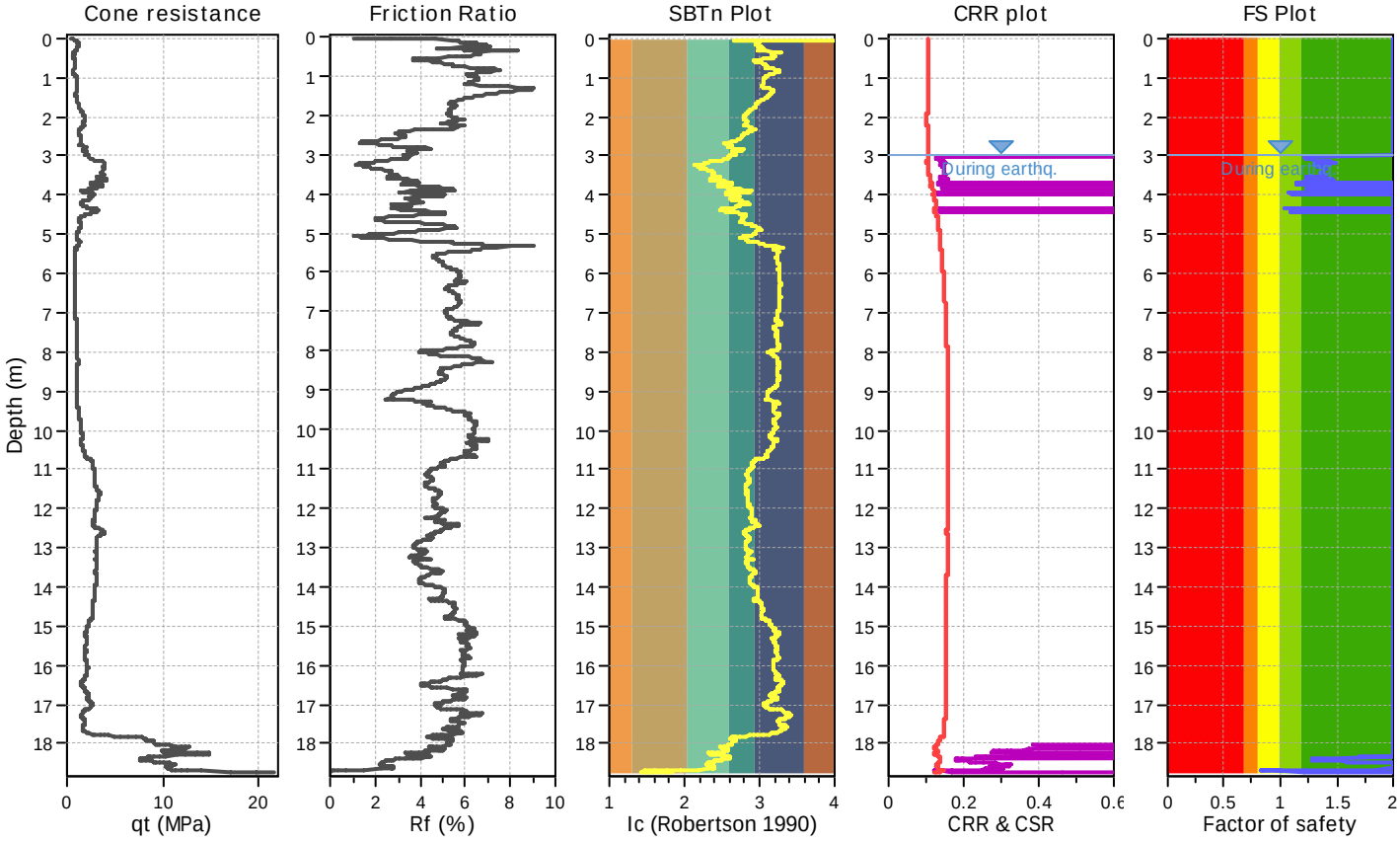
Project title :

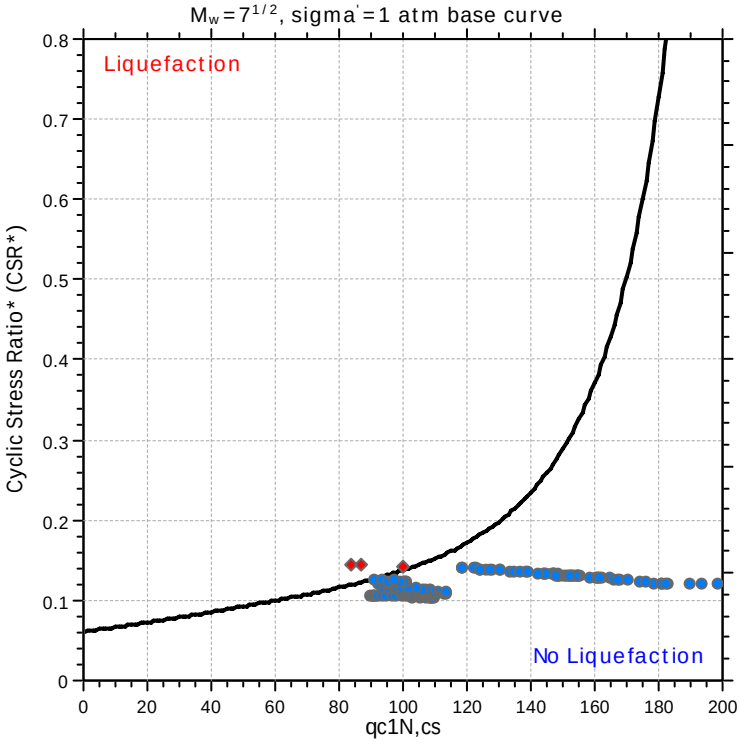
Location :

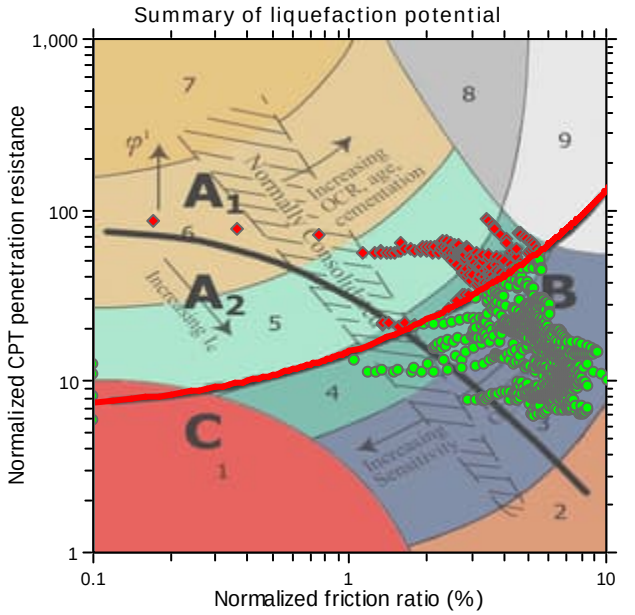
CPT file : CPT11-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 3.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 3.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

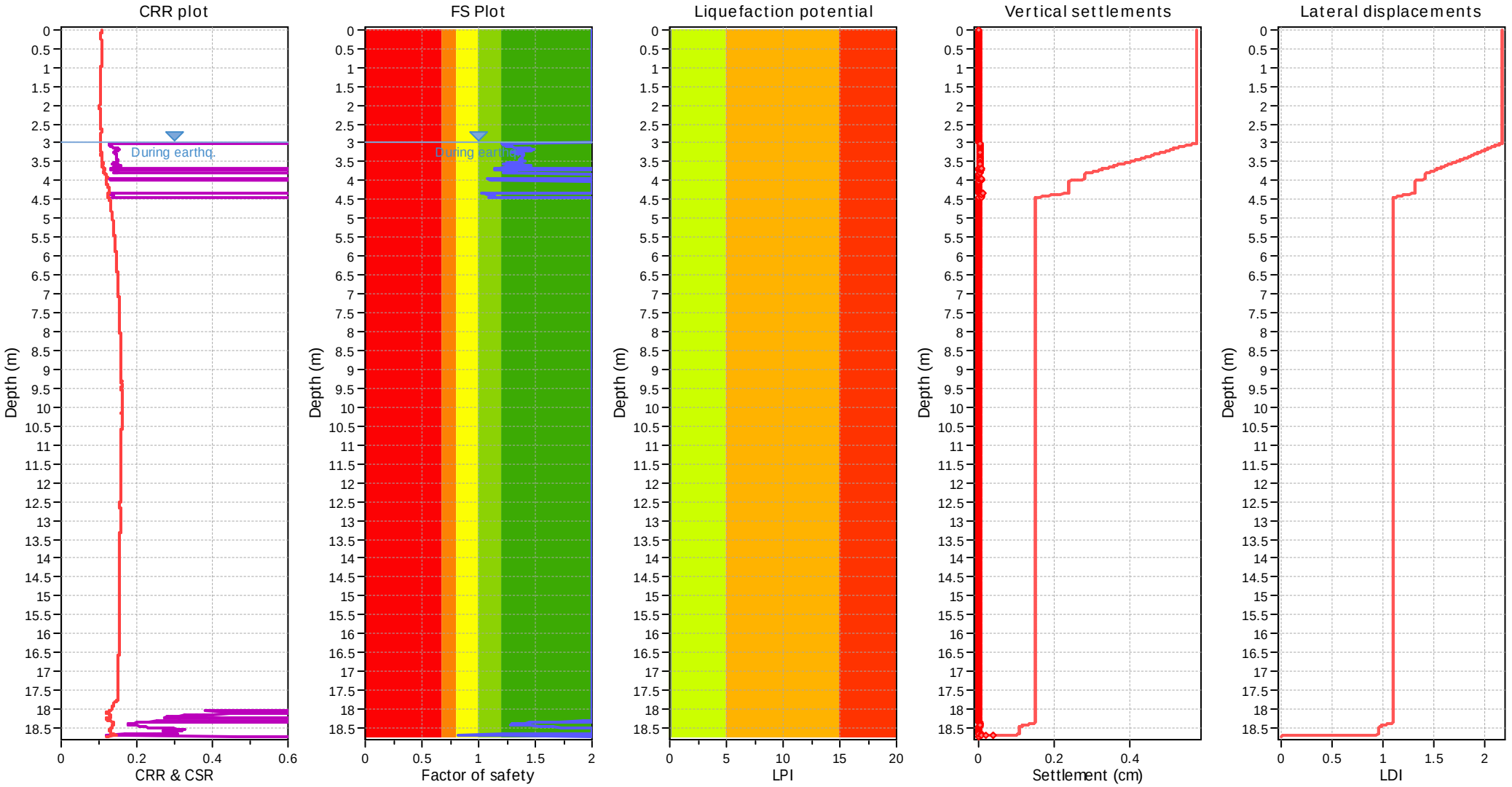



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 3.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 3.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

