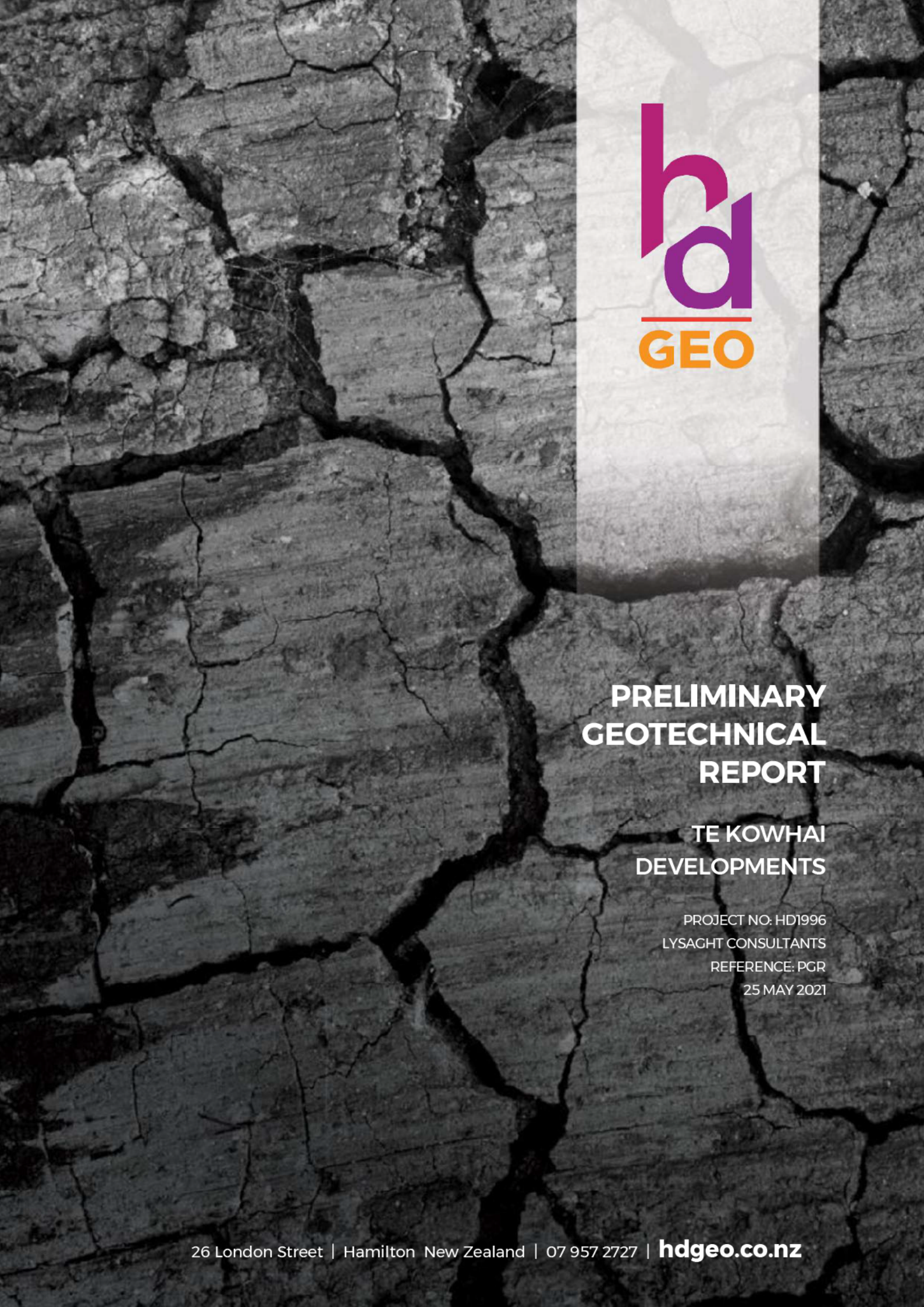

PRELIMINARY GEOTECHNICAL REPORT

TE KOWHAI DEVELOPMENTS

PROJECT NO: HD1996
LYSAGHT CONSULTANTS
REFERENCE: PGR
25 MAY 2021

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Executive Summary

Introduction

Lysaght Consultants have engaged us to undertake a preliminary geotechnical assessment for Bluehaven Holdings' site located at 28 Mathers Road Horotiu and 270 Te Kowhai Road. Our assessment will support master planning to guide concept design of the site.

Our scope included:

- a desktop study of geotechnical information, aerial photos and geological maps
- site walkover by engineering geologist to identify geohazards onsite
- an intrusive investigation which included:
    - 8 hand augers (HA) to 3.0 m depth with strength testing
    - 6 cone penetration tests (CPT) to maximum of 20 m
- a natural hazards assessment, including a quantitative liquefaction assessment
- settlement screening assessment
- qualitative slope stability assessment
- high level recommendations for development

Our key findings were:

- ground conditions were clayey soils in the Hills Terrain along the northern boundary of the site and alluvial (silty and sandy soils) on the Plains, the majority of the site.
- typically, groundwater was encountered between 1.9m and 2.2m bgl across the plains with a higher level, approx. 1m bgl, in east of the site
- the ground conditions are variable below the topsoil with very loose to dense soils at shallow depths

Our assessment is:

- the site is geotechnically suitable for development
- the site has a liquefaction hazard in the Plains Terrain
    - the site likely lies within performance level L1 to L3 (mild to high anticipated liquefaction effects)
    - this hazard is typical of the low lying areas in the Waikato
- the transition zone between the Hills and Plains terrains is likely to have a settlement hazard if loaded
- the existing slopes are typically stable. Modifications we anticipate during development would typically improve the stability
- there is a mild expansive soils hazard in the Hills Terrain
- all of the identified hazards can be mitigated during development of the site
- specific testing, assessment and design is needed for future works

Contents

PREPARED BY: **Shima Sheybaniaghdam**

Geotechnical Engineer

s 9(2)(a)

REVIEWED BY: **Andrew Holland, CPEng**

Technical Director
Principal Engineer

s 9(2)(a)

Introduction

Lysaght Consultants have engaged us to undertake a preliminary geotechnical assessment for Bluehaven Holdings Limited's site located at 28 Mathers Road Horotiu and 270 Te Kowhai Road. Our preliminary assessment is intended to broadly characterise the ground conditions at the site and to support master planning, guiding the concept design for development of the site.

Scope

Our scope for this assessment included:

- a desktop study of geotechnical information, historic aerial photos and geological maps
- site walkover by engineering geologist to identify geohazards onsite
- an intrusive investigation which included:
    - 8 hand augers (HA) to 3.0 m depth with strength testing
    - 6 cone penetration tests (CPT) to maximum of 20 m
- a natural hazards assessment, including a quantitative liquefaction assessment
- settlement screening assessment
- qualitative slope stability assessment
- high level recommendations for development

Site description

The site includes two separate lots at 28 Mathers Road, Horotiu and 270 Te Kowhai Road, Te Kowhai ('the site'). The site is bounded by rural residential properties and farmland to the north, west and south. State Highway 1 forms the eastern boundary of the northern site.

The site predominantly consists of flat-lying plains (referred to as the 'Plains') with rounded hill terrain (referred to as the 'Hill Terrain') in the north-western portion of the site rising up to 16m above the plains. The transition between these terrains is moderately steep (~ 20°).

Numerous open drains dissect the plains, with the Te Kowhai stream channel running through the southern portion of the site.

Currently there is a farmhouse on the hills in the north east of the site. There is farm infrastructure including sheds and an effluent pond in the north of the site (on, and adjacent to, the hills).

Desk study

We have completed a desk study including a review of existing geotechnical data near the site, historic aerial imagery and relevant geological maps of the area.

Geological setting

A geological map of the area indicates that the site is likely to be underlain mostly by Holocene Swamp Deposits. Deposits of the Walton Subgroup are shown near the northern part of the site and Hinuera Formation is shown on the fringes of the southern and eastern parts of the site.

Holocene Swamp Deposits are described as "*soft, dark brown to black, organic mud, muddy peat and woody peat*". These soils are typically highly variable in terms of strength and consistency.

Several geotechnical risks are commonly associated with these soils including settlement, liquefaction, reduced bearing capacity and elevated groundwater levels.

The Walton Subgroup is described as "*river deposits (alluvium) that is dominated by primary and reworked, non-welded ignimbrite*". The Hinuera Formation is described as "*Cross-bedded pumice sand, silt and gravel with interbedded peat".*

Historic aerial imagery

We reviewed historic[1] and recent[2] aerial photos, dating back to 1979, to identify features of interest at the site and within the surrounding area. In the photo of 1979, Paleochannel could be observed across the site. The Paleochannel were not visible in image of 1995, which may indicate that the channels been filled by that time. The effluent pond in the north of the site was built by 1995.

Reviewing the aerial photos, we could identify no features indicating historic or recent large-scale instability at the site or along the terrace slopes. Historic aerial imagery of the site are shown in Appendix D.

NZGD

We accessed the New Zealand Geotechnical Database (NZGD) to determine whether any data from previous ground investigations at or near the site are available. Several test results including test pits, CPTs, drill holes and hand augers have been completed within 1.5 km of the site. There are results available to the east and south of the site. Most of the data report soils consistent with Hinuera Formation geology.

Site investigation

Ground conditions

We completed our onsite investigation on 19 and 20 May 2021. We assessed ground conditions by conducting 8 hand augers (HA) and 6 cone penetration tests (CPT). In-situ strength testing was undertaken using a dynamic cone penetrometer (DCP) and shear vane. The hand augers had a target depth of 3.0 m, which was not achieved for HA04 and HA06 to HA08 due to hole collapse. Test locations are shown on Drawing No.2 in Appendix B.

Encountered ground conditions were generally consistent with the published geology of the area.

The site spans two terrains, the Hills Terrain which makes up a small fringe along the northern boundary, near Onion Road, and the Plains Terrain which covers the remainder of the site.

Hills Terrain

The Hills Terrain has stiff clayey soils (Hamilton Ash) and moderately steep slopes. The Hamilton ash is a stable cohesive material, good for earthworks and easy to develop. It is usually underlain at depth (2 to 5 m down) with more sensitive material that can be difficult to work with. The Hills Terrain typically has poor soakage characteristics.

[1] Sourced from http://retrolens.nz/map/ and licensed by LINZ CC-BY. Accessed 21/04/21
[2] Google Earth Pro. Accessed 22/04/21

Plains Terrain

The Plains Terrain is the majority of the site. The area is underlain by relatively young alluvial sediments of the Piako Formation. There was no surficial peat and no significant organic layers in the 3m augers. We found a layer of decomposing sticks at a depth of about 1m in the east of the site. Typically, the top ~1m of the site was silt or clay with sandier material deeper down. The silt and clay are typically loose/soft with the sand medium dense to dense below.

An approximate boundary between these zones is shown on Drawing No.1 in Appendix A. Hand auger logs of the recovered soils and raw CPT data are provided in Appendix B.

Groundwater

Typically, groundwater was found between 1.9m and 2.2 m bgl across the site at the time of site investigation (May 2021). In the east of the site, closer to expressway, groundwater was higher at approximately 1m bgl. We expect the groundwater in the Hills Terrain to be deeper based on the increased elevation.

Groundwater will rise and fall with rainfall, typically peaking late in the year (September/October). Fluctuations can be variable. Monitoring over a year or more should be undertaken to establish typical water levels for the detailed assessment stages.

Geotechnical assessment

The ground conditions encountered on-site are suitable for the proposed development, so long as the geotechnical recommendations below are incorporated into the design, and best practice construction methods are adopted.

Natural hazards

We have carried out an assessment of natural geotechnical hazards.

- **Earthquake:** The general earthquake hazard in the area is low with no active faults nearby. The soils class for the site is Class D (deep or soft soils), our screening assessment indicated there is a liquefaction hazard at the site (see 'Liquefaction' section below).
- **Volcanic, geothermal or sedimentation activity:** The site is not near any known sources of these hazards.
- **Landslips:** The site is generally flat with Hills Terrain limited to the northern edge of the site. There is a low land slip hazard. Refer to slope stability section below.
- **Erosion:** There are no significant watercourses on the site and we consider the site to be at low risk of damage due to erosion.
- **Expansive soils:** the soils in the Hills terrain could be expansive. Refer to expansive soils section below.
- **Subsidence:** There is a potential subsidence hazard in the north of the site due to softer soils at the geological transition. (see 'Subsidence' below).

Liquefaction

We have undertaken a quantitative liquefaction assessment using site specific CPT data obtained from the intrusive investigation. The assessment has been undertaken in accordance with the NZGS and MBIE guidelines[3]. The assessment is a high-level characterisation of the site (an area-wide assessment – level C). Outputs from the CPT analysis are included in Appendix B. The liquefaction assessment is included in Appendix C.

Assessment inputs

We completed a screening analysis using the CPTs undertaken at the site for 1 in 500-year (ULS) and 1 in 25-year (SLS) design events. The test results were analysed using the proprietary software CLIQ (Geologismiki) and engineering calculations in accordance with the recent NZGS guideline.

The design earthquake for the analysis of liquefaction susceptibility has been assessed from Section 6 of the NZTA Bridge Manual[4]. Input parameters are listed below:

- site seismic classification[5]: Class D (Deep soil site)
- structure Importance Level[6]: Level 2 (Normal importance, residential)
- peak ground acceleration:
    - 0.06g (SLS) for 1 in 25-year event
    - 0.22g (ULS) for 1 in 500-year event
- earthquake magnitude: 5.9
- groundwater depth:
    - East portion of the site – 1 m bgl
    - West portion of the site – 2 m bgl

Liquefaction susceptibility

The susceptibility of a site to liquefaction is a combination of the expected earthquake shaking for the required design return period, the soil types and their strength/density state, and the groundwater conditions at the site. There are several measures of a sites overall susceptibility to liquefaction including liquefaction potential index (LPI), liquefaction severity number (LSN), ground surface settlement and lateral spreading.