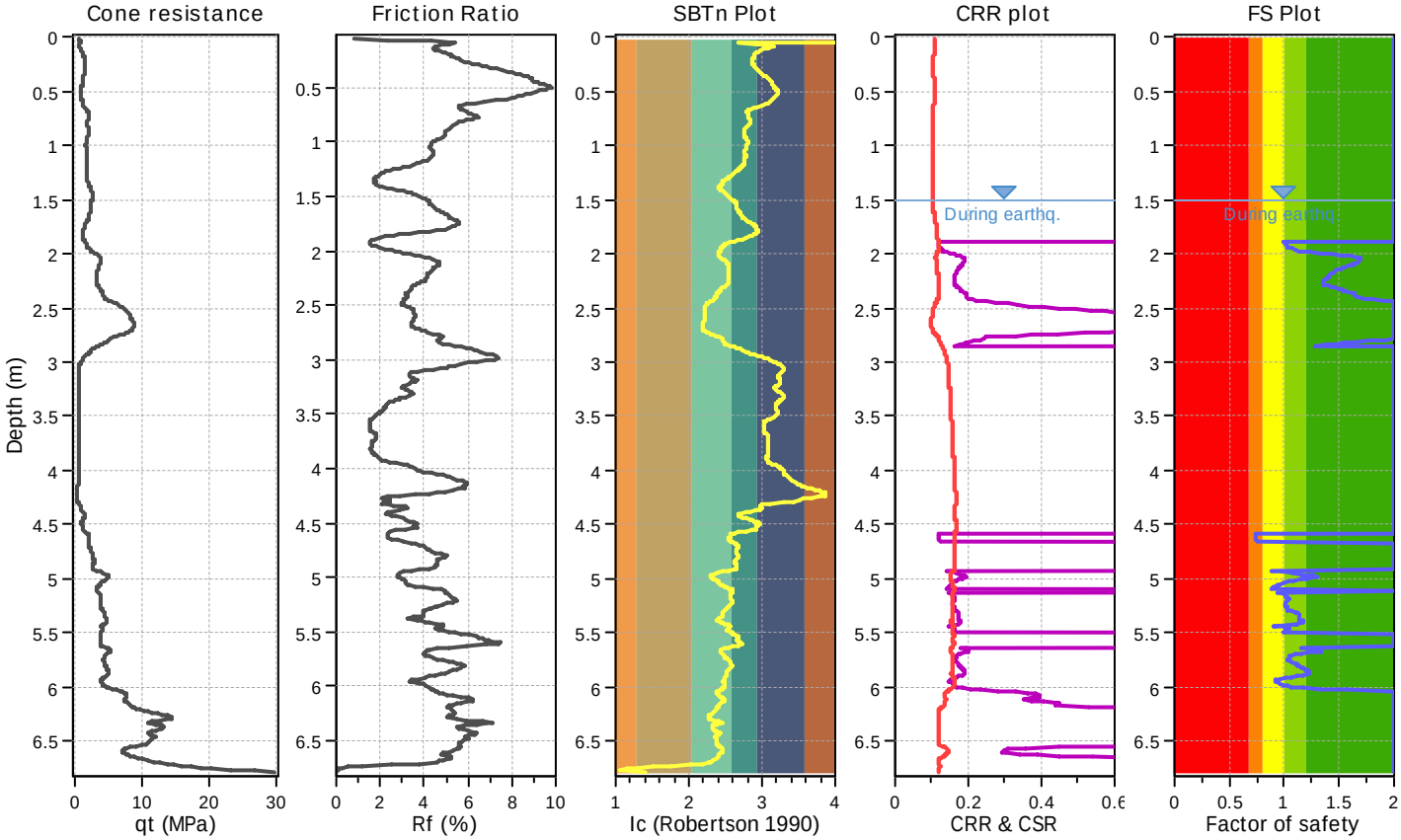
Project title :

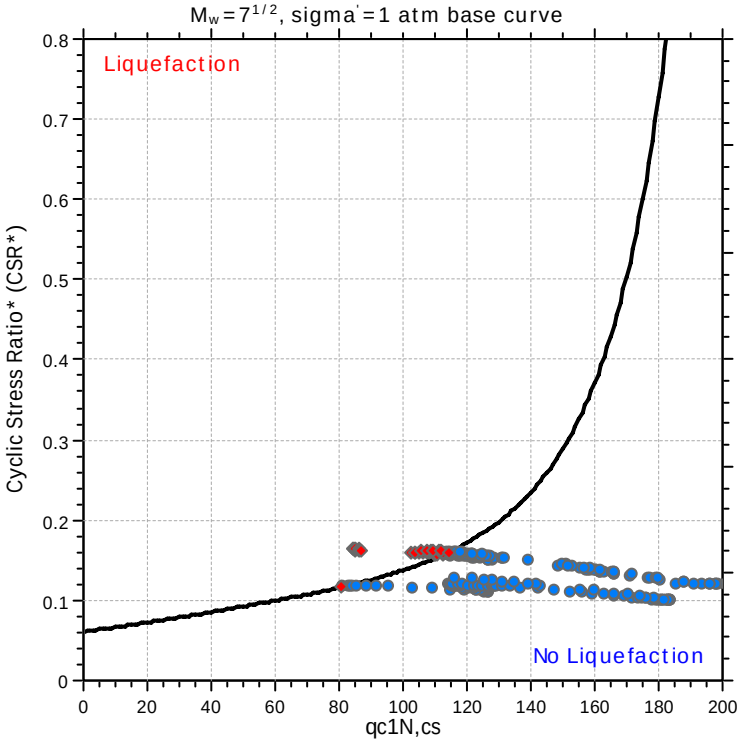
Location :

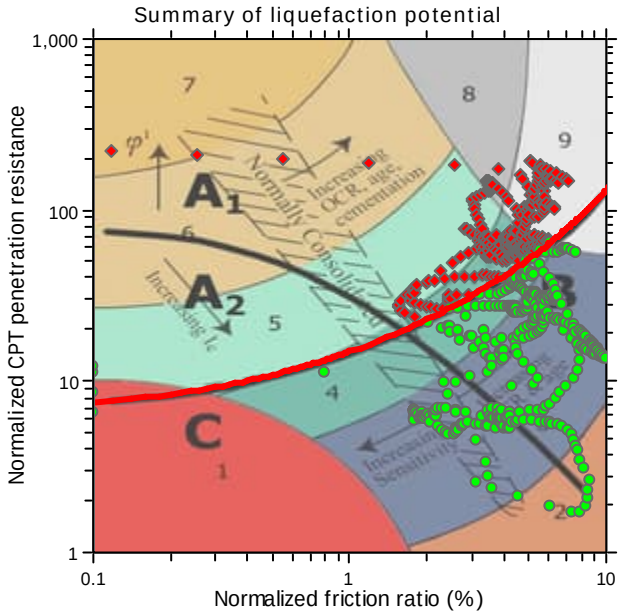
CPT file : CPT12-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

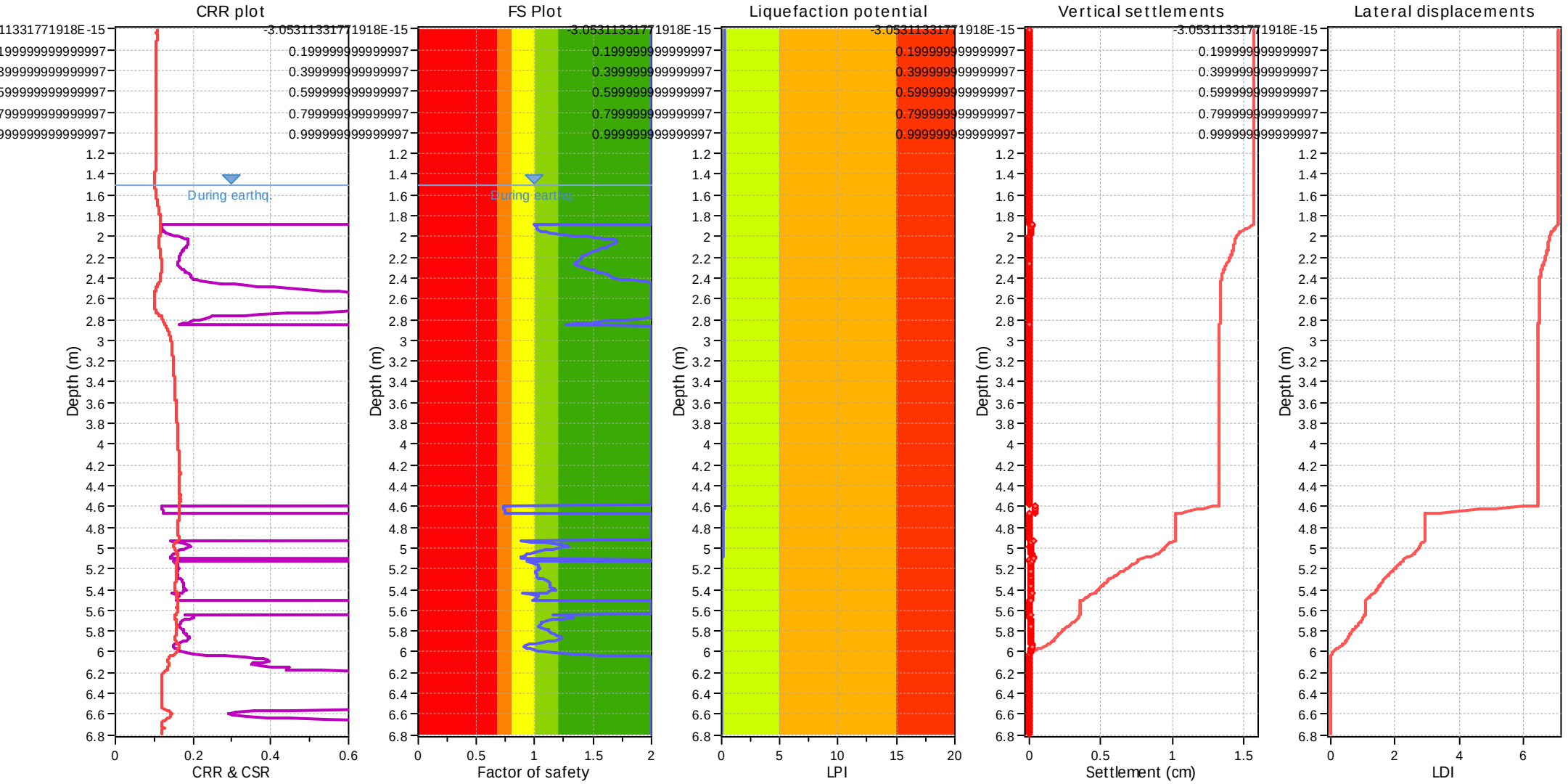



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

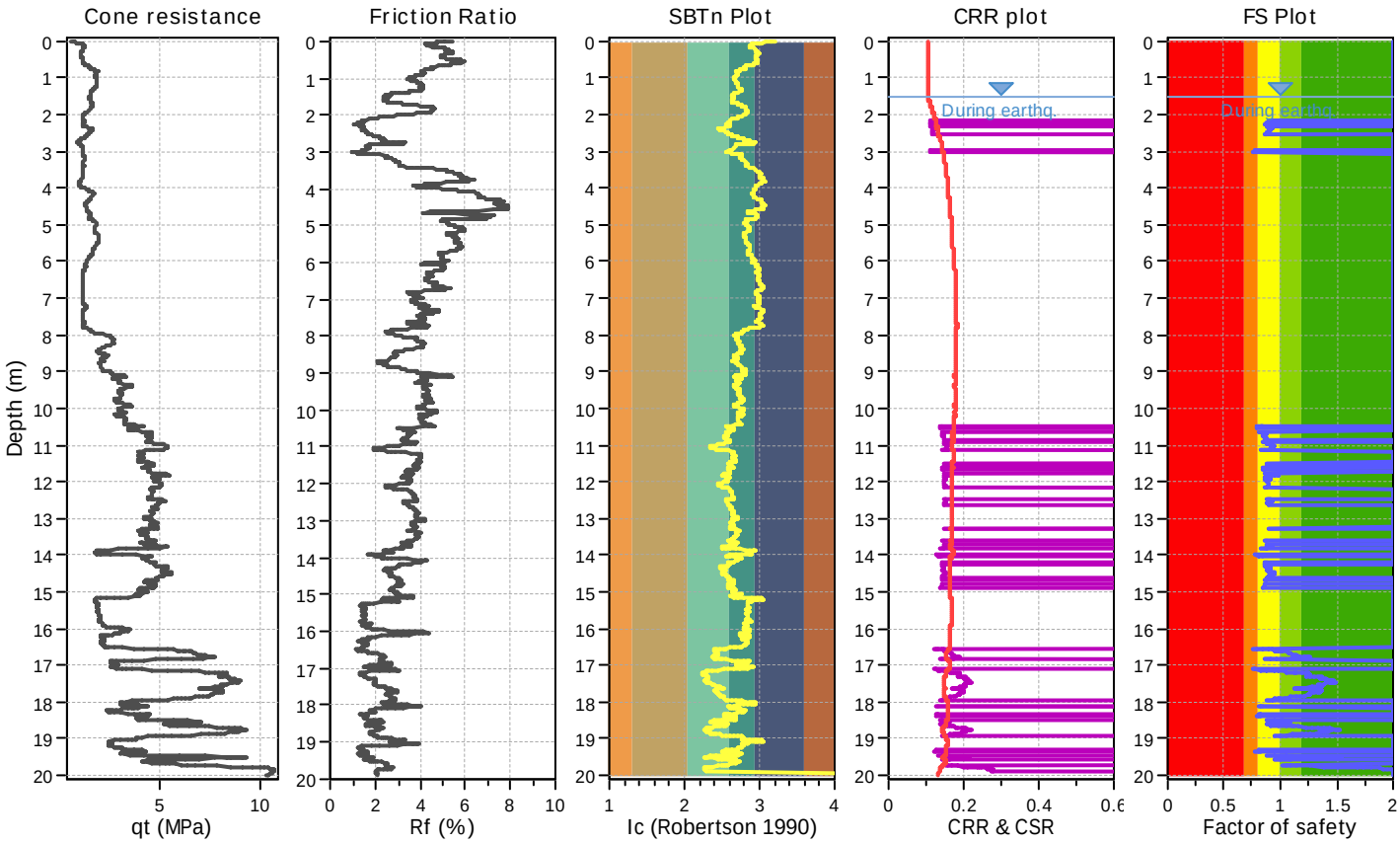
Project title :

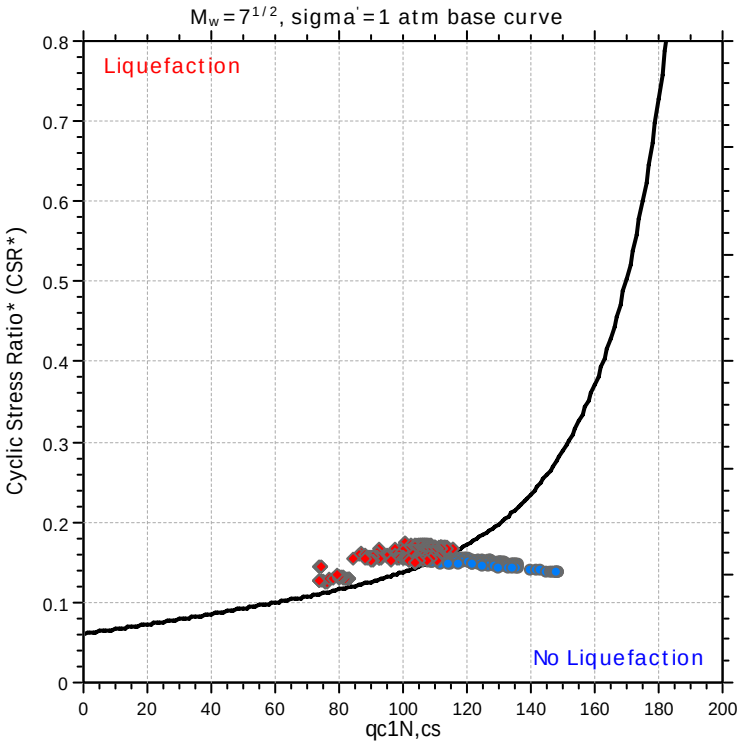
Location :

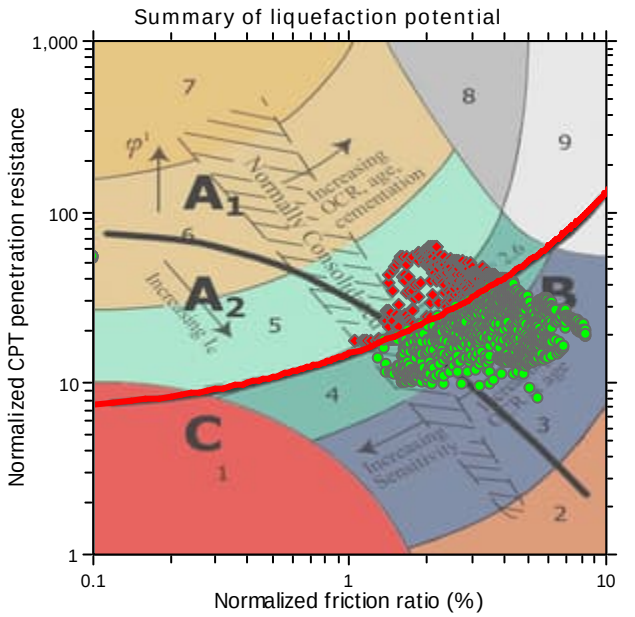
CPT file : CPT001-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

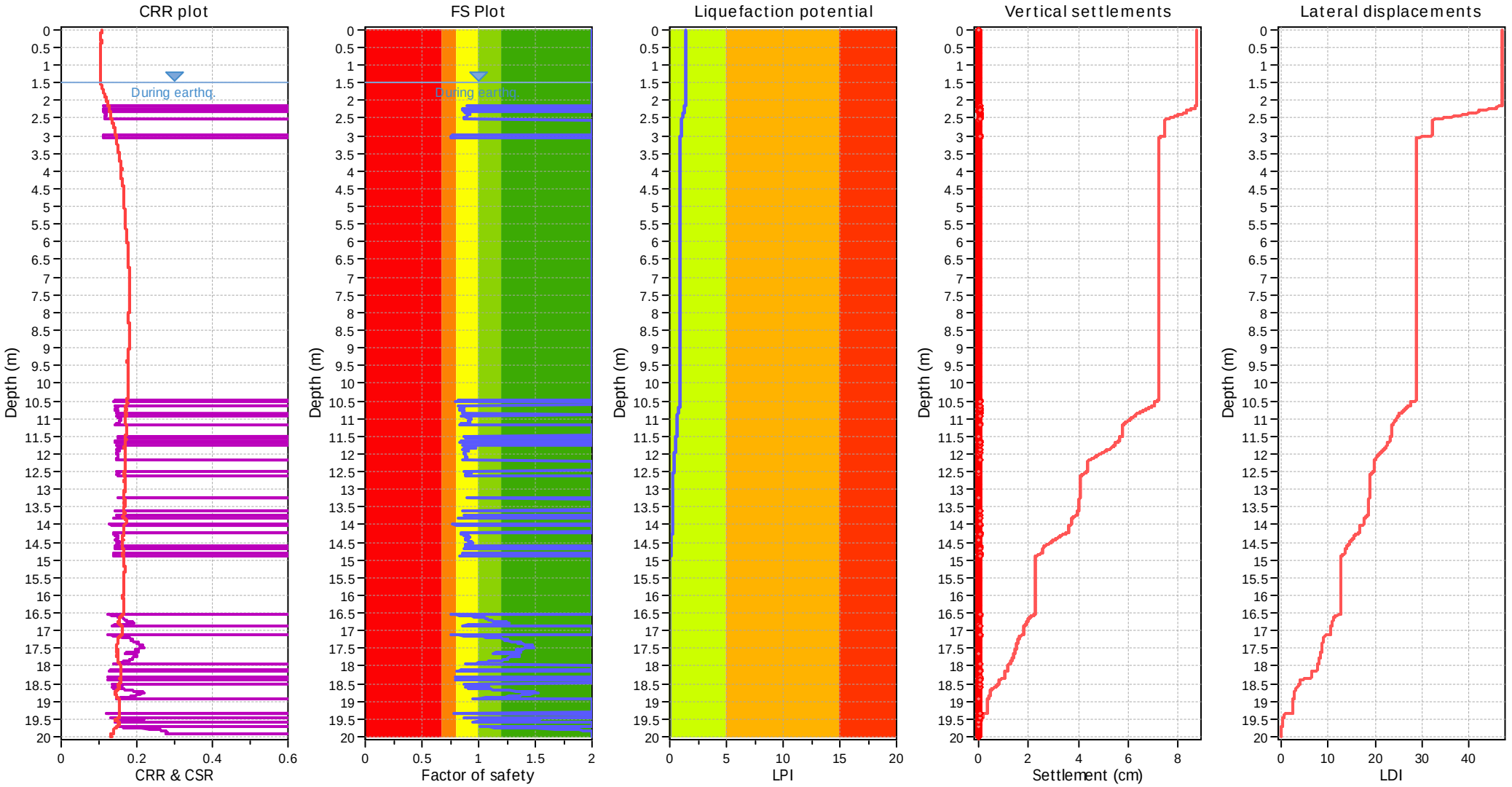



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

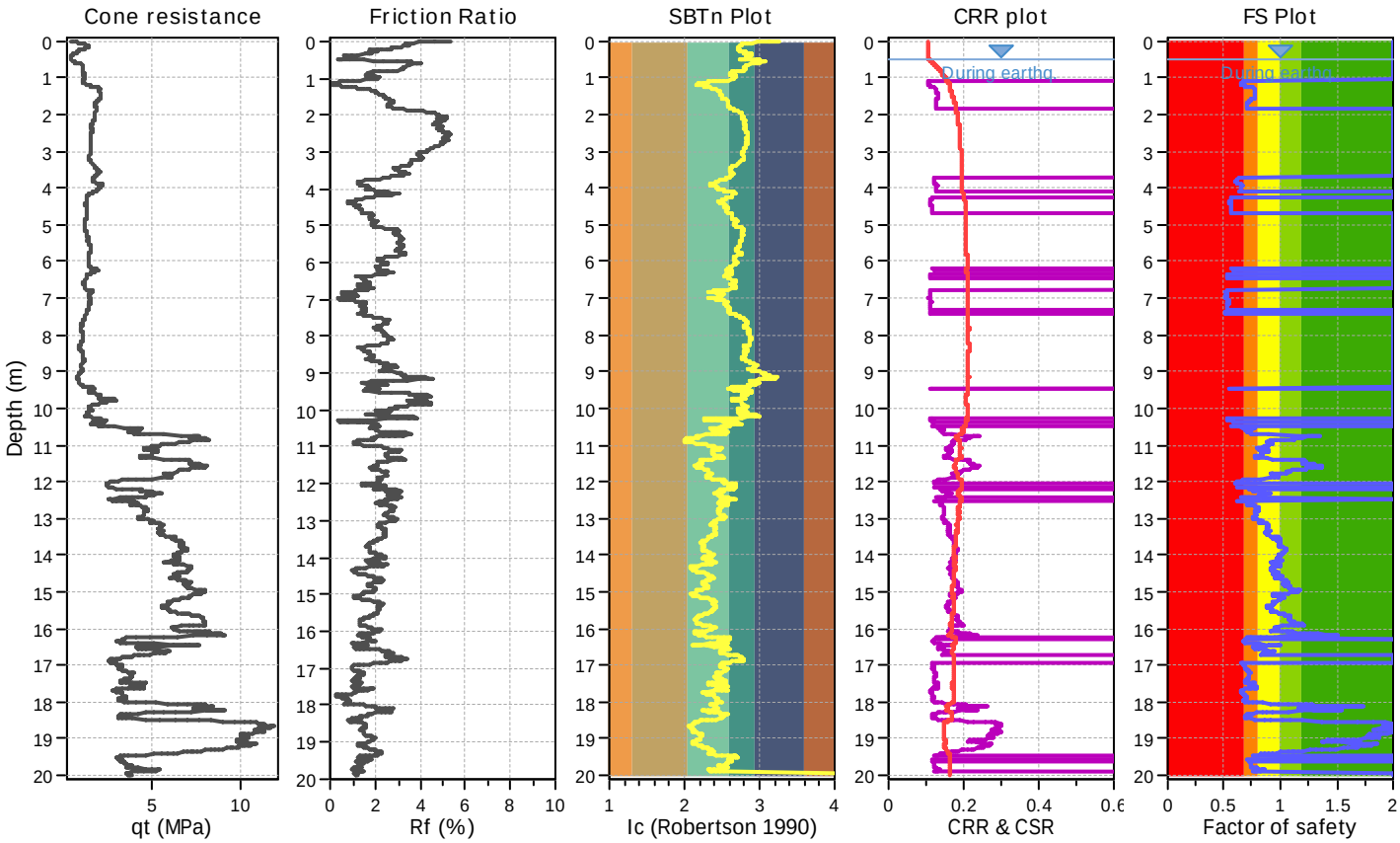
Project title :