The CPTs have been assessed under ULS conditions with the analysis limited to 10 m depth for the screening assessment in accordance with the guidelines. Beneath 10 m the effects of liquefaction may contribute to global settlements however are unlikely to have significant surface expression. Liquefaction should be considered below 10 m if deep foundations are proposed.

Serviceability Limit State (SLS) Earthquake

An SLS earthquake is an event after which there is high expectation that the building or structure can be used as intended without repair or with minimal repair. The assessment showed that under SLS conditions there is no liquefaction damage expected at the site.

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[3] Ministry of Business Innovation and Employment (MBIE) / New Zealand Geotechnical Society (NZGS). Module 3: Identification, assessment and mitigation of liquefaction hazards. Dated May 2016.
[4] New Zealand Transport Agency (May 2016). Bridge manual (SP/N/022) Third edition.
[5] NZS 1170.5:2004. Structural Design Actions – *Earthquake Actions (New Zealand). SANZ*
[6] NZS 1170.0:2002. Structural Design Actions – *General Principles. SANZ*

Ultimate Limit State (ULS) Earthquake

A ULS earthquake is an event after which a building should retain its integrity to allow safe evacuation of people but is likely to be severely damaged and may not be repairable. The assessment showed that under ULS conditions there is a liquefaction hazard at the site.

Under ULS conditions, our assessment indicated:

East (GW at 1m bgl):

- between 115 and 155 mm of predicted vertical settlement
- Liquefaction Potential Index (LPI) between 5.5 and 9 (high risk)
- Liquefaction Severity Number (LSN) between 27 and 28 (high expression expected)

West (GW at 2m bgl):

- between 25 mm and 65 mm of predicted vertical settlement
- Liquefaction Potential Index (LPI) between 1 and 2.5 (mild to moderate risk)
- Liquefaction Severity Number (LSN) between 4 and 8 (mild expression expected)

Site performance level

Our assessment indicates that the site lies within performance level L1 (west) to L3 (east), mild to high anticipated liquefaction effects in accordance with Table 5.1 of the latest MBIE and NZGS guidelines[7]. Liquefaction hazards area is shown on Drawing No.3 in Appendix C.

Sensitivity to groundwater

To understand the variability of the liquefaction risk, we have conducted a sensitivity analysis on the groundwater conditions and assumed a peak high groundwater table of 0.5 m higher.

The sensitivity analysis predicted:

East (GW at 0.5m bgl):

- increase in overall vertical settlement of between 5 mm and 15 mm (130 mm to 160 mm)
- Liquefaction Potential Index (LPI) between 9 and 12 (high risk)
- Liquefaction Severity Number (LSN) between 32 and 35 (high to severe expression expected)

West (GW at 1.5m bgl):

- increase in overall vertical settlement of between 1 mm and 5 mm (25 mm to 70 mm)
- Liquefaction Potential Index (LPI) between 1 and 3 (mild to moderate risk)
- Liquefaction Severity Number (LSN) between 5 and 10 (mild to moderate expression expected)

The site performance level will increase to L2 to L3 (east & west), moderate to high anticipated liquefaction effects.

Lateral spreading

There are no significant free faces on site that would cause a lateral spreading hazard. During development, free faces may be created by the construction of wetlands, stormwater conveyance channels or fill batter slopes on the Plains area. These features should be assessed for potential lateral spreading during design.

[7] Module 3: Identification, assessment and mitigation of liquefaction hazards. Prepared by Ministry for the Environment and Ministry of Business, Innovation and Employment, Rev 0.1, dated September 2017.

Settlement

We have completed a screening assessment to check the response of the soils to loading. For the screening assessment, we used the CPT data and the propriety software CPeT (Geologismiki). We have estimated load induced settlement on the deposits for a range of loads (anticipating fill loads and building loads). We assessed loads between 30kPa and 60kPa.

The analysis indicates that most of the site has a low risk of static settlement with between 10 mm and 30mm predicted.

The analysis indicates that the north-west portion of the site (CPT05) is generally subject to static settlement of between 70 mm and 140 mm. Reviewing the soil behaviour types in CPT05, there is lower strength material at approximately 7m depth which is susceptible to settle on loading. This material is likely to be associated with the transition from the Hills Terrain to the Plains Terrain. This transition zone can be an area where lower strength soils accumulated during deposition.

In order to ease grades from the steep Hill Terrain to the Plains it is likely that the Hills will be cut down and fill will be placed on the plains. This may be an area that is more susceptible to settlement and some mitigation (such as preloading) may be needed.

While not encountered during this investigation, our experience in the area is that organic and soft soils are commonly (but not exclusively) found in Paleochannel features and close to the Hill Terrain in 'embayments'. As the risk of consolidation settlements is often greatest in these areas, they should be a target area for future investigations.

Further investigation and analysis should be undertaken to define the static settlement hazard and whether mitigation measures such as excavation or preloading are required. Further engineering design is recommended for development of this part of the site.

Slope stability

There are no indications of any recent, large scale instability having occurred at the site, or in the immediate surrounding area. Features that may be indicative of small to medium-scale instability were observed to the north of the site, however, historic aerial imagery indicates these failures have not changed significantly in at least the last 50 years. Active observed instability in the area tends to be shallow creep on steeper slopes and is often associated with springs, saturated soils or stock movement. Earthworks on the site are likely to reduce the overall stability risk by reducing both the heights and grades of current slopes. Cuts up to 3 m height at 1V:3H sloped batters are expected to be stable, however shallower grades may be required for other purposes (e.g. Landscaping). Where cut slopes are steeper or higher than this, specific assessment and design will be required.

Earthworks on the Hill Terrain may demand grades that will require retaining. Specific design will be required for retaining walls.

Instability is often driven by, or significantly influenced by, surface water or groundwater. Control of water from the development will be necessary to ensure that there is no adverse effect on the slopes. Water should be collected and directed away from slopes. Any collected water will need to be discharged in a controlled manner to a protected outlet.

Expansive soils

The Hills Terrain consisted of clayey soils (Walton Subgroup) are normally subject to low to high plasticity. These soils have a potential to change in volume ("shrink and swell") in response to moisture content changes, typically with seasonal periodicity.

Based on our experience of the geology and the Waikato Soil's clay minerology, we expect the subgrade across the Hills Terrain to range between Class A and Class M, non-expansive to moderately expansive soils. These classes are typical in the Waikato and Class S to M soils can be easily mitigated.

Earthworks

The site is relatively flat with a small section of elevated hills along the northern boundary of the site. Earthworks at the site are likely to consist of cut and fill operations in order to ease grades on the site, create level building platforms, fill open drains, form stormwater storage and conveyance, and to raise the Plains above flood levels.

Any proposed earthworks plans should be reviewed by suitably qualified geotechnical engineer. Site-specific earthworks specifications will be needed prior to construction.

Preliminary foundation assessment

The site investigation indicates loose/soft material at shallow depths and a liquefaction hazard. The site will not be suitable for standard shallow foundations however, common foundations used in the area, such as raft foundations designed for the low bearing capacity and liquefaction hazard will likely be appropriate foundations for the site. Further assessment and refining of these recommendations will be needed for developing the site.

Further work

Based on our assessment, the site is geotechnically suitable for the development, subject to the following recommendations:

- given there are geotechnical hazards present, we recommend geotechnical involvement and review as the development proposals are progressed
- more comprehensive testing will be needed to inform the design of the site and support consent applications
- pavements will need to be designed for the low strength subgrade and any earthworks modifications
- earthworks specifications will be needed for development

Limitations

This report has been prepared for our client, Lysaght Consultants and Bluehaven Holdings Ltd for the purpose detailed above and may not be relied on by any other parties or for any other purposes. This report contains a preliminary assessment for master planning of the site. Further testing and assessment is required to support other future works. Inferences about the conditions at the site have been made based on our testing and our understanding of the site geology. Ground conditions in this geology can be highly variable vertically and laterally.

APPENDIX A – GEOLOGIC TRANSITION PLAN

GEO

LEGEND:

Hill Terrain

Plains

PROJECT:
Te Kowhai properties

PROJECT NO:
HD1996

CLIENT:
Lysaght Consultants

TITLE:
Geological Transition Plan

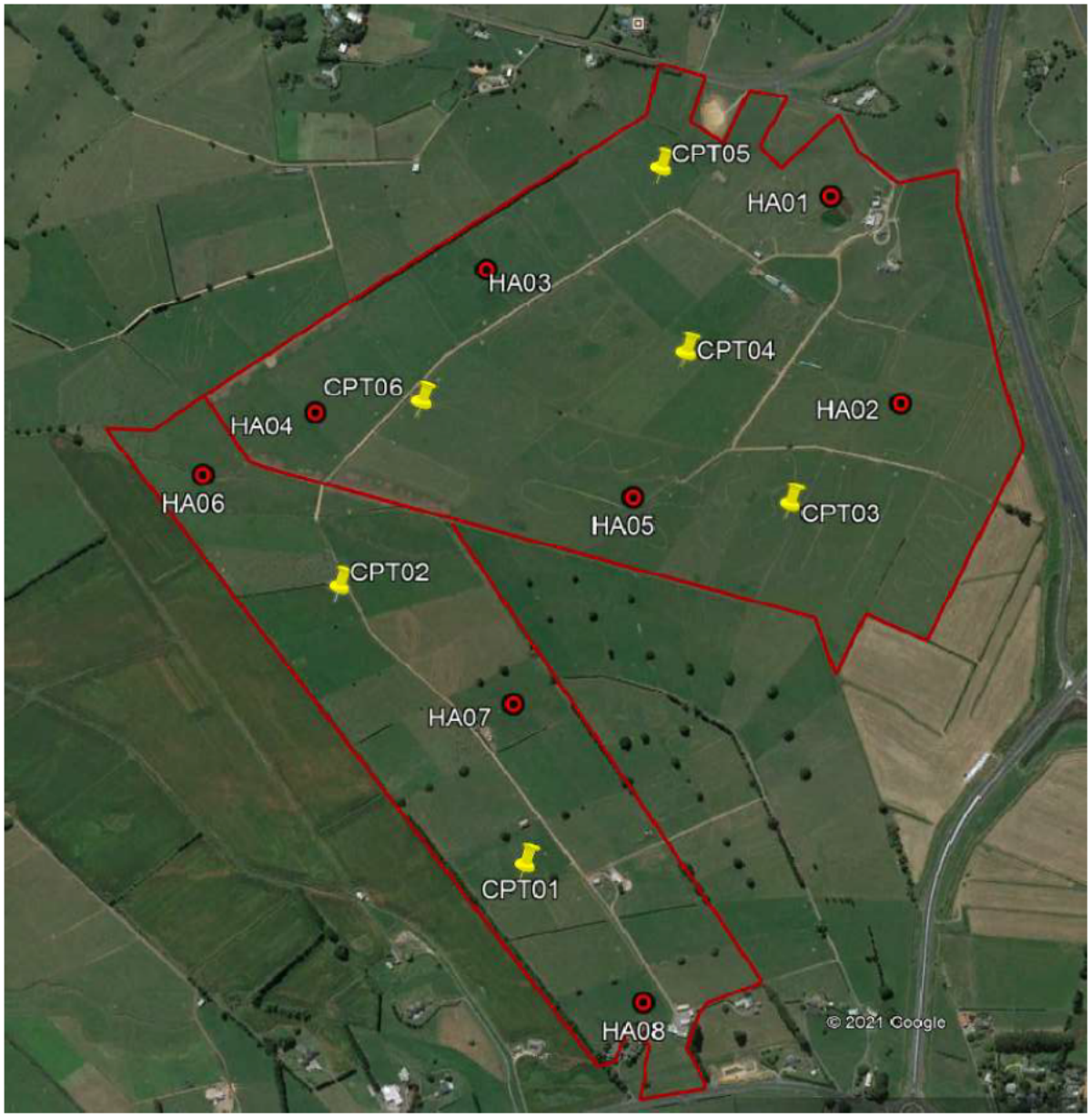
SCALE: N/A

Drawing No: 1

Drawing by : SSA

Rev Number	
1	12.05.21

APPENDIX B – SITE PLAN AND INVESTIGATION DATA



GEO

LEGEND:

- Hand auger
- CPT Test
- Boundary

PROJECT: Te Kowhai properties	
PROJECT NO: HD1996	
CLIENT: Lysaght Consultants	
TITLE: Site plan	
SCALE: N/A	
Drawing No: 2	
Drawing by : SSA	
Rev Number	
1	12.05.21

INVESTIGATION LOG

Client: Lysaght	**Job No.:** HD1996
Project: Te Kowhai Development	**No.:** HA01
Location: By drainage ponds.	**Date:** 19.05.21
Co-ordinates: 1794242mE, 5822380mN	**Logged By:** AM
Elevation: Ground	**Checked By:** SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.4
Piako Subgroup	CLAY; grayish brown. Stiff; moist; high plasticity.	1.2
	Silty SAND; light gray. Very dense; saturated; high dilatency; well graded; sand, fine to coarse.	2.0
	Sandy SILT; light gray. Firm to stiff; saturated; sand, fine.	3.0
	EOH: 3.00 m	3.4

Legend: TS

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.2	1, 1, 1
0.4	2
0.6	1, 1
0.8	2
1.0	1, 1
1.2	2
1.4	7, 8
1.6	8, 11
1.8	11, 11
2.0	11

Vane Shear Strength (kPa) Vane: 534

Depth (m)	Peak	Remoulded
0.4	148	34
0.6	124	15
0.8	108	19
1.2	49	12
2.0	31	25
2.4	77	40
2.8	62	46
3.0	80	43

Water: 1.2 m

Photo

Remarks

End of log at 3.0 m - target depth.

Shear Vanes
- Peak
- Remoulded

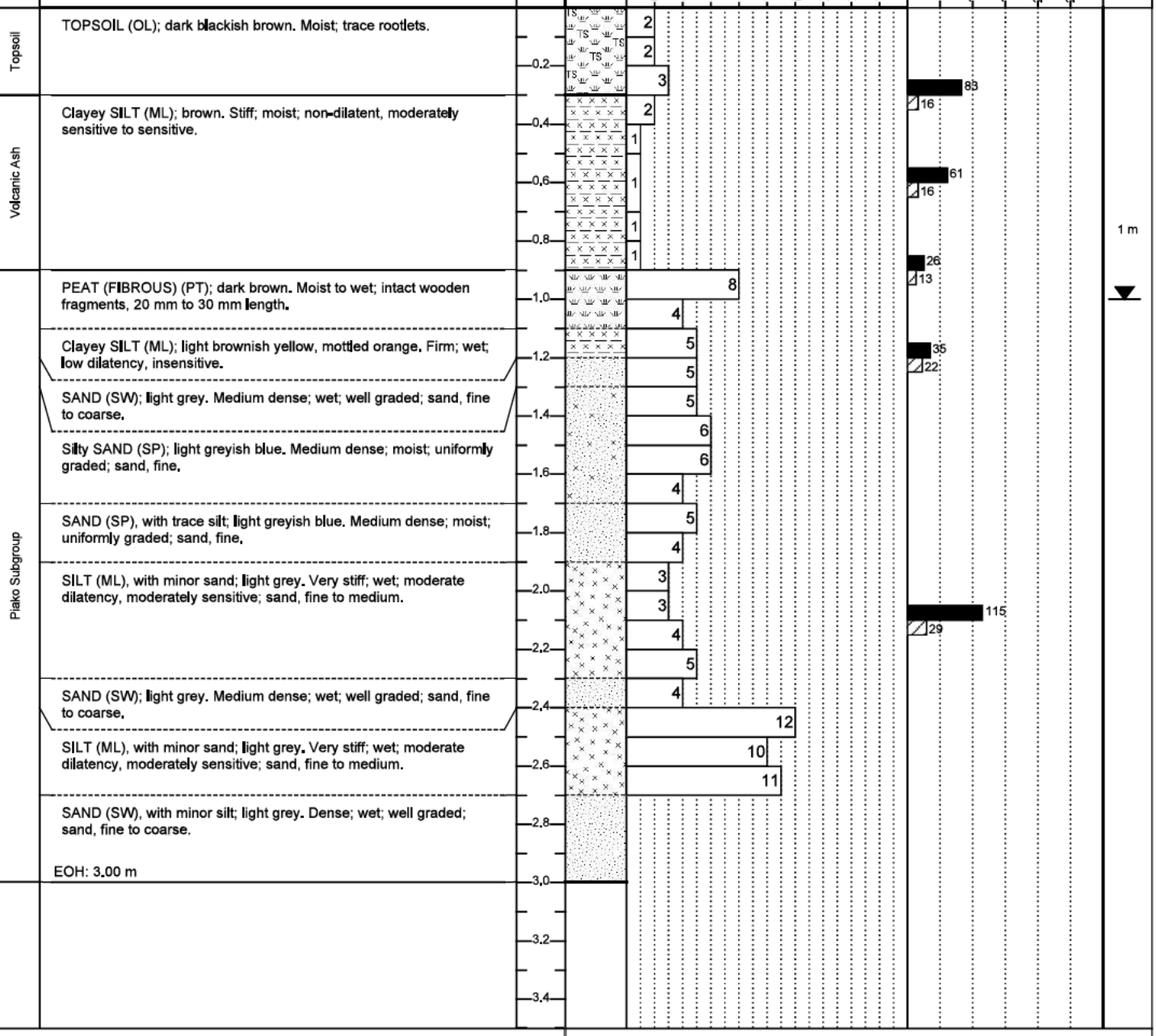
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Lysaght	**Job No.:**	HD1996
Project:	Te Kowhai Development	**No.:**	HA02
Location:	Eastern end of site, 250 m south of farmhouse.	**Date:**	20.05.21
Co-ordinates:	1794348mE, 5821988mN	**Logged By:**	MM
Elevation:	Ground	**Checked By:**	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Volcanic Ash	Clayey SILT (ML); brown. Stiff; moist; non-dilatent, moderately sensitive to sensitive.	0.4
		0.6
		0.8
Piako Subgroup	PEAT (FIBROUS) (PT); dark brown. Moist to wet; intact wooden fragments, 20 mm to 30 mm length.	1.0
	Clayey SILT (ML); light brownish yellow, mottled orange. Firm; wet; low dilatency, insensitive.	1.2
	SAND (SW); light grey. Medium dense; wet; well graded; sand, fine to coarse.	1.4
	Silty SAND (SP); light greyish blue. Medium dense; moist; uniformly graded; sand, fine.	1.6
	SAND (SP), with trace silt; light greyish blue. Medium dense; moist; uniformly graded; sand, fine.	1.8
	SILT (ML), with minor sand; light grey. Very stiff; wet; moderate dilatency, moderately sensitive; sand, fine to medium.	2.0
	SAND (SW); light grey. Medium dense; wet; well graded; sand, fine to coarse.	2.4
	SILT (ML), with minor sand; light grey. Very stiff; wet; moderate dilatency, moderately sensitive; sand, fine to medium.	2.6
	SAND (SW), with minor silt; light grey. Dense; wet; well graded; sand, fine to coarse.	2.8
	EOH: 3.00 m	3.0
		3.2
		3.4



Photo

Remarks

End of log at 3 m - target depth.

Shear Vanes	Water	Investigation Type
Peak	Standing Water Level	☑ Hand Auger
Remoulded	Out flow	☐ Investigation Pit
	In flow	☐ Machine Borehole

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INVESTIGATION LOG

Job No.:	HD1996
Client:	Lysaght
No.:	HA03
Project:	Te Kowhai Development
Location:	Within paddocks along north-western boundary.
Date:	20.05.21
Co-ordinates:	1793612mE, 5822253mN
Logged By:	MM
Elevation:	Ground
Checked By:	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Volcanic Ash	Clayey SILT (ML); brown. Very stiff; moist; non-dilatent, sensitive. 0.5 m: becomes light grey, streaked orange.	0.4 0.6 0.8
Piako Subgroup	SAND (SP), with trace silt; light brown, mottled orange. Loose to medium dense; moist; poorly graded; sand, fine to medium.	1.0
	Silty SAND (SP); light grey, streaked orange. Medium dense; moist; uniformly graded; sand, fine.	1.2 1.4
	SILT (ML), with minor sand; light grey, streaked orange. Loose to medium dense; moist; non-dilatent; sand, fine to medium. 1.9 m: becomes wet; low dilatency.	1.6 1.8
	SAND (SW), with trace silt; grey. Medium dense; wet; well graded; sand, fine to coarse.	2.0 2.2
	SILT (ML), with some clay; grey. Very stiff; wet; low to moderate dilatency, moderately sensitive.	2.4 2.6 2.8
	EOH: 3.00 m	3.0
		3.2 3.4

Legend: TS

Scala Penetrometer (Blows / 100 mm): 1, 2, 1, 1, 3, 2, 2, 3, 2, 2, 4, 4, 4, 3, 3, 5, 2, 4, 7, 3, 3, 3, 3, 4, 5, 4, 6, 9, 7, 12

Vane Shear Strength (kPa), Vane: 1710: 195 / 45; 179 / 32; 108 / 35

Water: 1.9 m

Photo

Remarks

End of log at 3 m - target depth.

Shear Vanes	Water	Investigation Type
Peak	Standing Water Level	☑ Hand Auger
Remoulded	Out flow	☐ Investigation Pit
	In flow	☐ Machine Borehole

INVESTIGATION LOG

Job No.:	HD1996
No.:	HA04
Client:	Lysaght
Project:	Te Kowhai Development
Location:	West of area boundary.
Co-ordinates:	1793321mE, 5821972mN
Elevation:	Ground
Date:	19.05.21
Logged By:	AM
Checked By:	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2, 0.4
Volcanic Ash	Clayey SILT; light brown. Stiff; moist.	0.6, 0.8
Piako Subgroup	SILT, with minor clay; light gray. Stiff; moist.	1.0
	Silty SAND; light gray. Very loose to loose; moist; moderate dilatency; well graded; sand, fine to coarse.	1.2, 1.4
	Silty CLAY, with trace sand; light gray. Very stiff; moist to wet; moderate plasticity; sand, fine.	1.6
	SAND, with some silt; light gray. Medium dense; moist; high dilatency; well graded; sand, fine to coarse.	1.8, 2.0, 2.2, 2.4
	Sandy SILT; light gray. Medium dense to dense; saturated; high dilatency.	2.6, 2.8
	EOH: 2.80 m	3.0, 3.2, 3.4

Legend: TS

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0 – 0.2	2, 2
0.2 – 0.4	1, 1, 1
0.4 – 0.6	1, 1
0.6 – 0.8	2
0.8 – 1.0	1, 3
1.0 – 1.2	2, 2
1.2 – 1.4	1, 2
1.4 – 1.6	1, 4, 8
1.6 – 1.8	6, 6
1.8 – 2.0	7, 6
2.0 – 2.2	4, 5
2.2 – 2.4	5
2.4 – 2.6	10, 8
2.6 – 2.8	9, 8
2.8 – 3.0	7, 3
3.0 – 3.2	5, 10
3.2 – 3.4	8, 8

Vane Shear Strength (kPa) Vane: 534

Depth (m)	Peak	Remoulded
0.2 – 0.4	108	34
0.6 – 0.8	99	19
0.8 – 1.0	133	37
1.2 – 1.4	120	46
1.4 – 1.6	139	34
1.8 – 2.0	UTP	

Water: 2 m

Photo

Remarks

End of log at 2.8 m. Borehole collapse.

Shear Vanes
- Peak
- Remoulded

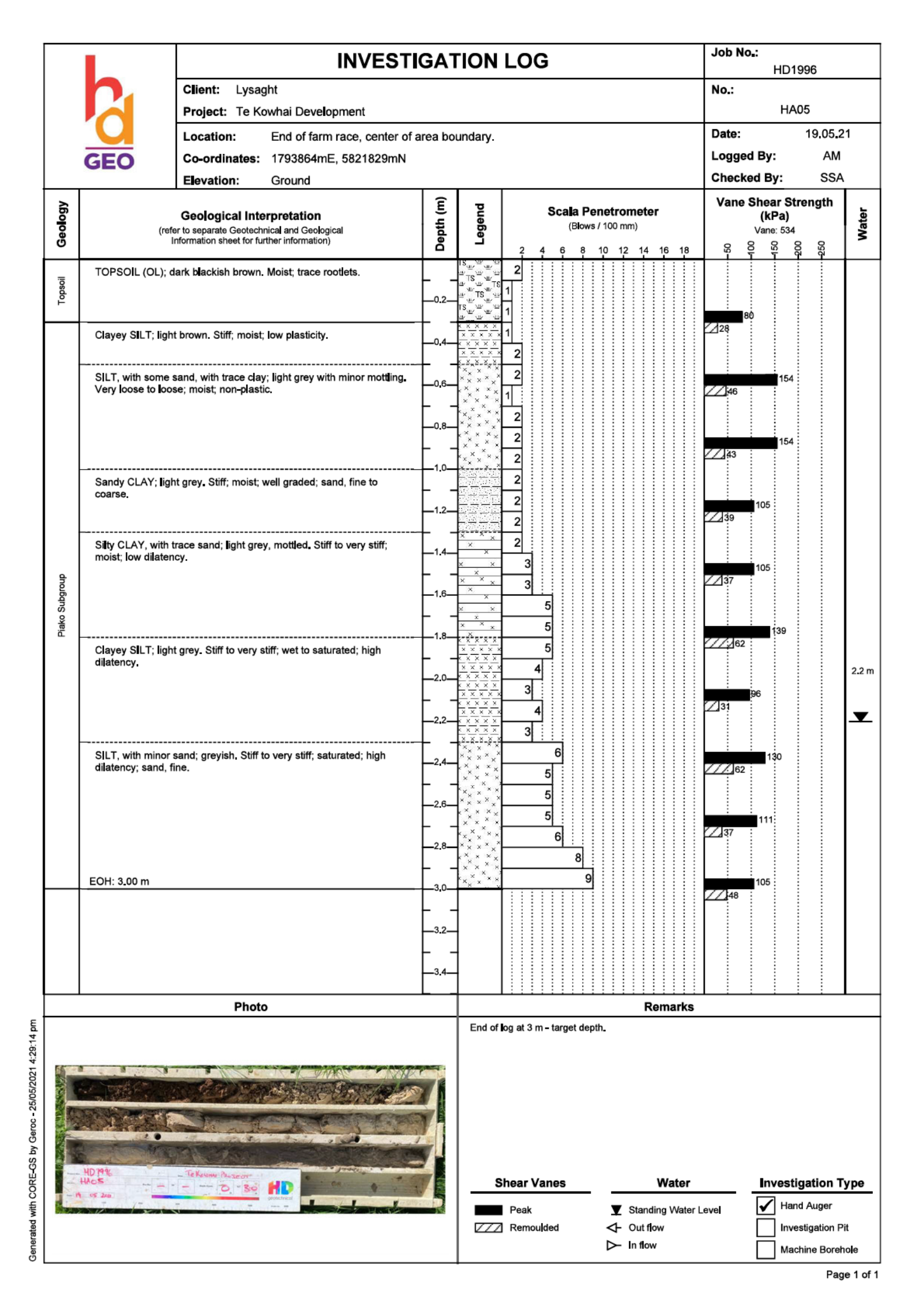
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Job No.:	HD1996
Client:	Lysaght
No.:	HA05
Project:	Te Kowhai Development
Location:	End of farm race, center of area boundary.
Date:	19.05.21
Co-ordinates:	1793864mE, 5821829mN
Logged By:	AM
Elevation:	Ground
Checked By:	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Piako Subgroup	Clayey SILT; light brown. Stiff; moist; low plasticity.	0.4
	SILT, with some sand, with trace clay; light grey with minor mottling. Very loose to loose; moist; non-plastic.	0.6
		0.8
		1.0
	Sandy CLAY; light grey. Stiff; moist; well graded; sand, fine to coarse.	1.2
	Silty CLAY, with trace sand; light grey, mottled. Stiff to very stiff; moist; low dilatency.	1.4
		1.6
		1.8
	Clayey SILT; light grey. Stiff to very stiff; wet to saturated; high dilatency.	2.0
		2.2
	SILT, with minor sand; greyish. Stiff to very stiff; saturated; high dilatency; sand, fine.	2.4
		2.6
		2.8
	EOH: 3.00 m	3.0
		3.2
		3.4



Photo

Remarks

End of log at 3 m - target depth.