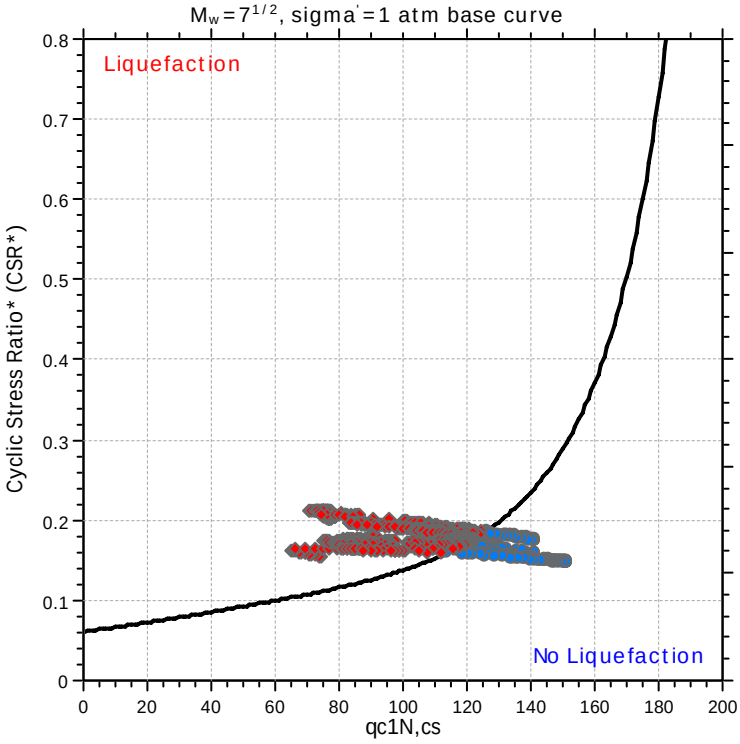
Location :

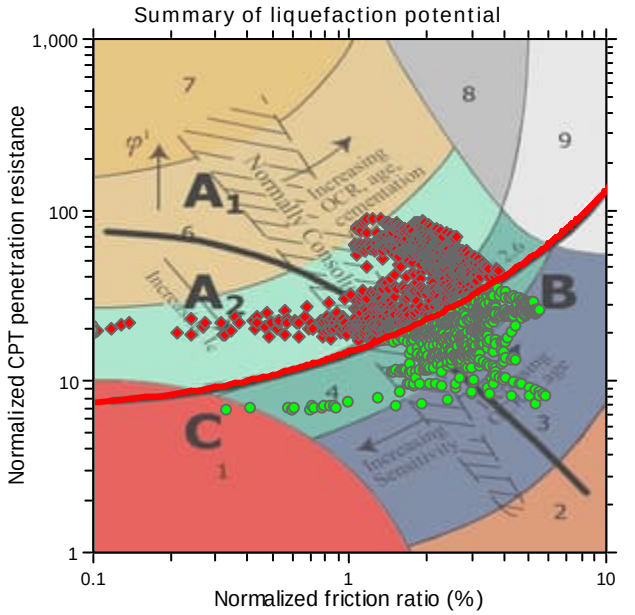
CPT file : CPT002-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 0.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 0.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

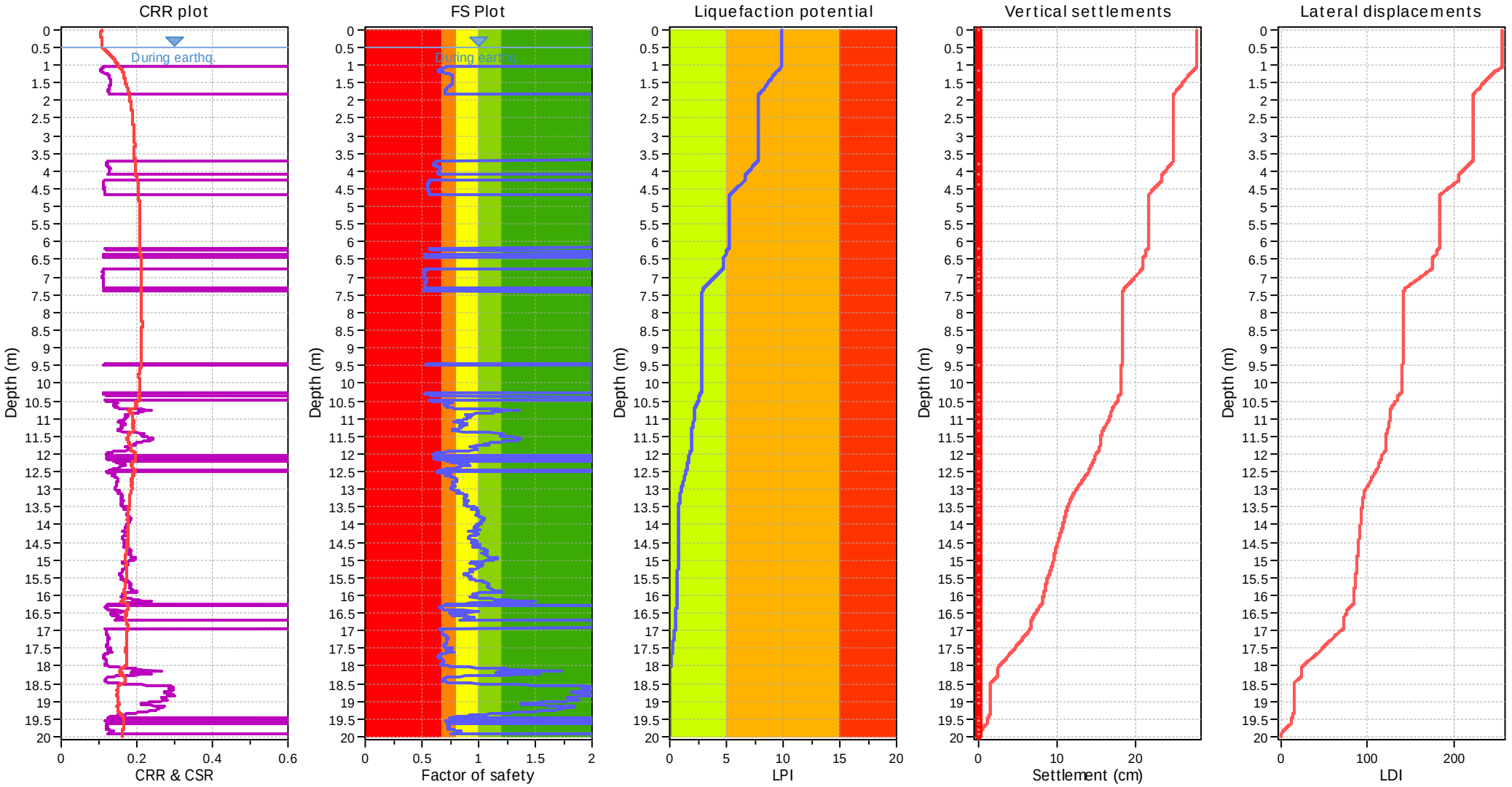



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 0.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 0.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

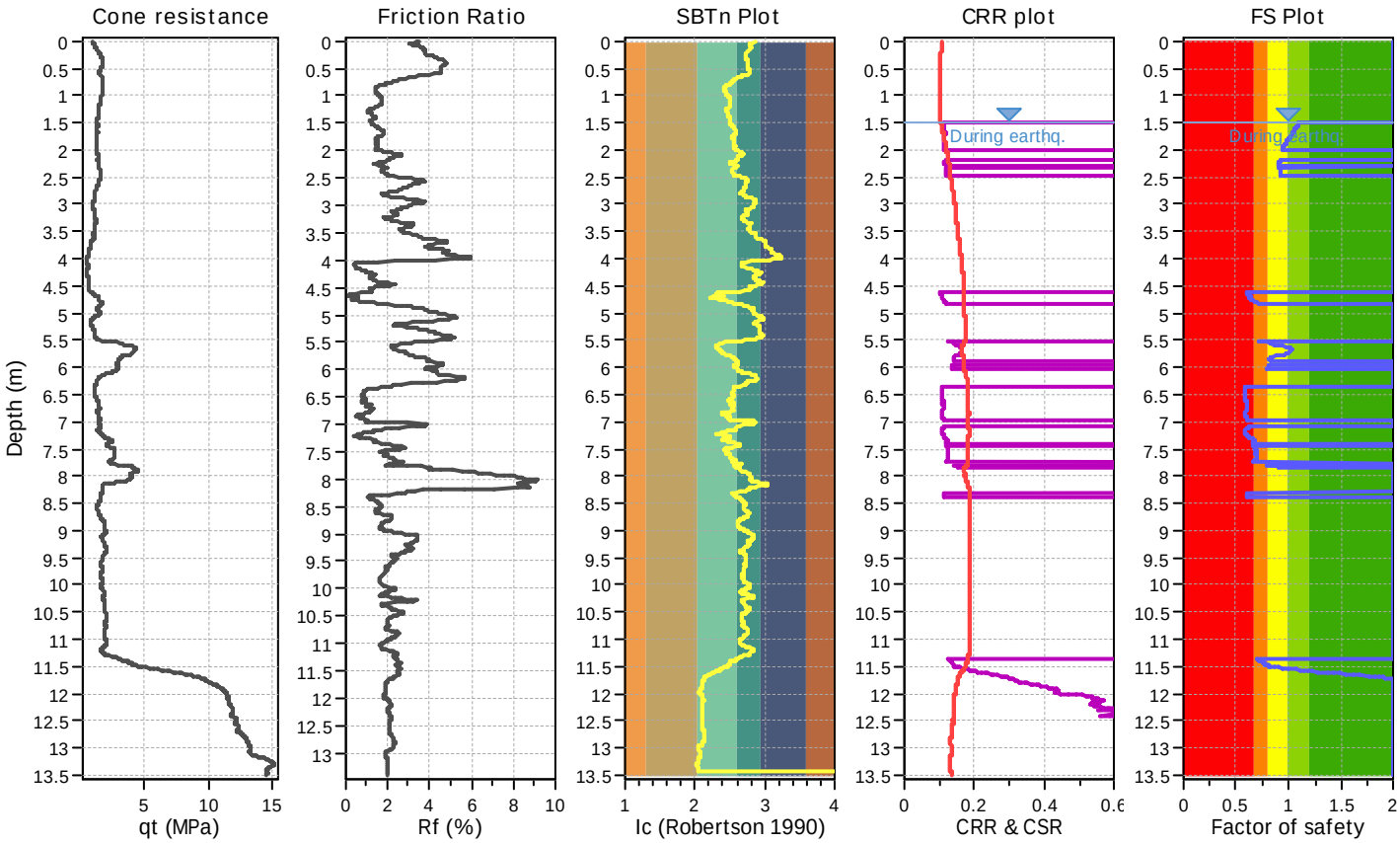
Project title :

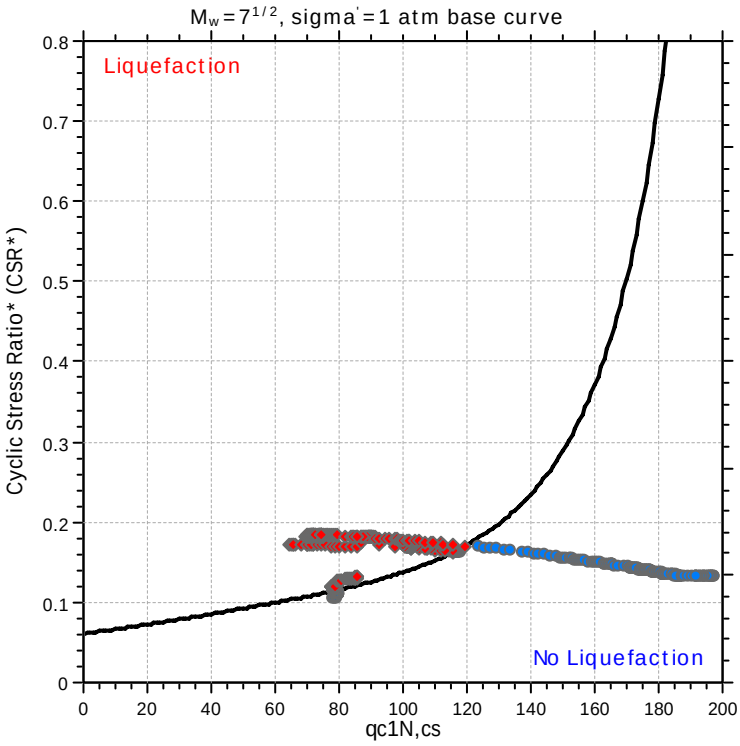
Location :