Shear Vanes
- Peak
- Remoulded

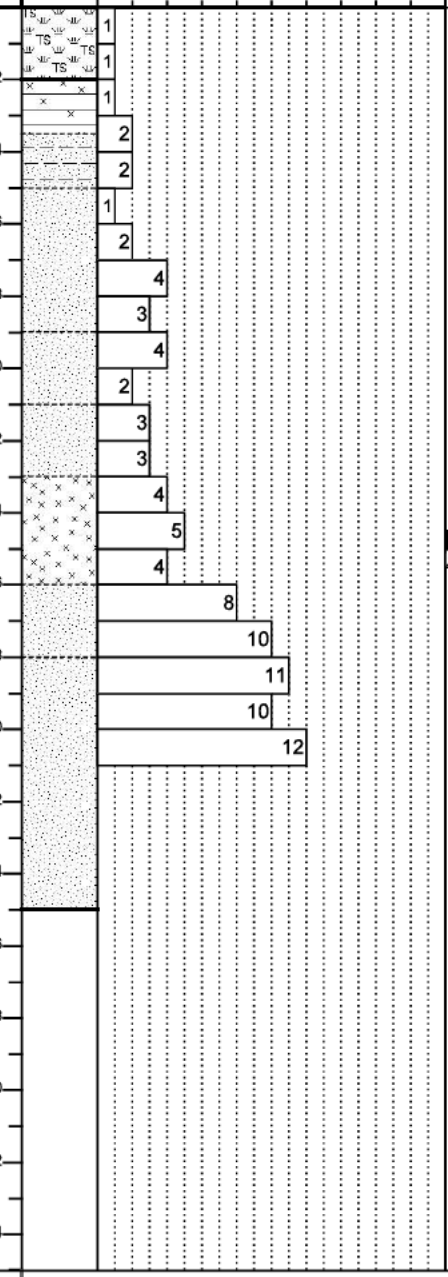
Water
- Standing Water Level
- Out flow
- In flow

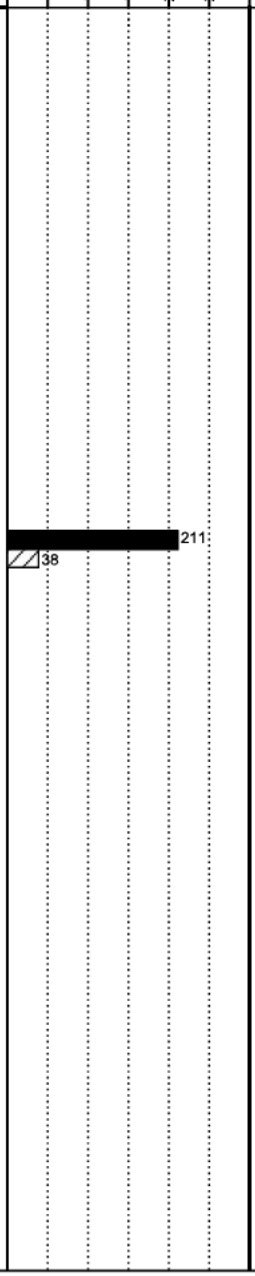
Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client: Lysaght	**Job No.:** HD1996
Project: Te Kowhai Development	**No.:** HA06
Location: Western extent of site, south of drainage trench.	**Date:** 20.05.21
Co-ordinates: 1793107mE, 5821853mN	**Logged By:** MM
Elevation: Ground	**Checked By:** SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Piako Subgroup	Silty CLAY (CL); light yellowish brown, mottled orange. Moist; low to moderate plasticity.	0.4
	Clayey SAND (SW); light yellowish brown, mottled orange. Loose; moist; well graded; sand, fine to coarse.	0.6
	SAND (SW), with trace silt; light brown, mottled orange. Loose to medium dense; moist; well graded; sand, fine to coarse.	0.8
	SAND (SP), with trace silt; light brown, mottled orange. Loose to medium dense; moist; poorly graded; sand, fine to medium.	1.0
	SAND (SP), with trace silt; light brown, mottled orange. Loose to medium dense; moist; uniformly graded; sand, fine.	1.2
	SILT (ML), with minor sand; light greyish blue. Hard; moist; non-dilatent, sensitive; sand, fine.	1.4
	SAND (SP), with trace silt; light greyish blue. Dense; moist; uniformly graded; sand, fine.	1.6
	SAND (SW); grey. Dense; wet; well graded; sand, fine to coarse.	1.8
	EOH: 2.50 m	2.0
		2.2
		2.4
		2.6
		2.8
		3.0
		3.2
		3.4





Photo

Remarks

End of log at 2.5 m - material collapse within borehole.

Shear Vanes
- Peak
- Remoulded

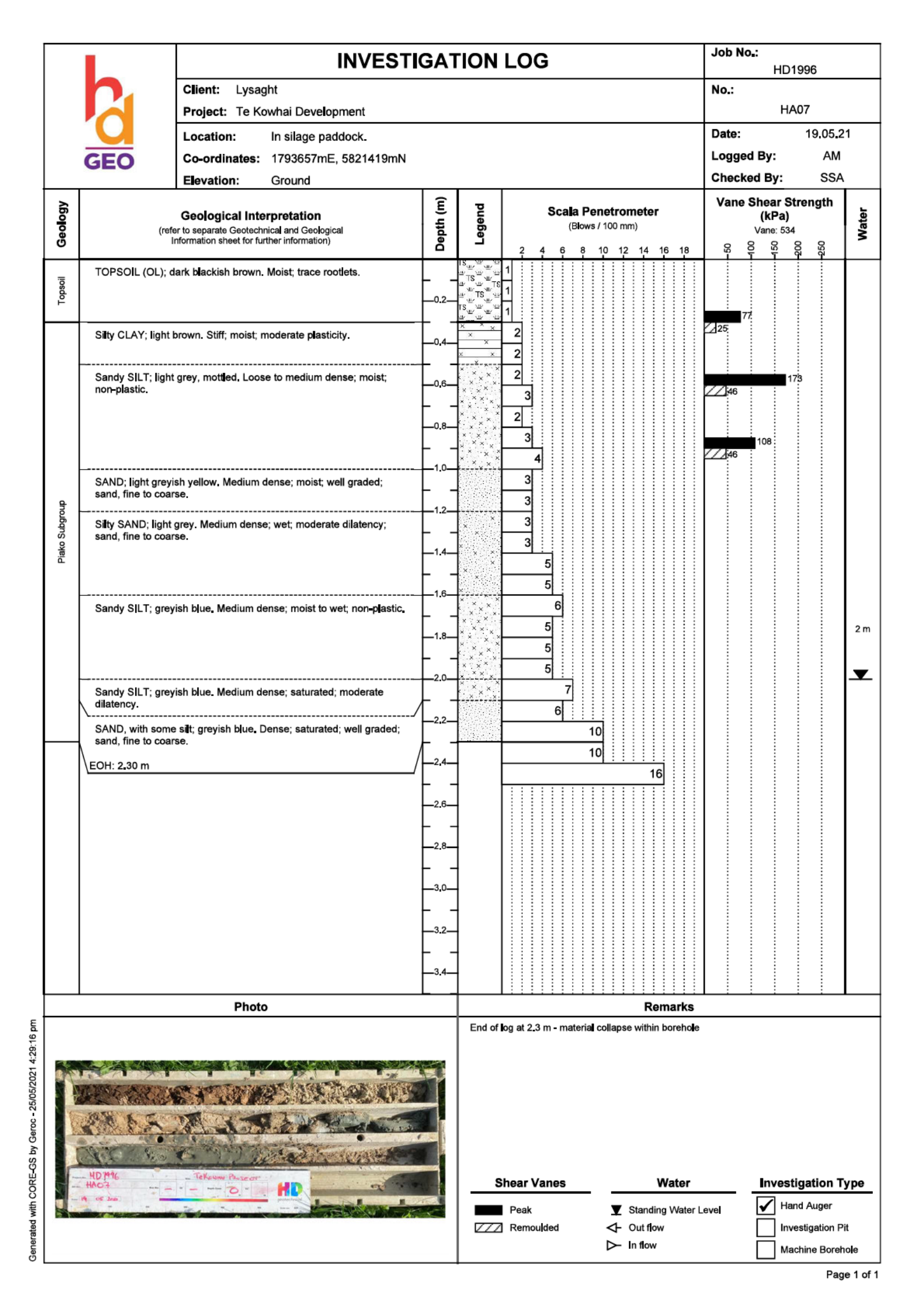
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Lysaght	**Job No.:**	HD1996
Project:	Te Kowhai Development	**No.:**	HA07
Location:	In silage paddock.	**Date:**	19.05.21
Co-ordinates:	1793657mE, 5821419mN	**Logged By:**	AM
Elevation:	Ground	**Checked By:**	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Piako Subgroup	Silty CLAY; light brown. Stiff; moist; moderate plasticity.	0.4
	Sandy SILT; light grey, mottled. Loose to medium dense; moist; non-plastic.	0.6
		0.8
		1.0
	SAND; light greyish yellow. Medium dense; moist; well graded; sand, fine to coarse.	1.2
	Silty SAND; light grey. Medium dense; wet; moderate dilatency; sand, fine to coarse.	1.4
		1.6
	Sandy SILT; greyish blue. Medium dense; moist to wet; non-plastic.	1.8
		2.0
	Sandy SILT; greyish blue. Medium dense; saturated; moderate dilatency.	2.2
	SAND, with some silt; greyish blue. Dense; saturated; well graded; sand, fine to coarse.	2.4
	EOH: 2.30 m	2.6
		2.8
		3.0
		3.2
		3.4



Photo

Remarks

End of log at 2.3 m - material collapse within borehole

Shear Vanes
- Peak
- Remoulded

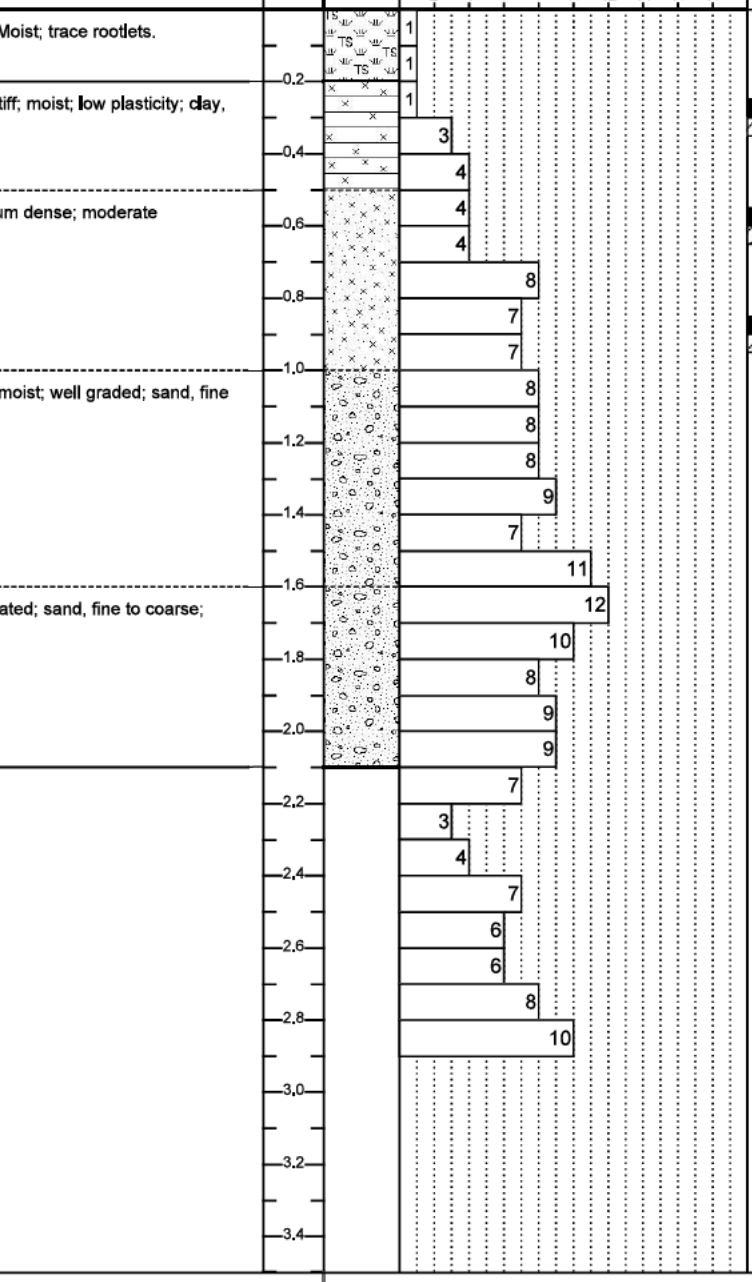
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Job No.:	HD1996
Client:	Lysaght
No.:	HA08
Project:	Te Kowhai Development
Location:	Far south of area boundary, by tennis court.
Date:	19.05.21
Co-ordinates:	1793854mE, 5820887mN
Logged By:	AM
Elevation:	Ground
Checked By:	SSA

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark blackish brown. Moist; trace rootlets.	0.2
Plako Subgroup	Silty CLAY; light greyish white. Very stiff; moist; low plasticity; clay, dark red mottled.	0.4
	Sandy SILT; light greyish white. Medium dense; moderate dilatency; silt, orange mottled.	0.6
		0.8
		1.0
	Gravelly SAND; greyish blue. Dense; moist; well graded; sand, fine to coarse; gravel, fine to medium.	1.2
		1.4
		1.6
	Gravelly SAND; greyish. Dense; saturated; sand, fine to coarse; gravel, fine to medium.	1.8
	EOH: 2.10 m	2.0
		2.2
		2.4
		2.6
		2.8
		3.0
		3.2
		3.4