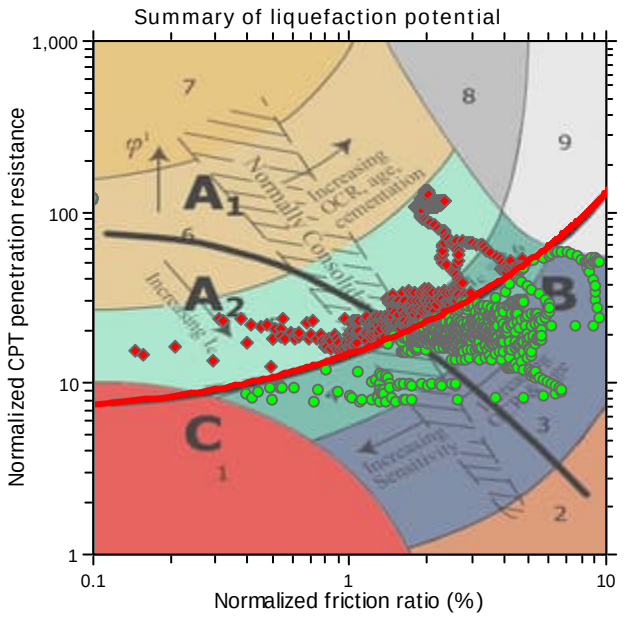
CPT file : CPT003-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

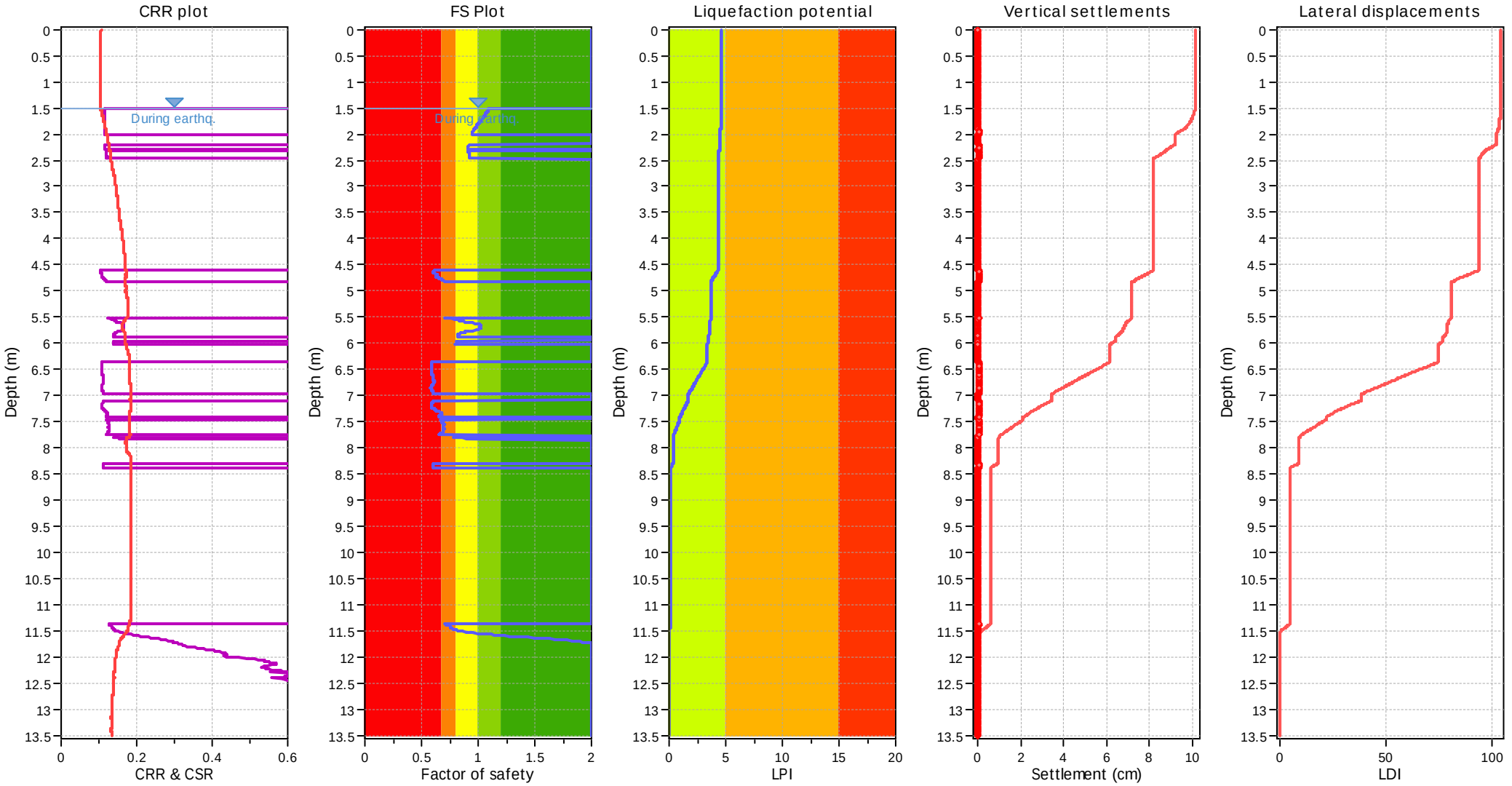



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

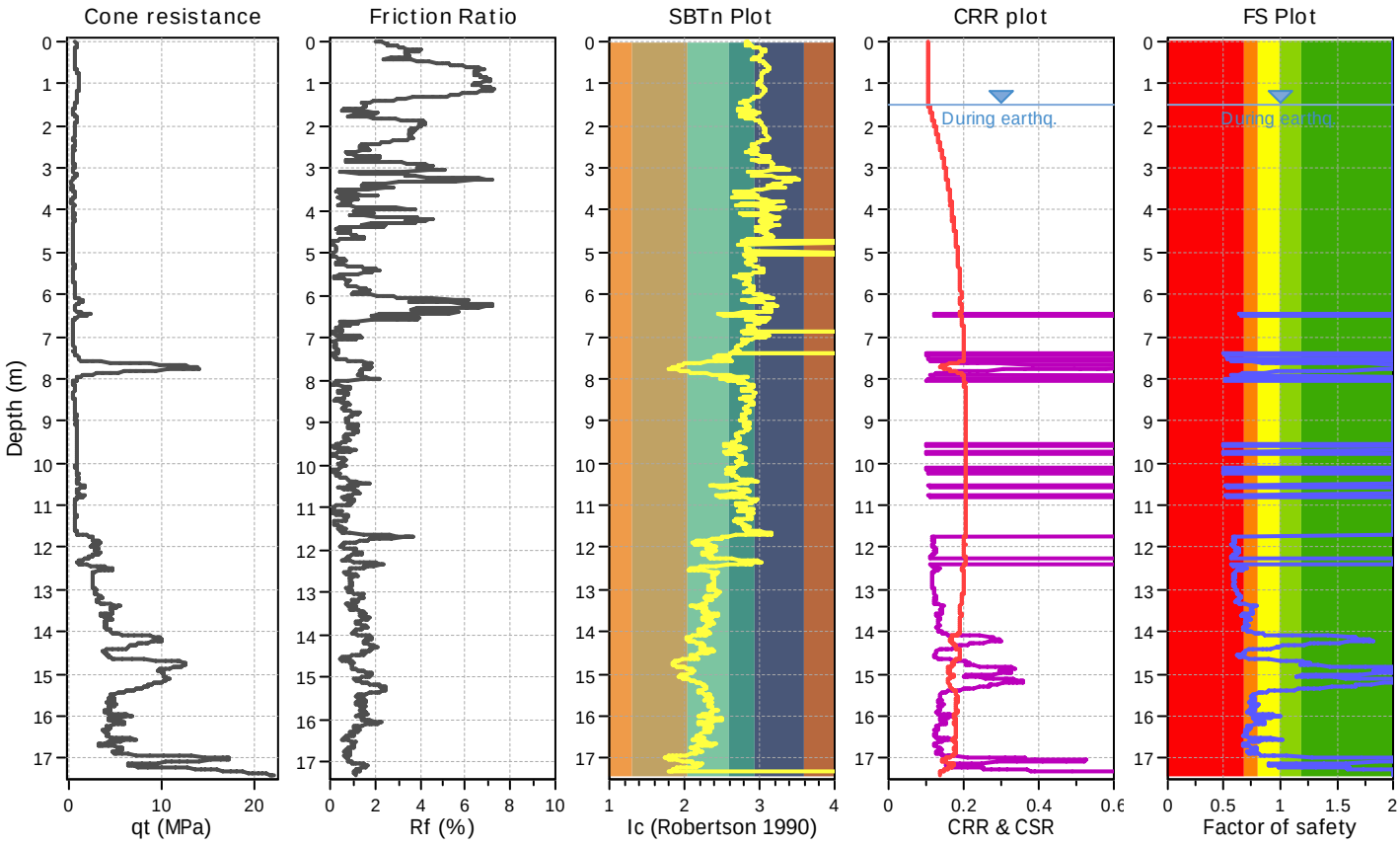
Project title :

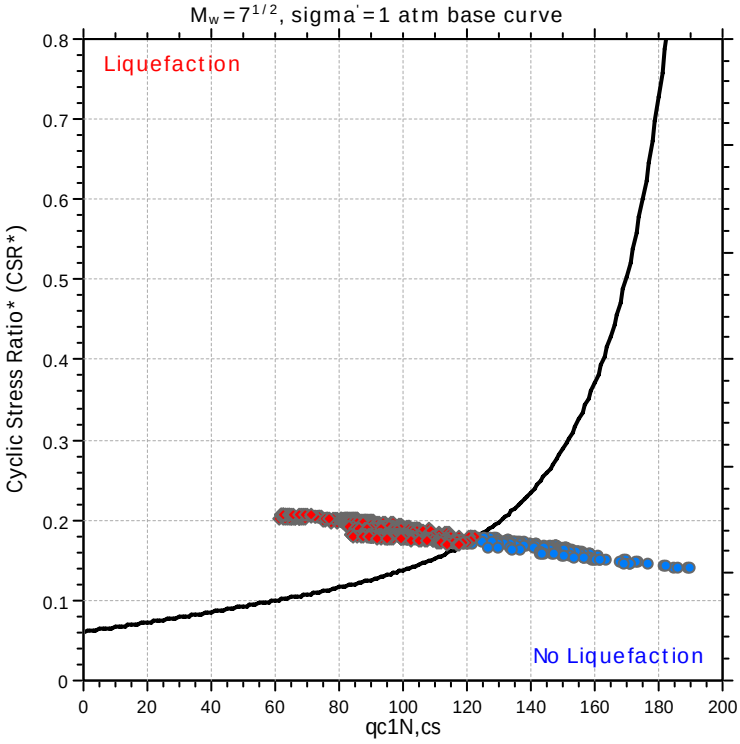
Location :

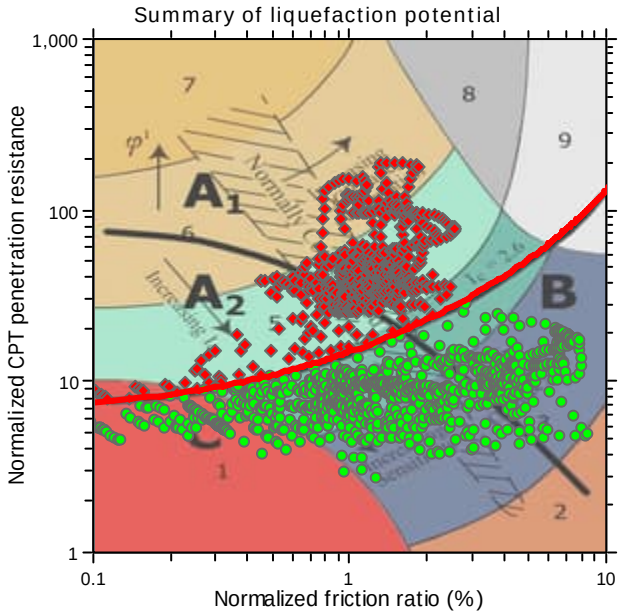
CPT file : CPT004-ULS

Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

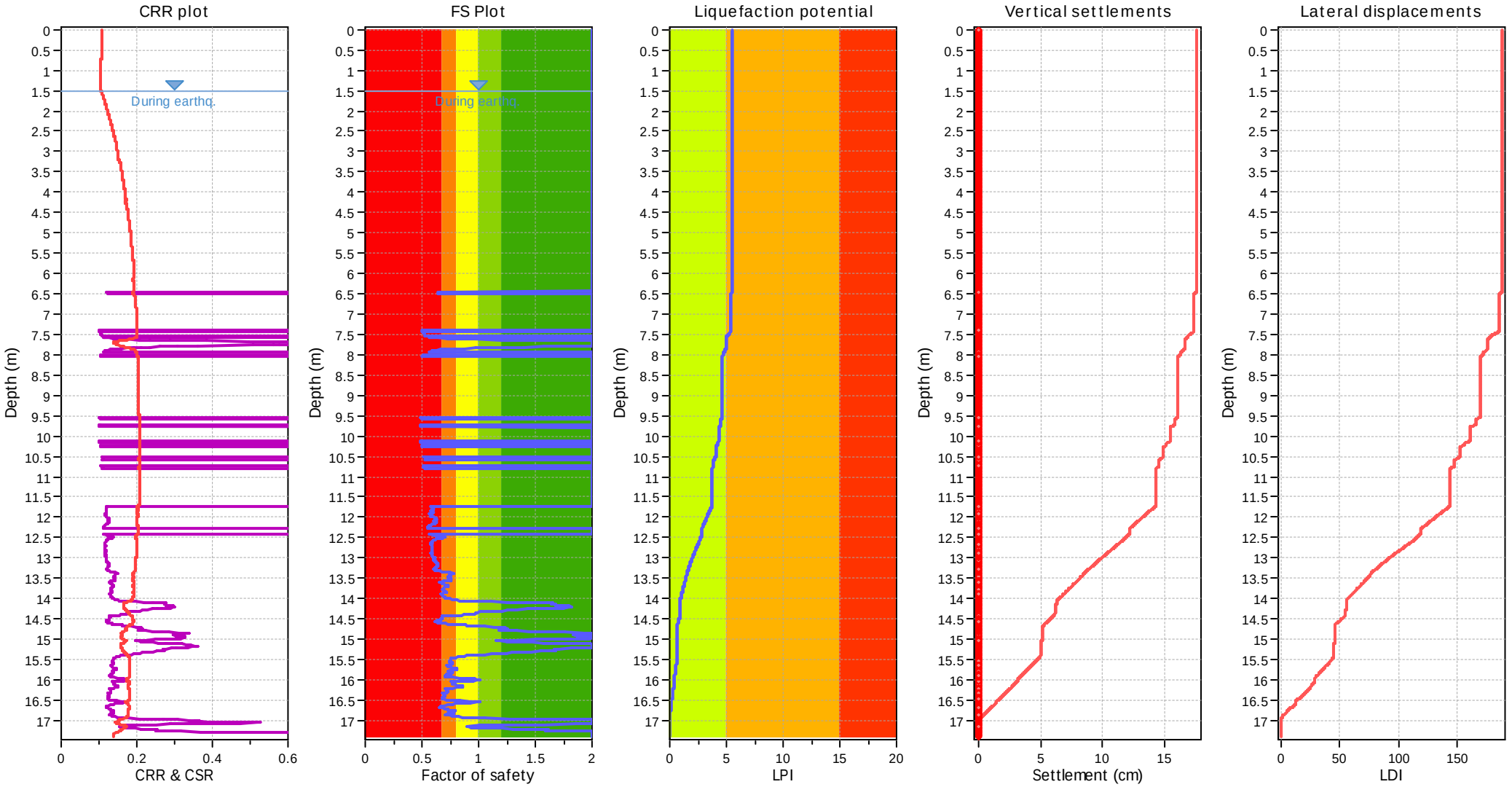



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

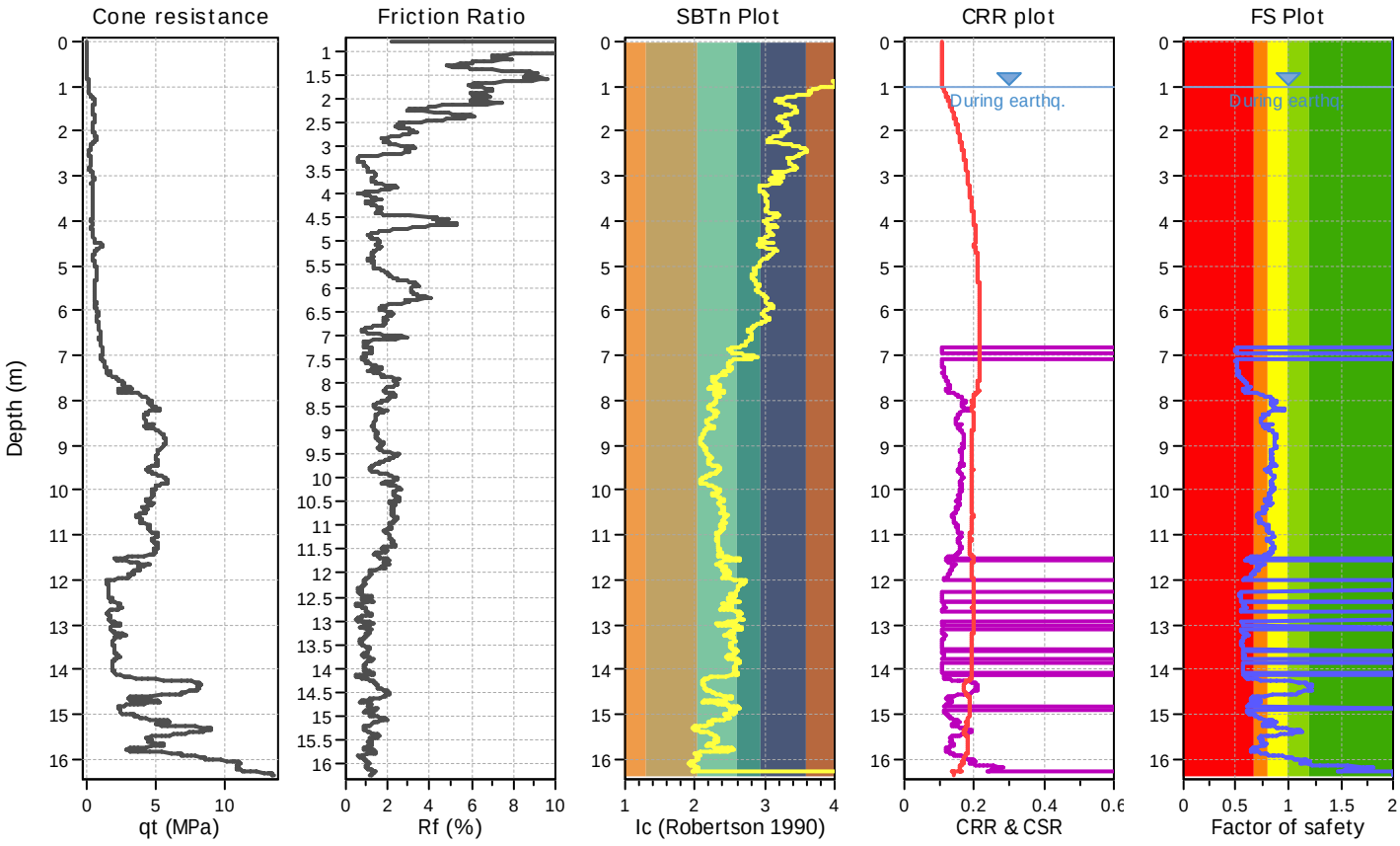
Project title :

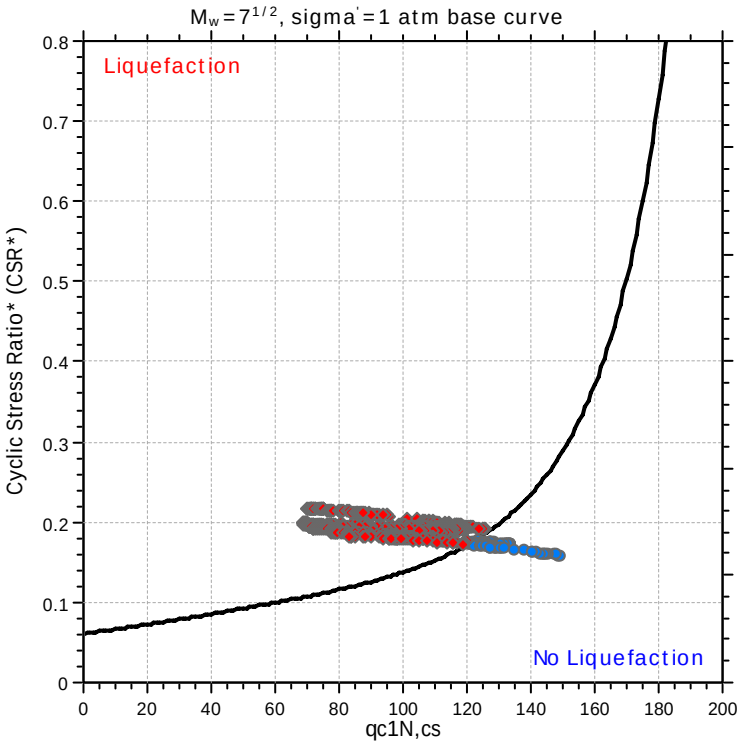
Location :

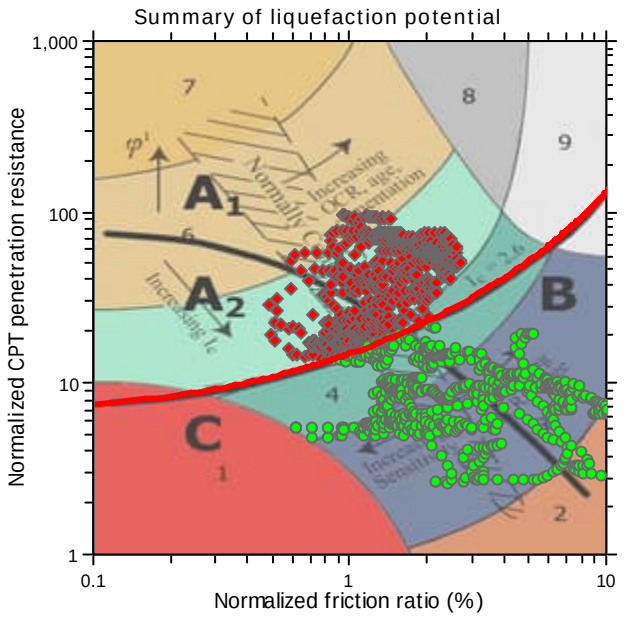
CPT file : CPT005-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 1.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 1.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

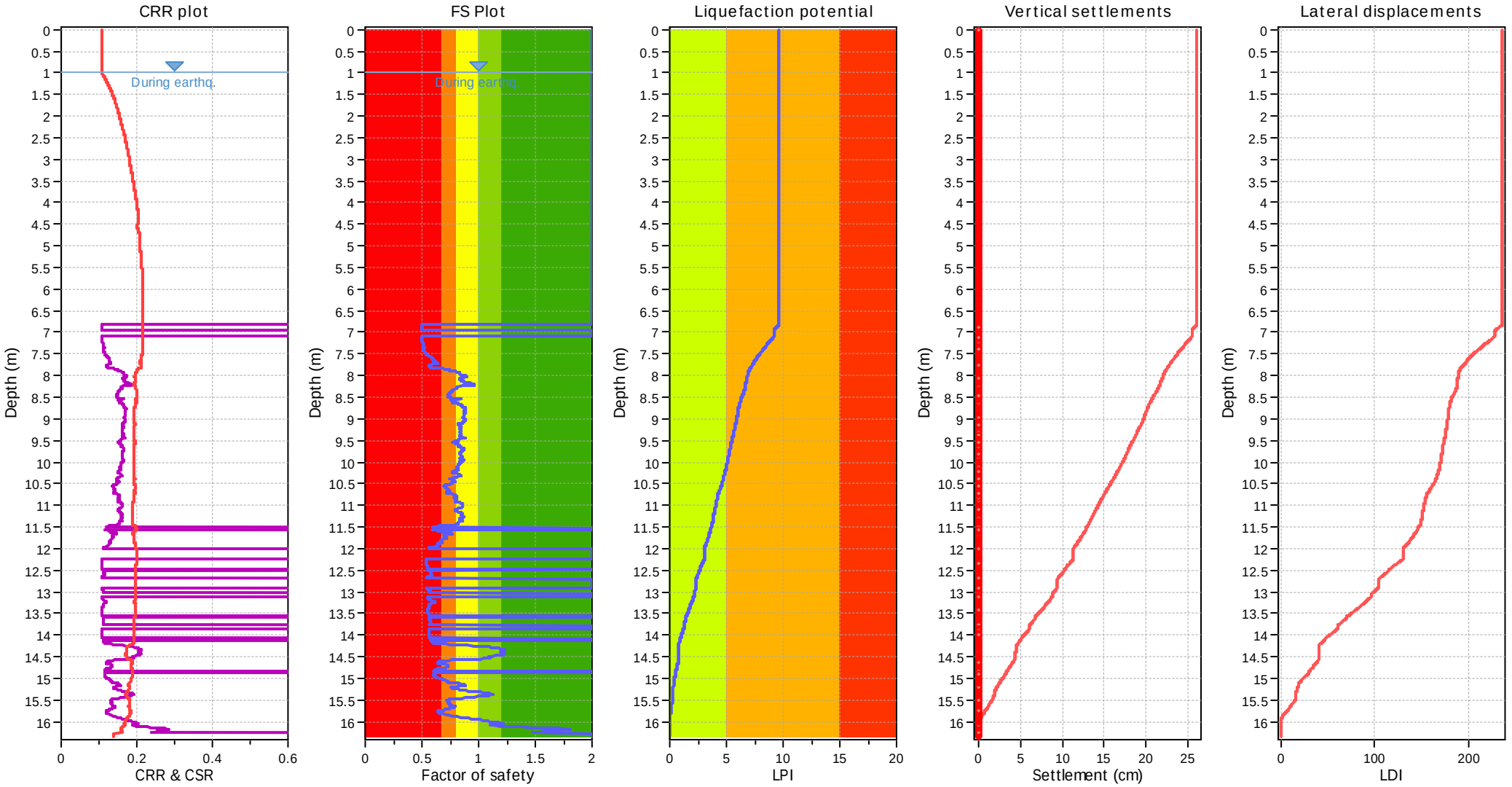



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 1.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 1.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