Photo

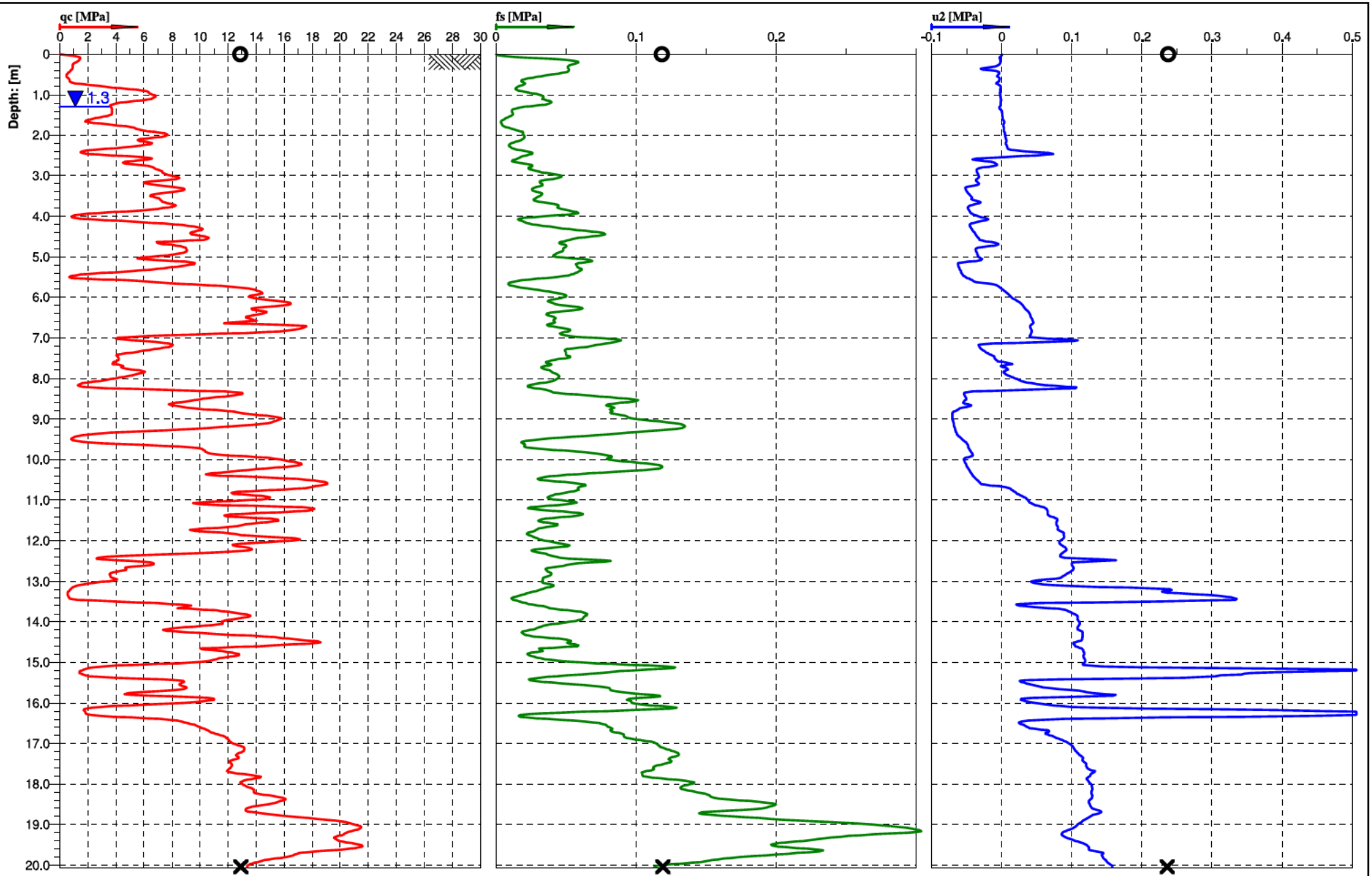
Remarks

End of log at 2.1 m - material collapse within borehole

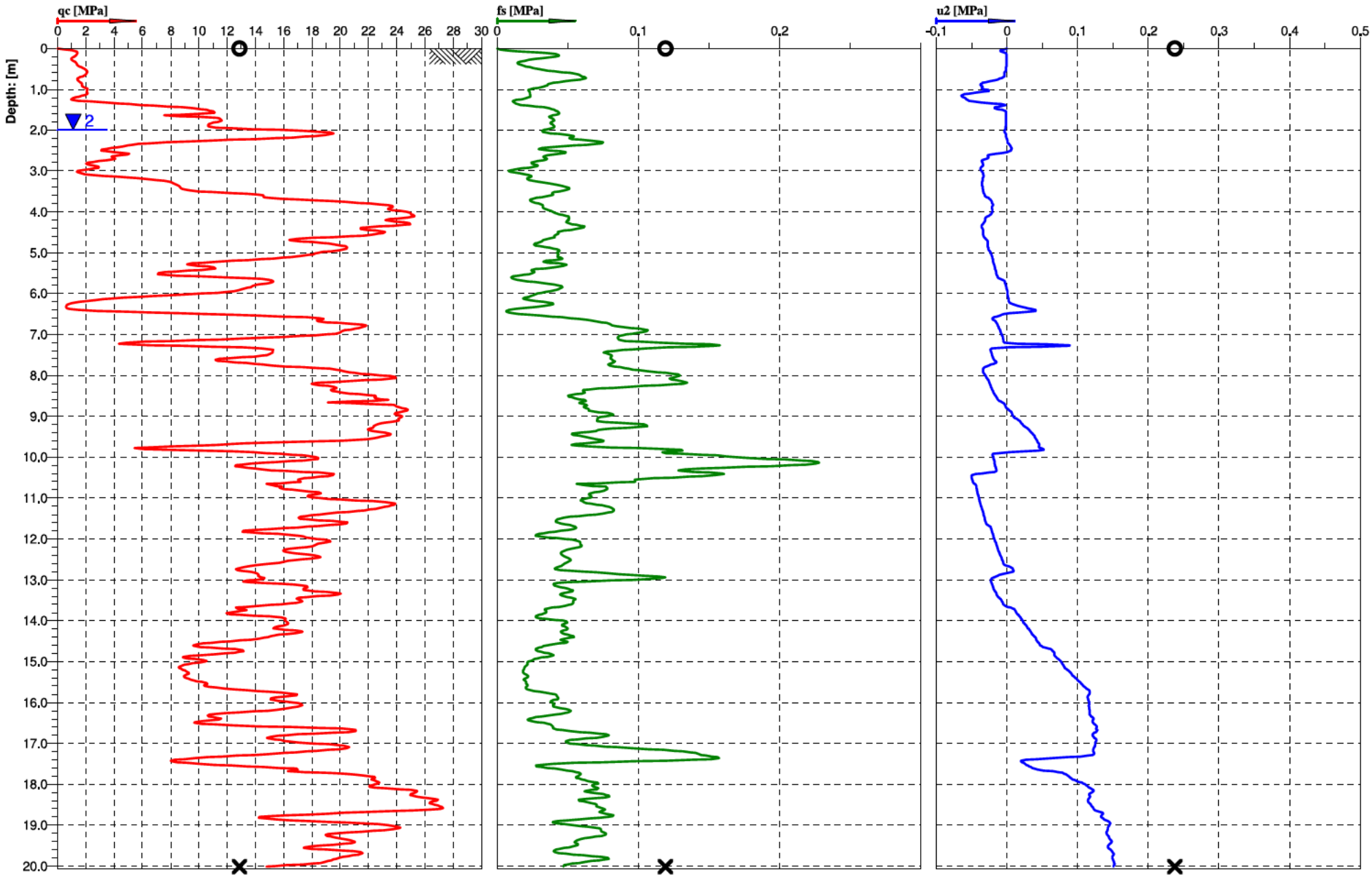
Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole



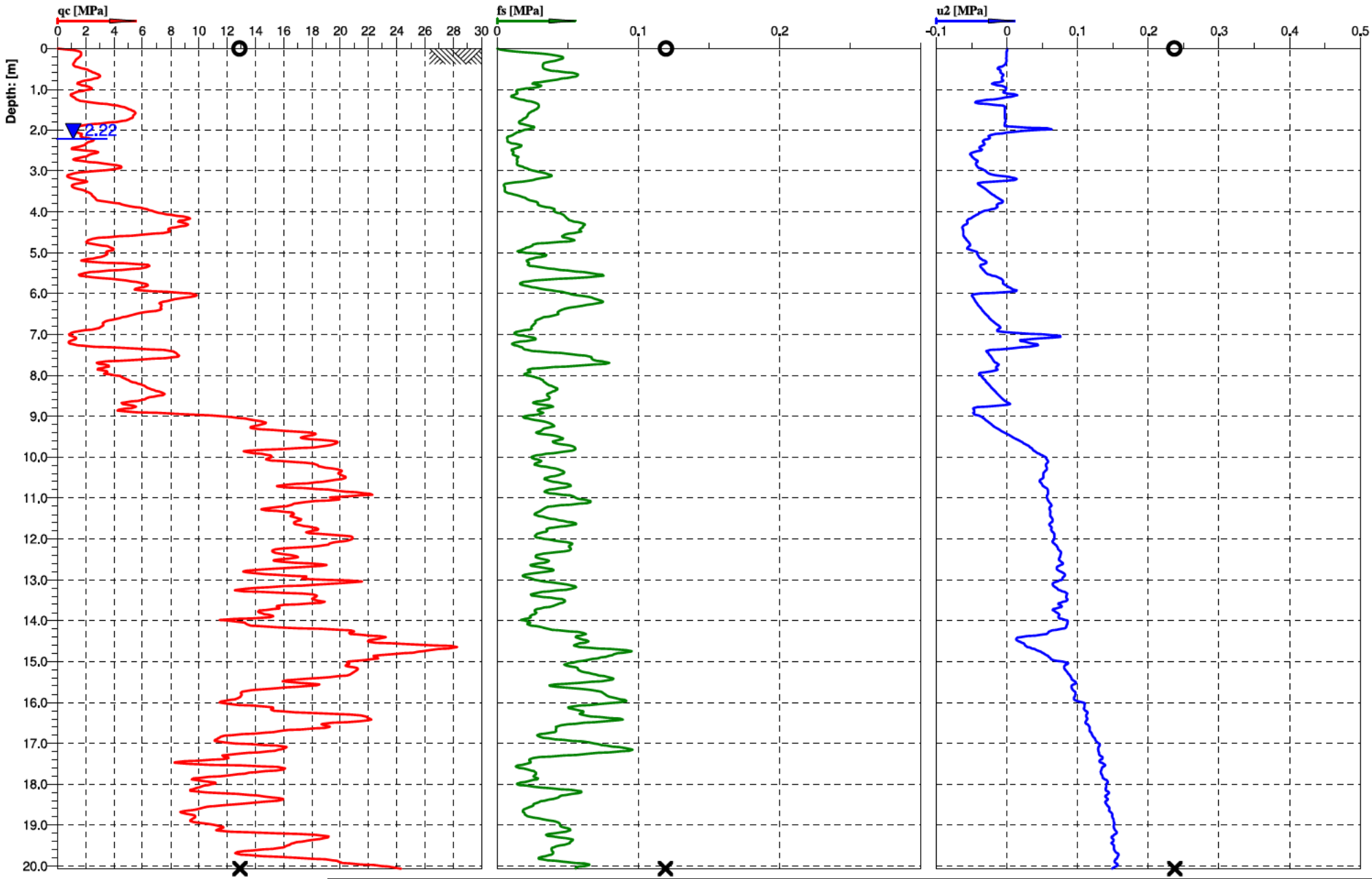
Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID: E1793703 N5821119	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 127
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m.		File: CPT01.cpt	



drillcore

Cone No: 5465
Tip area [cm2]: 10
Sleeve area [cm2]: 150

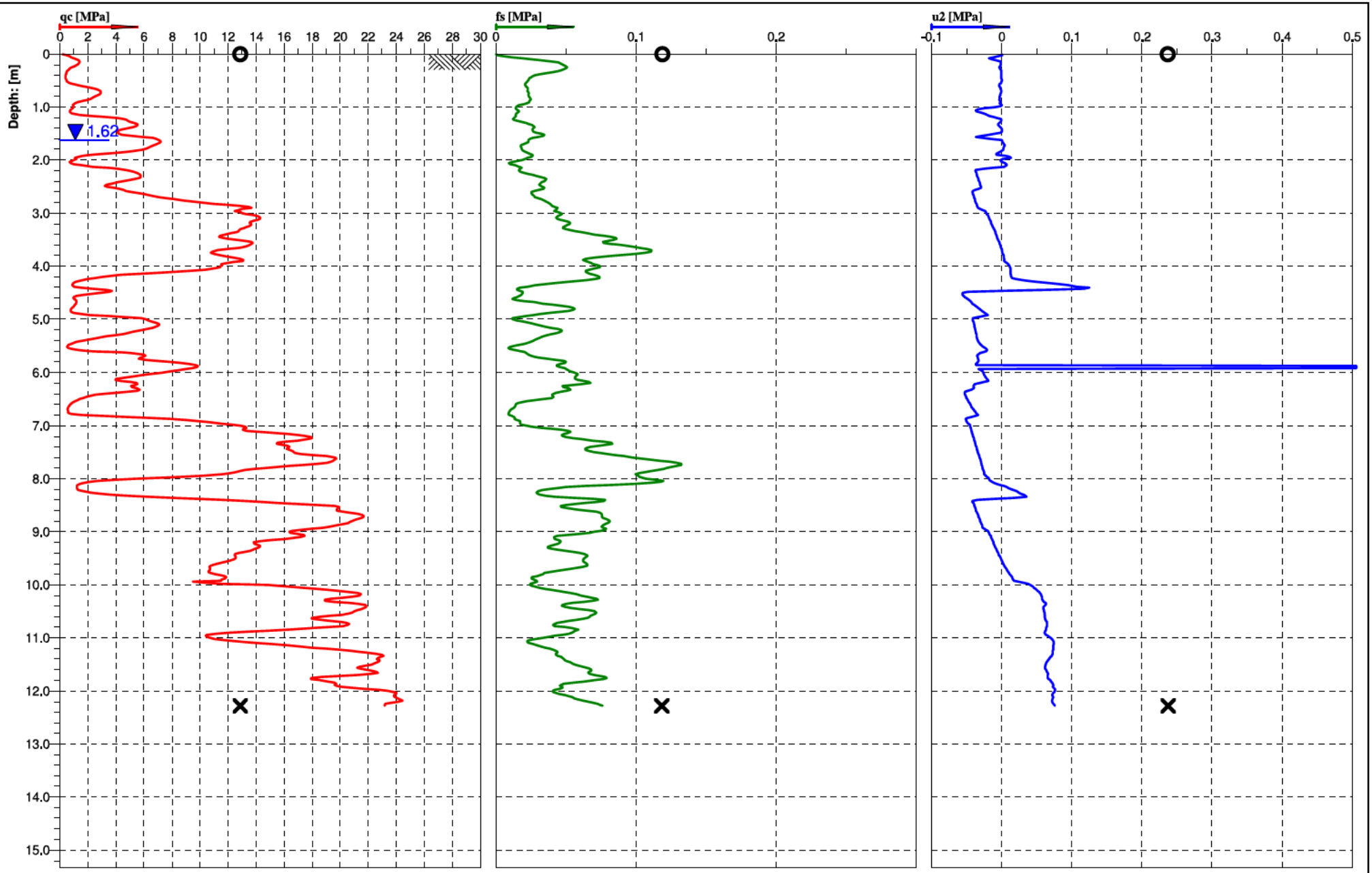
Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID: E1793359 N5801655	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 127
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m.		File: CPT02.cpt	