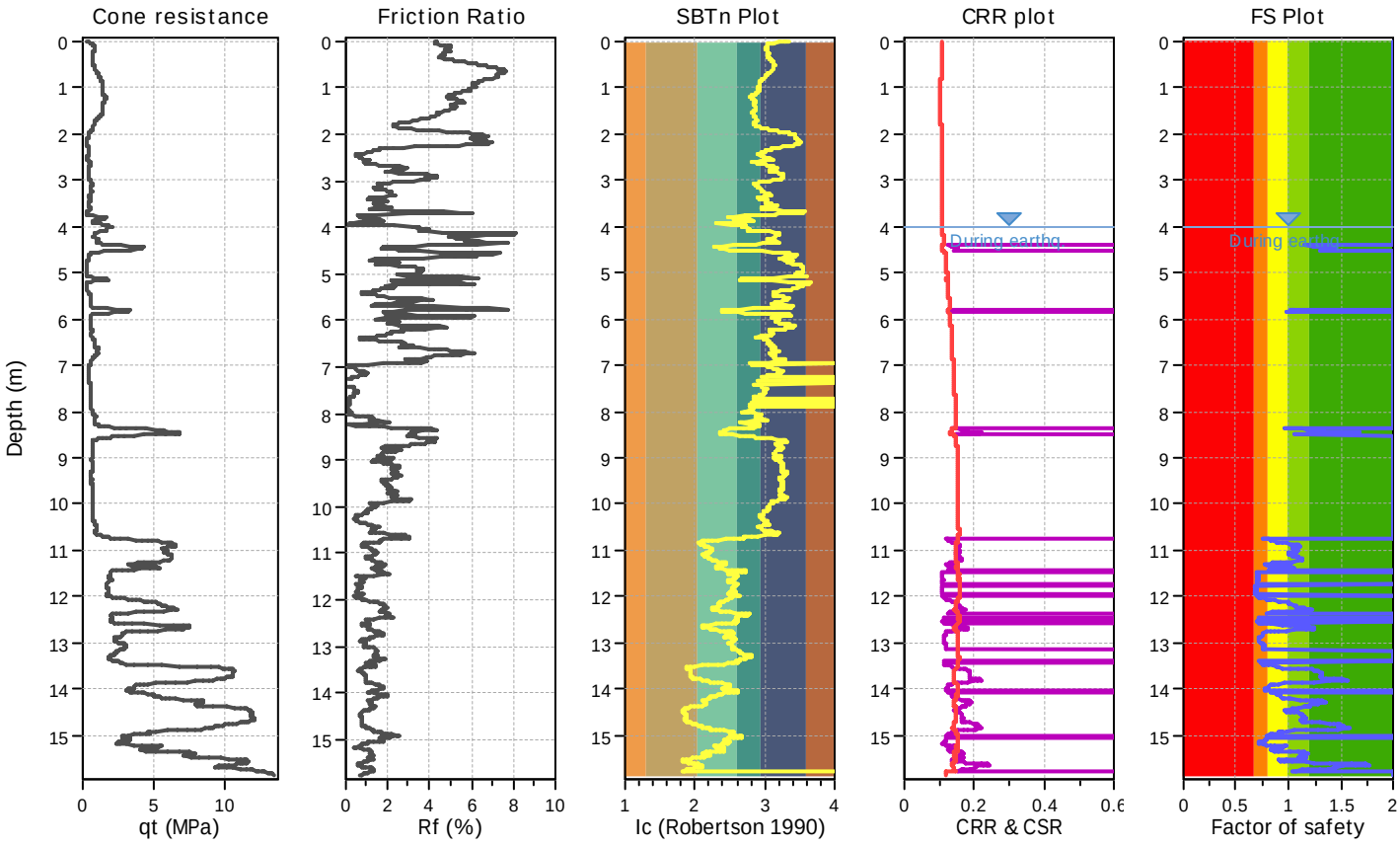
Project title :

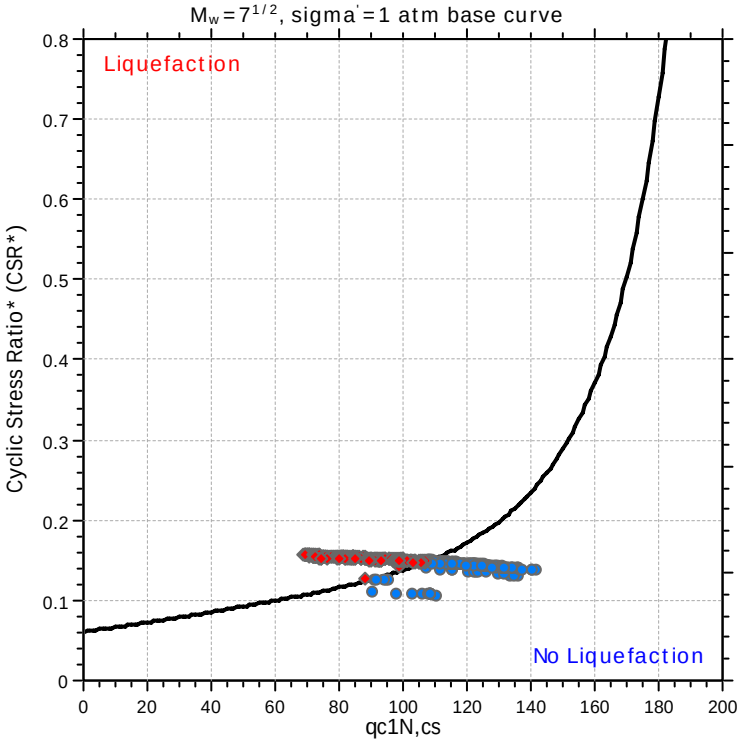
Location :

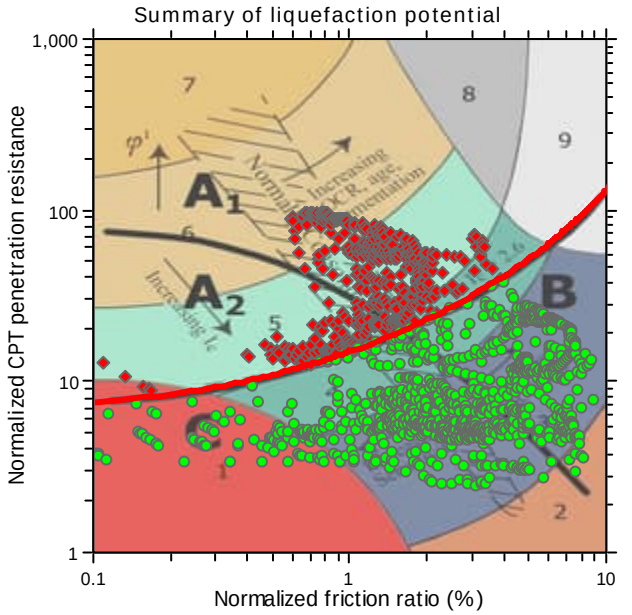
CPT file : CPT006-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 4.00 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 4.00 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

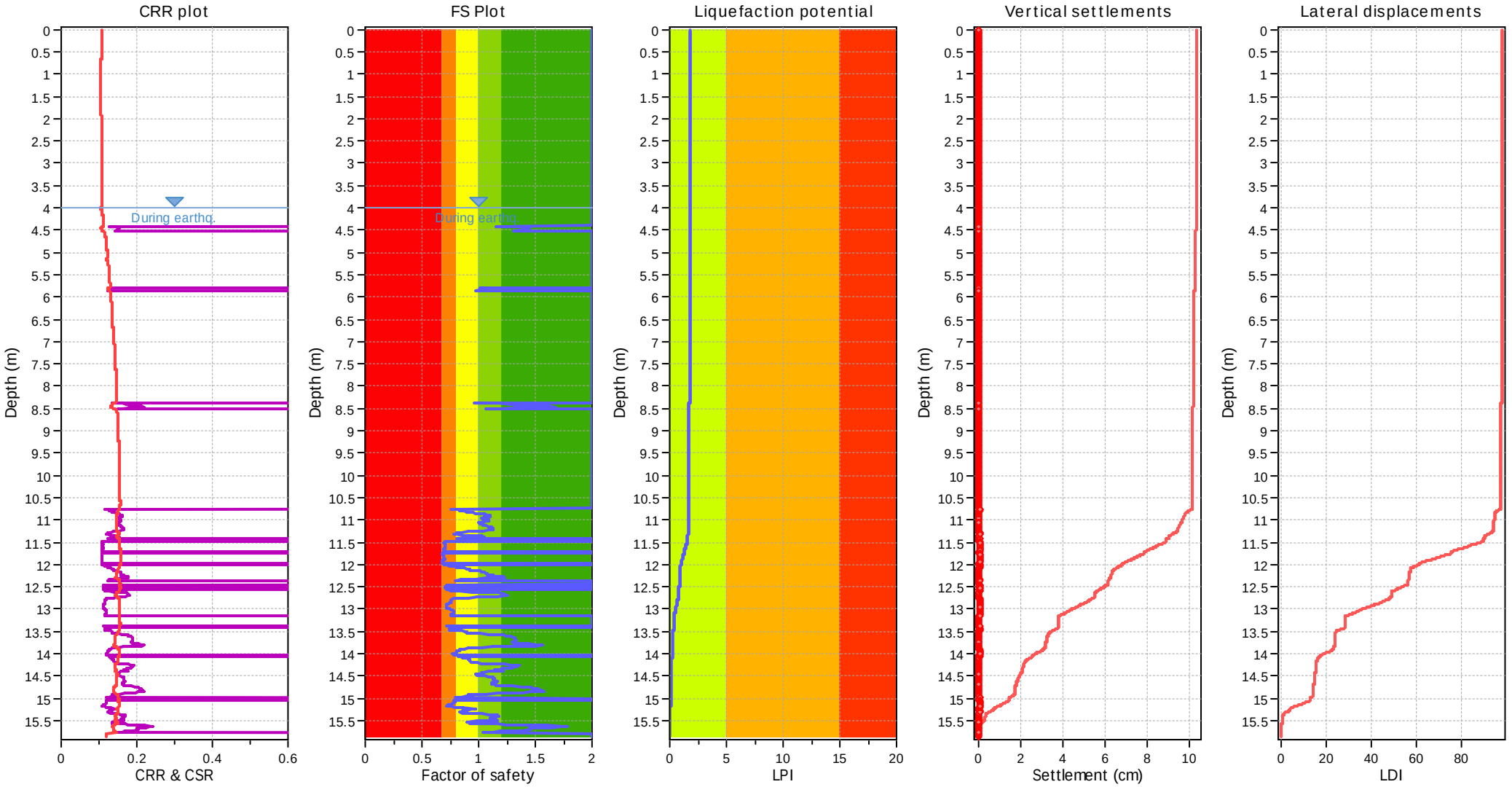



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 4.00 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 4.00 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