u2

Cone No: 5465
Tip area [cm2]: 10
Sleeve area [cm2]: 150

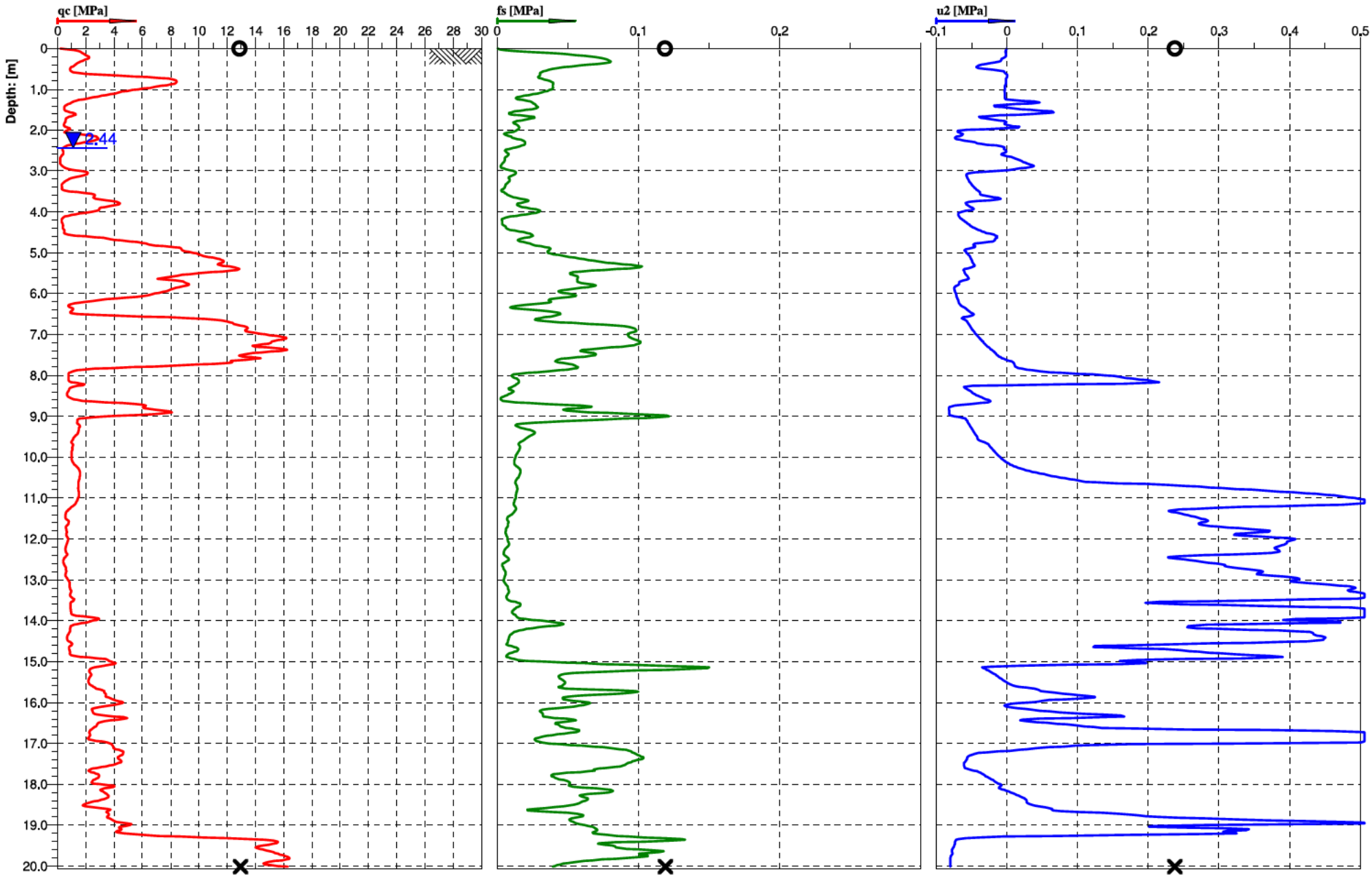
Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID: E1794157 N5821827	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 127
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m.		File: CPT03.cpt	



drillcore

Cone No: 5465
Tip area [cm2]: 10
Sleeve area [cm2]: 150

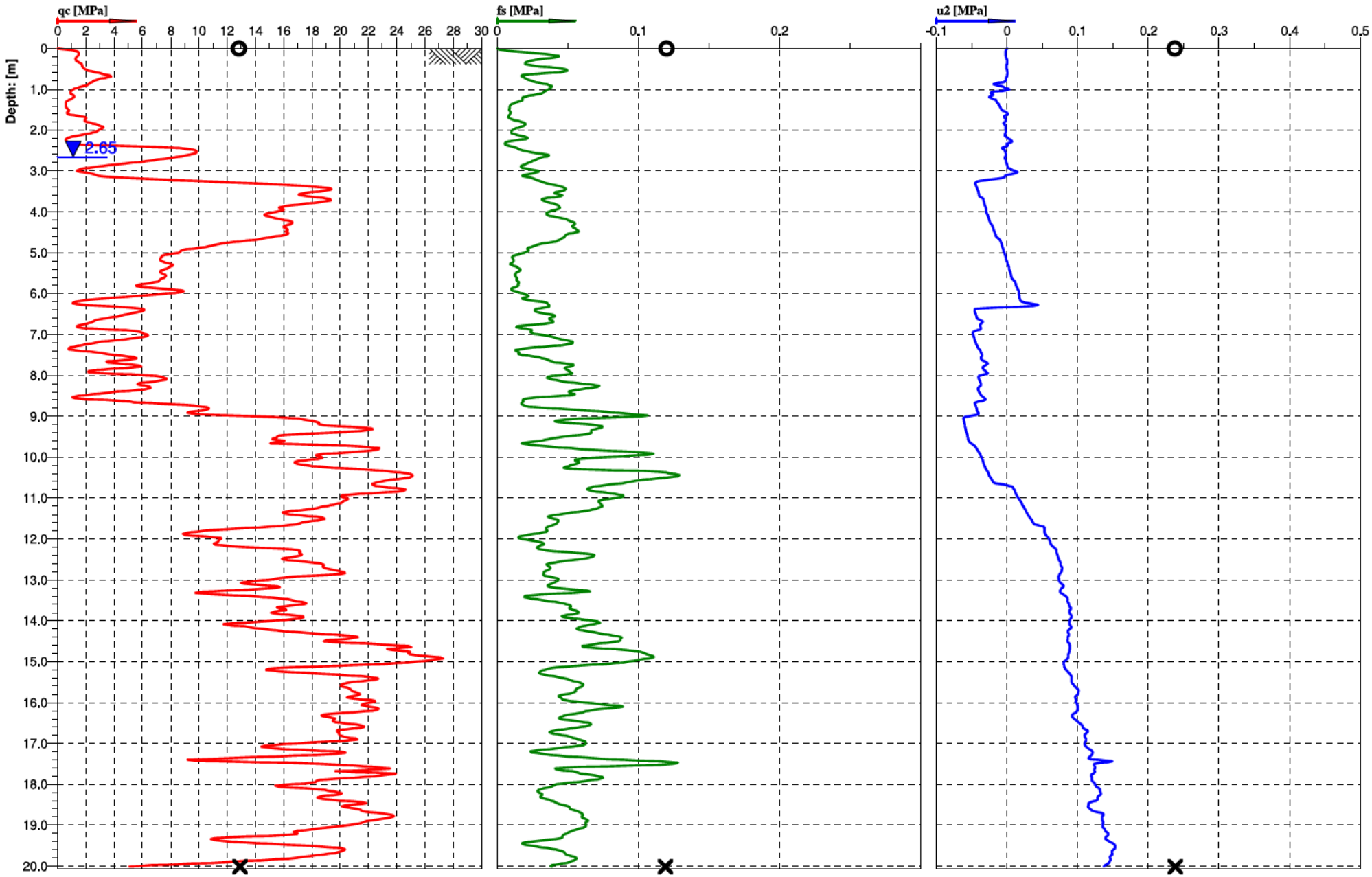
Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID: E1793983 N5822678	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 97
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m. Refused 12.28m.		File: CPT04.cpt	



u2

Cone No: 5465
Tip area [cm2]: 10
Sleeve area [cm2]: 150

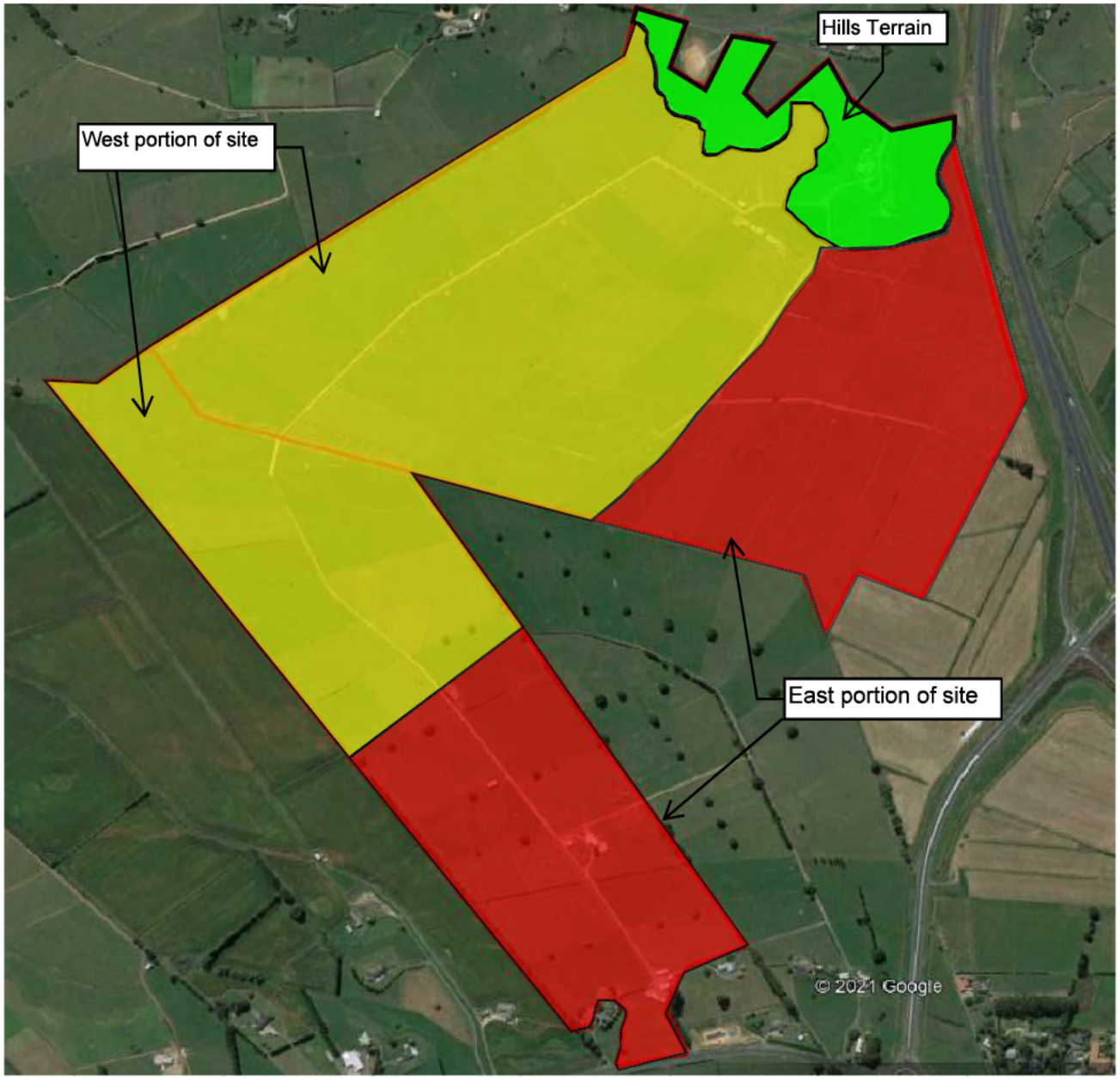
Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID: E1793938 N5822395	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 127
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m.		File: CPT05.cpt	



Cone No: 5465
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Te Kowhai	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID: E1793478 N5822022	Client: HD Geo Ltd	Date: 19/05/2021	Scale: 1 : 127
Project: 268 TE KOWHAI ROAD		Page: 1/2	Fig.:
Target depth 20m.		File: CPT06.cpt	

APPENDIX C – LIQUEFACTION ASSESSMENT



* Note the indicated boundaries are just an approximation

LEGEND:

- None
- Low to Moderate
- Moderate to High

PROJECT: Te Kowhai properties

PROJECT NO: HD1996

CLIENT: Lysaght Consultants

TITLE: Liquefaction Hazard Plan

SCALE: N/A

Drawing No: 3

Drawing by : SSA

Rev Number	
1	12.05.21

HD geo

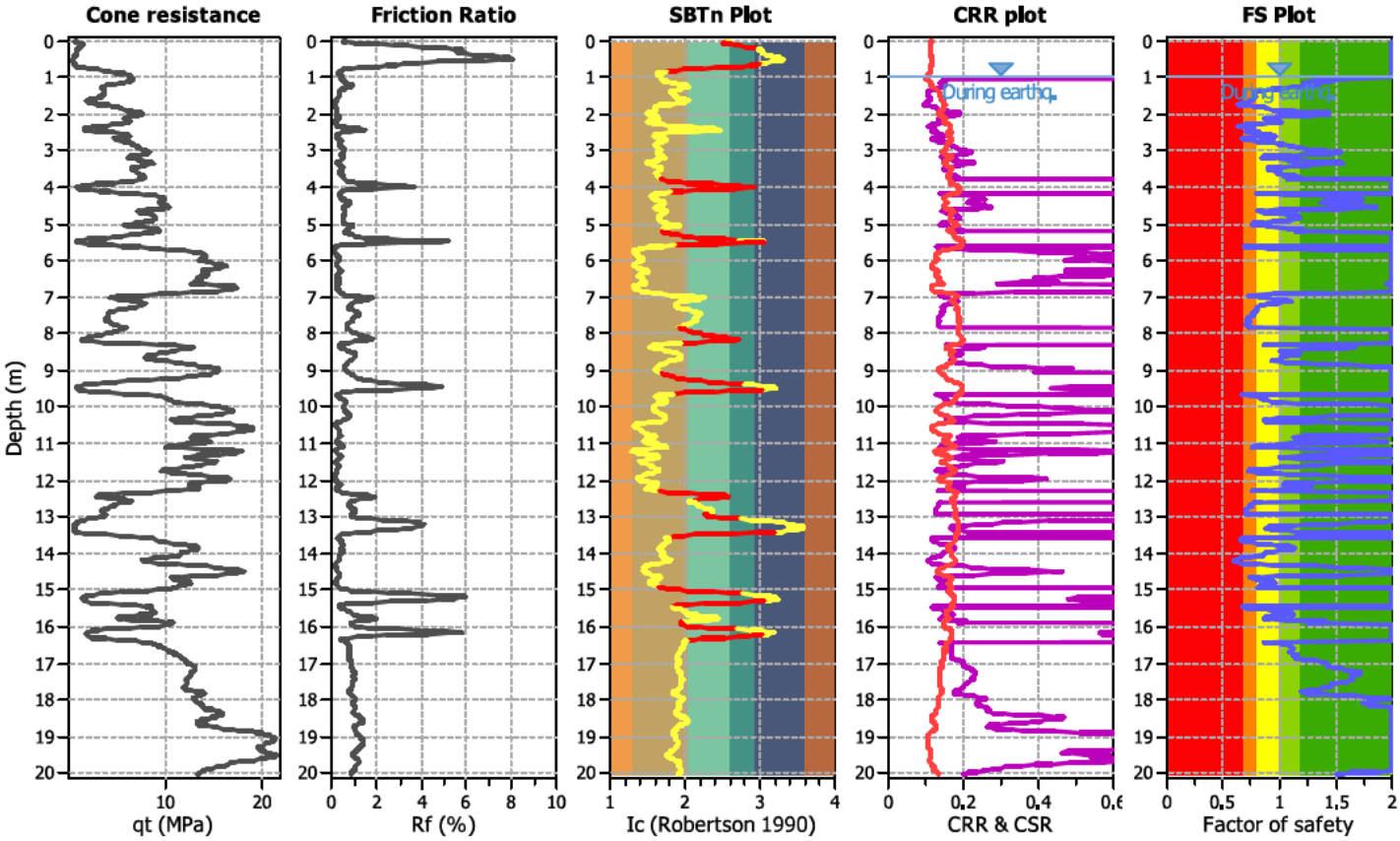
LIQUEFACTION ANALYSIS REPORT

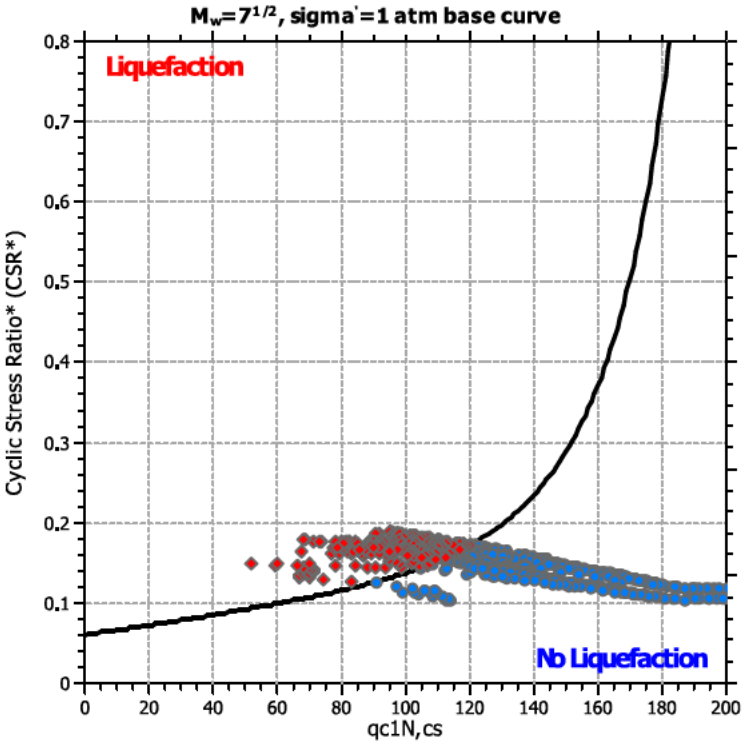
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

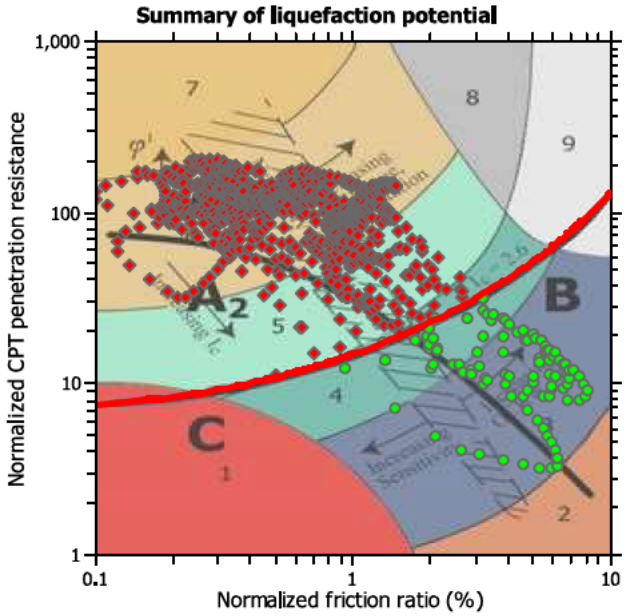
CPT file : CPT01, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

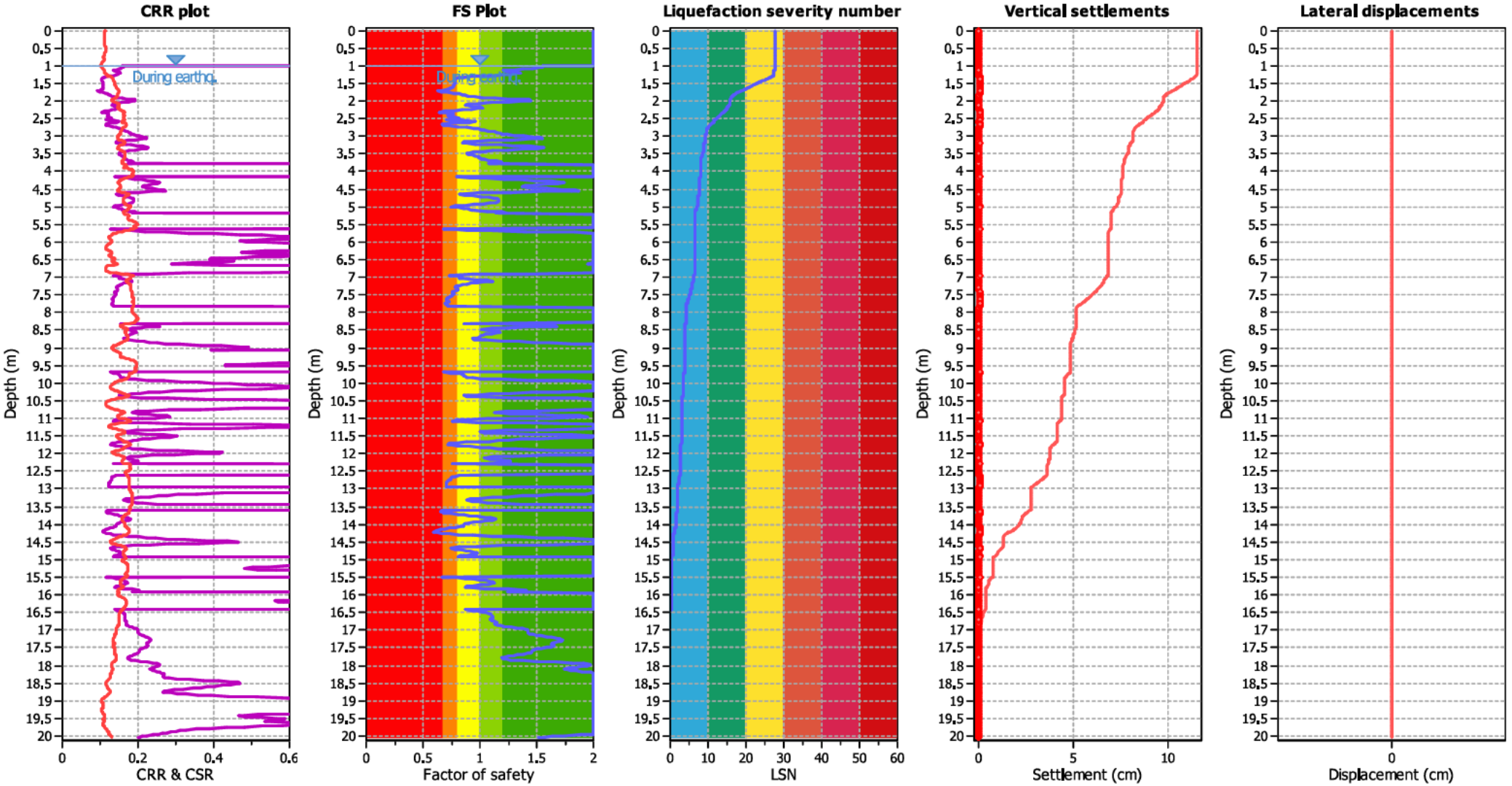






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

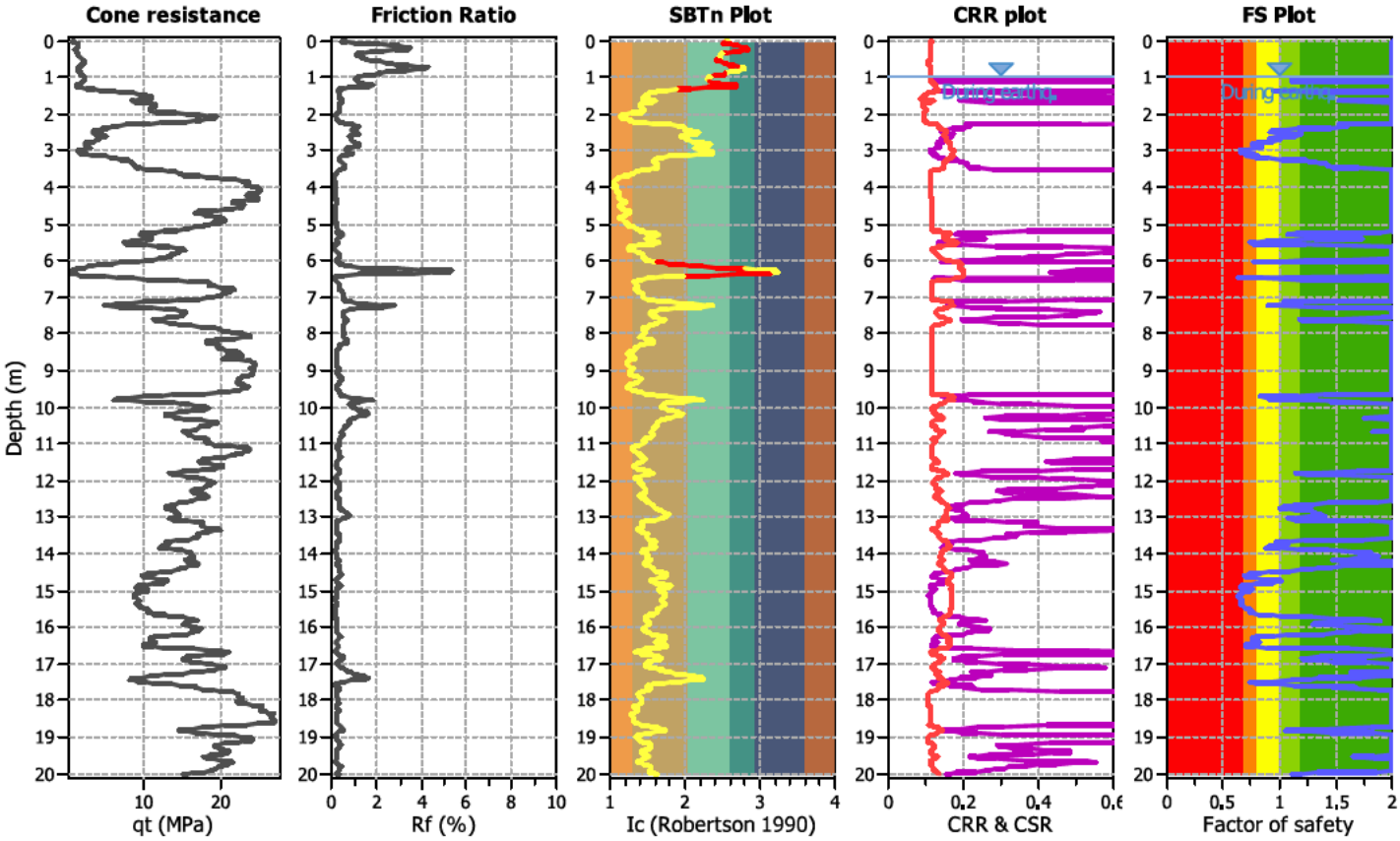
LIQUEFACTION ANALYSIS REPORT

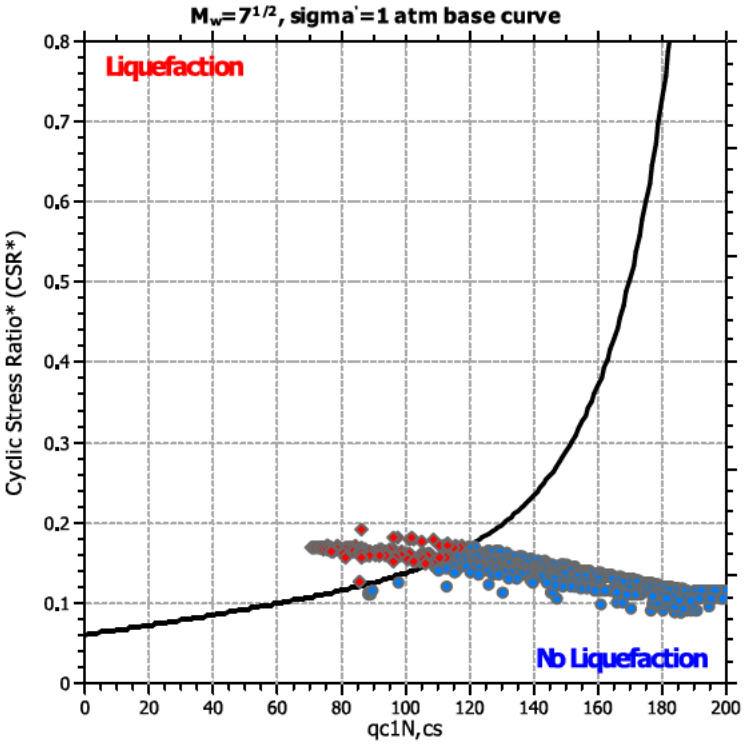
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

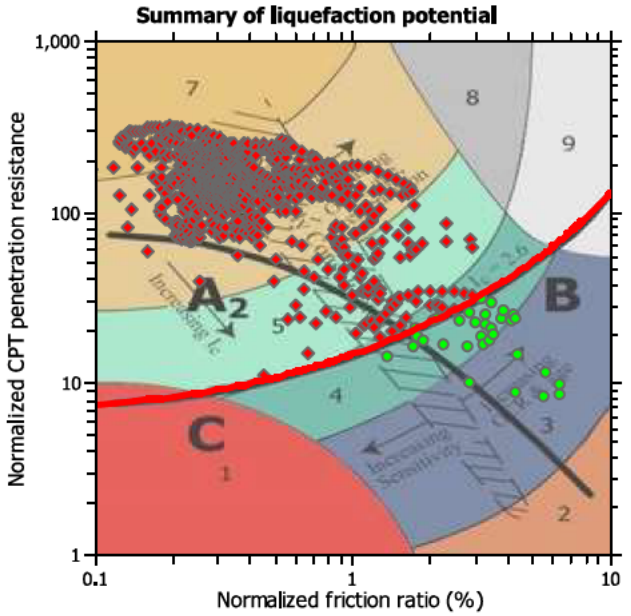
CPT file : CPT02, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

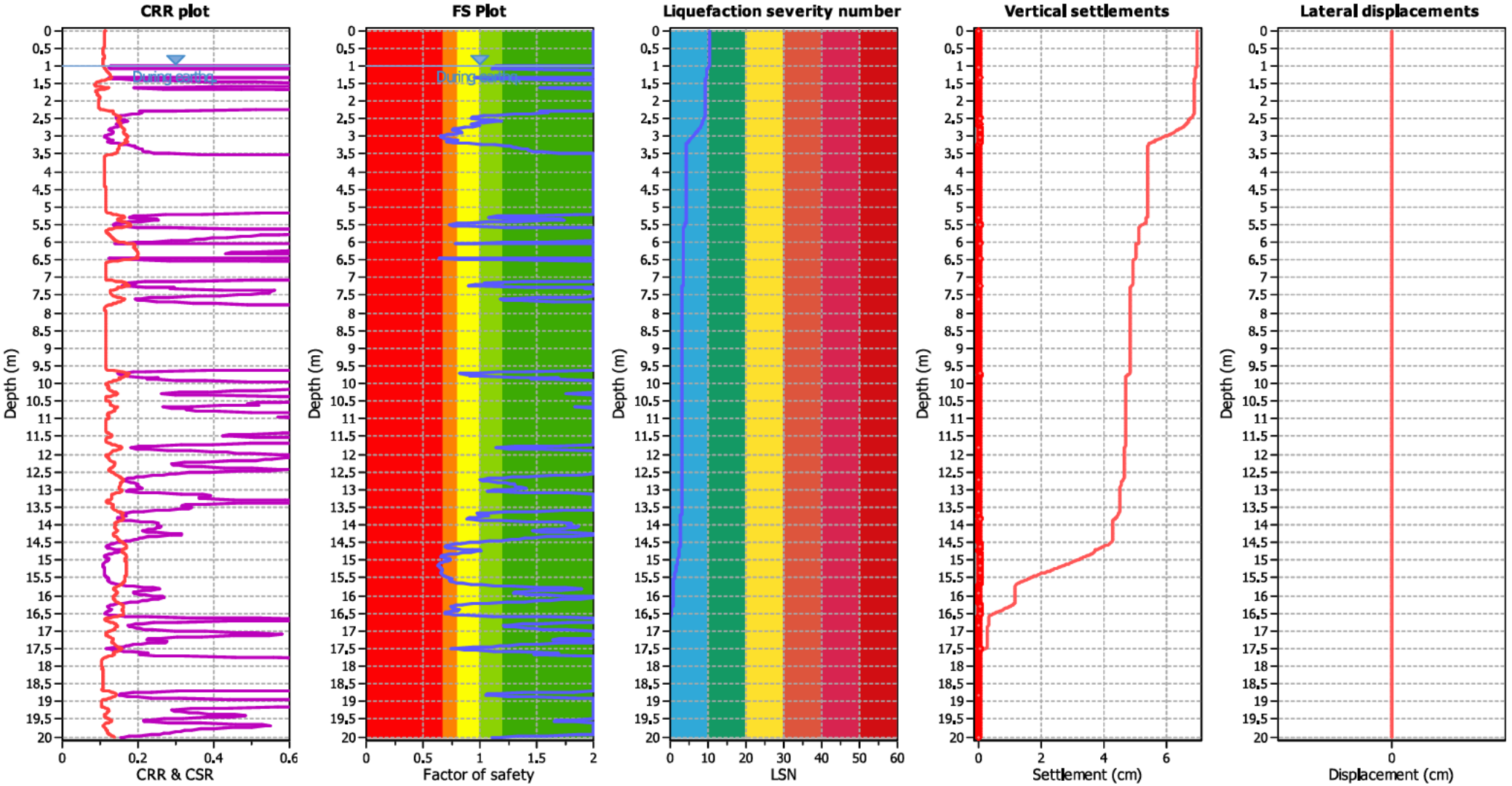






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

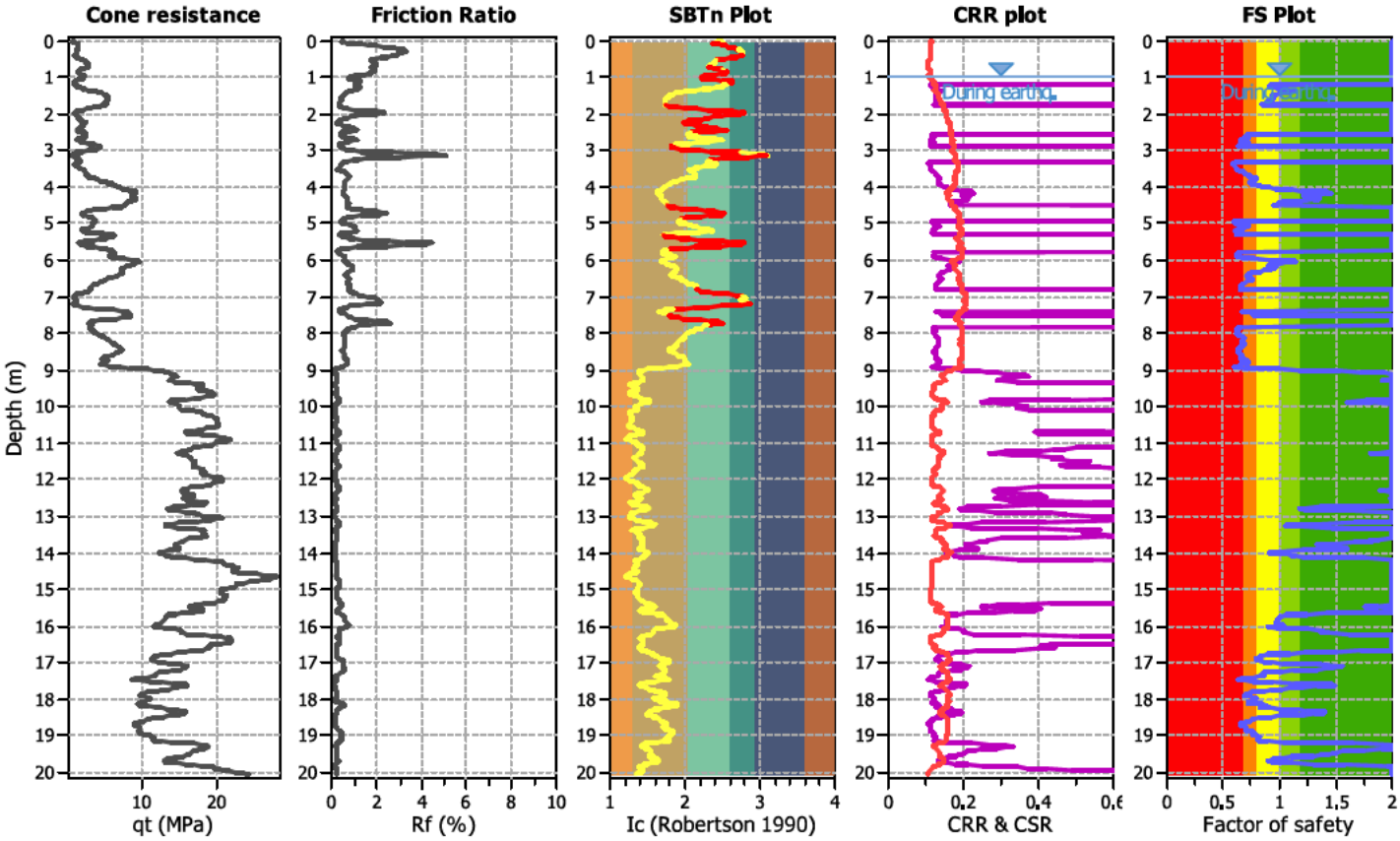
LIQUEFACTION ANALYSIS REPORT

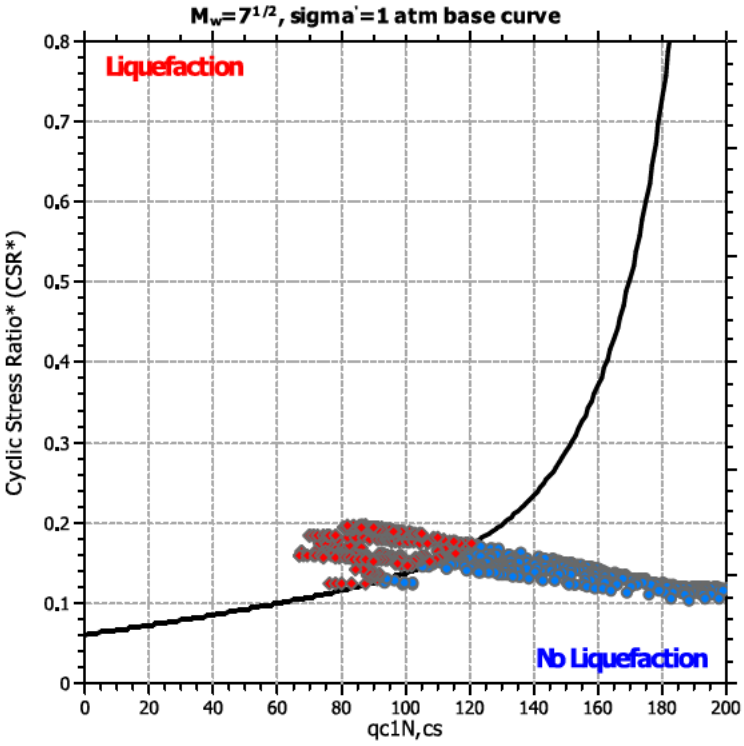
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