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# LIQUEFACTION ANALYSIS REPORT

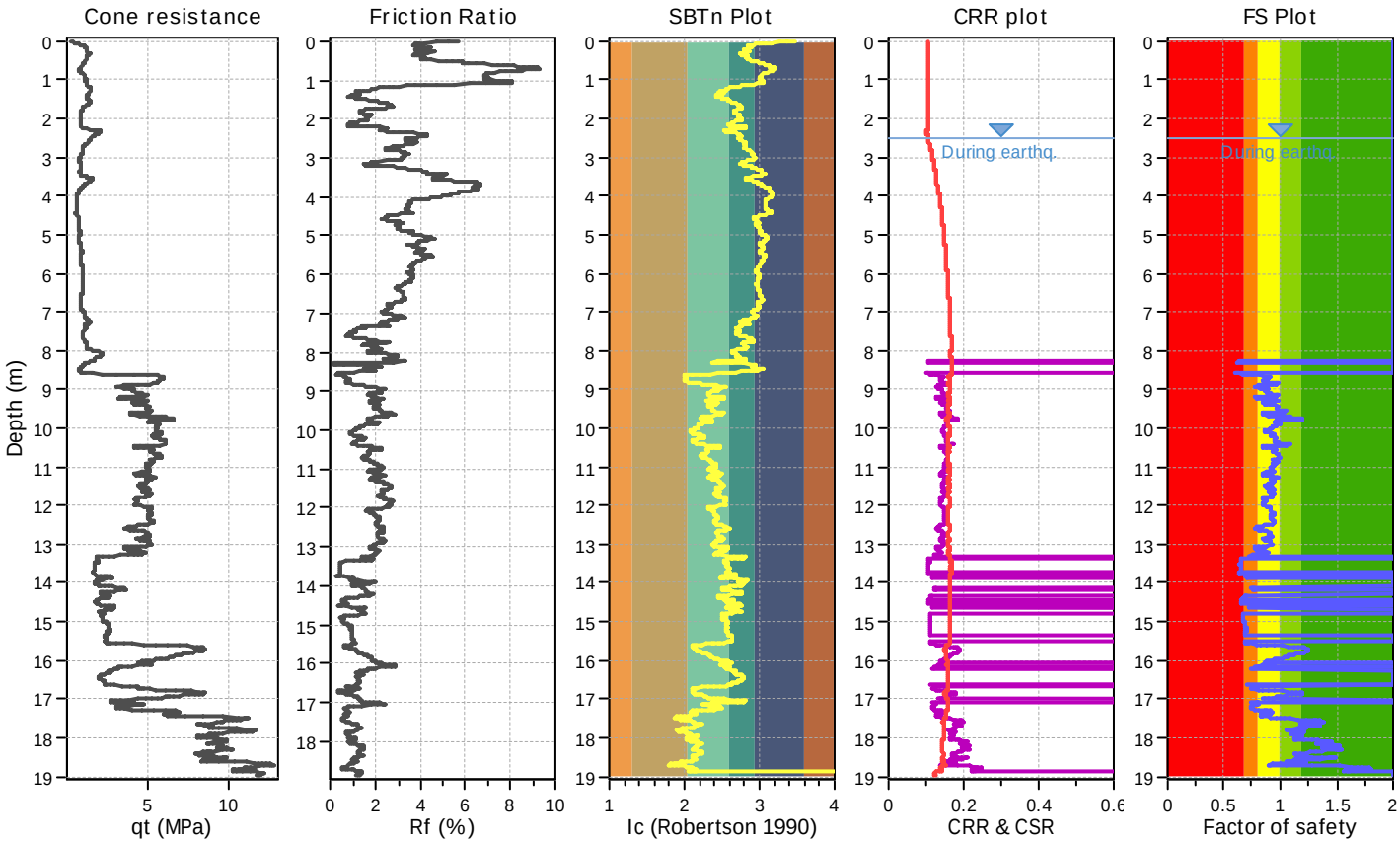
Project title :

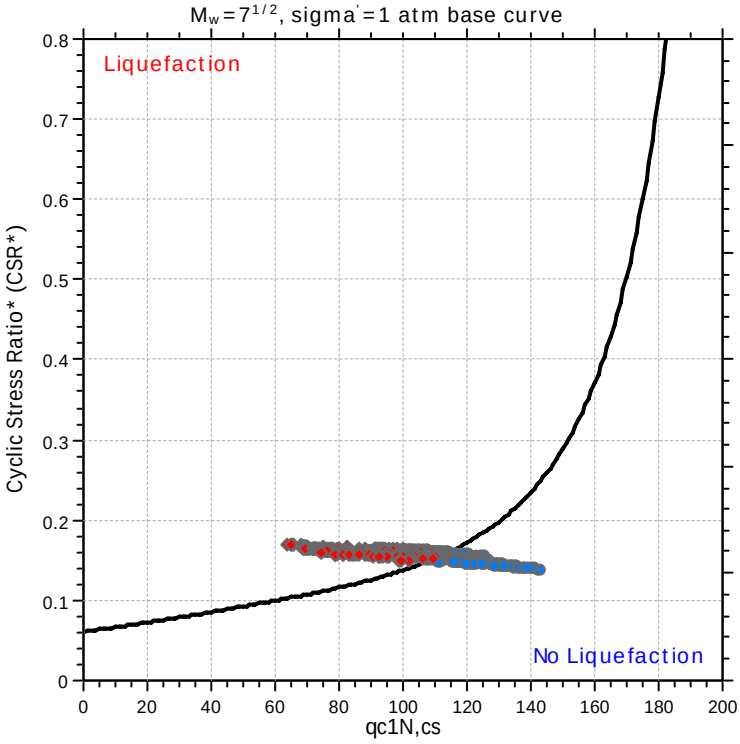
Location :

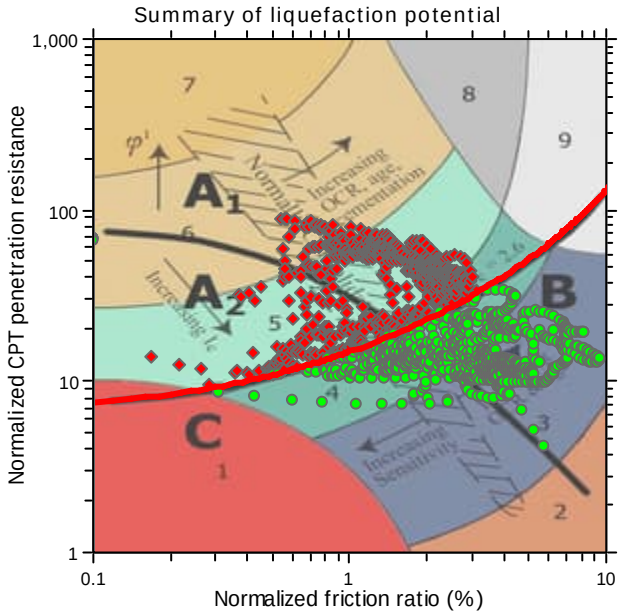
CPT file : CPT007-ULS

## Input parameters and analysis data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | G.W.T. (in-situ): | 2.50 m | Use fill: | No | Clay like behavior applied: | Sands only |
| Fines correction method: | B&I (2014) | G.W.T. (earthq.): | 2.50 m | Fill height: | N/A | Limit depth applied: | No |
| Points to test: | Based on Ic value | Average results interval: | 3 | Fill weight: | N/A | Limit depth: | N/A |
| Earthquake magnitude $M_w$: | 6.50 | Ic cut-off value: | 2.60 | Trans. detect. applied: | No | MSF method: | Method |
| Peak ground acceleration: | 0.19 | Unit weight calculation: | Based on SBT | $K_\sigma$ applied: | Yes | | |

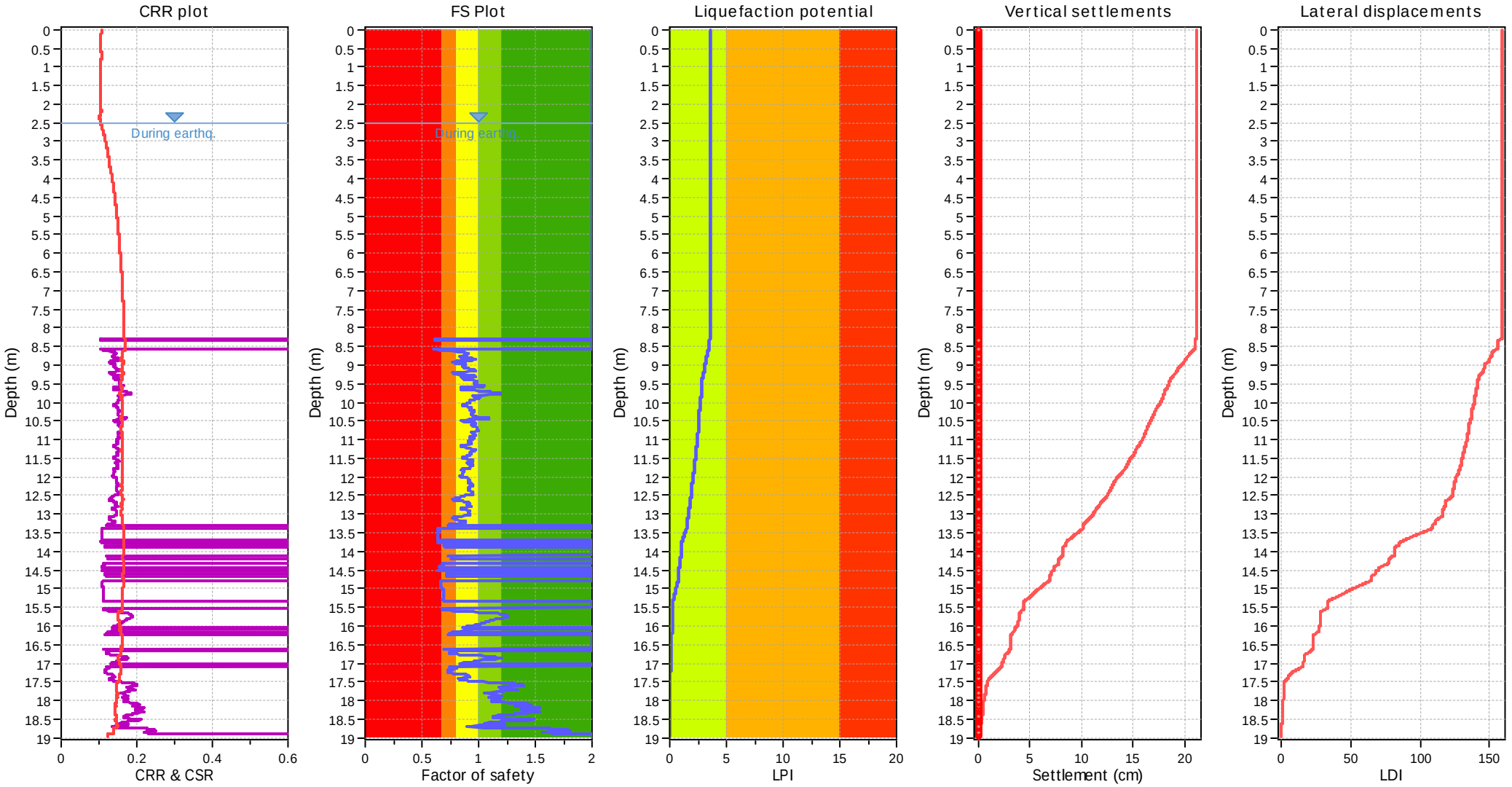



Zone $A_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone $A_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

# Liquefaction analysis overall plots




## Input parameters and analysis data

| | | | | | |
|---|---|---|---|---|---|
| Analysis method: | B&I (2014) | Depth to GWT (erthq.): | 2.50 m | Fill weight: | N/A |
| Fines correction method: | B&I (2014) | Average results interval: | 3 | Transition detect. applied: | No |
| Points to test: | Based on Ic value | Ic cut-off value: | 2.60 | $K_\sigma$ applied: | Yes |
| Earthquake magnitude $M_w$: | 6.50 | Unit weight calculation: | Based on SBT | Clay like behavior applied: | Sands only |
| Peak ground acceleration: | 0.19 | Use fill: | No | Limit depth applied: | No |
| Depth to water table (insitu): | 2.50 m | Fill height: | N/A | Limit depth: | N/A |

**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk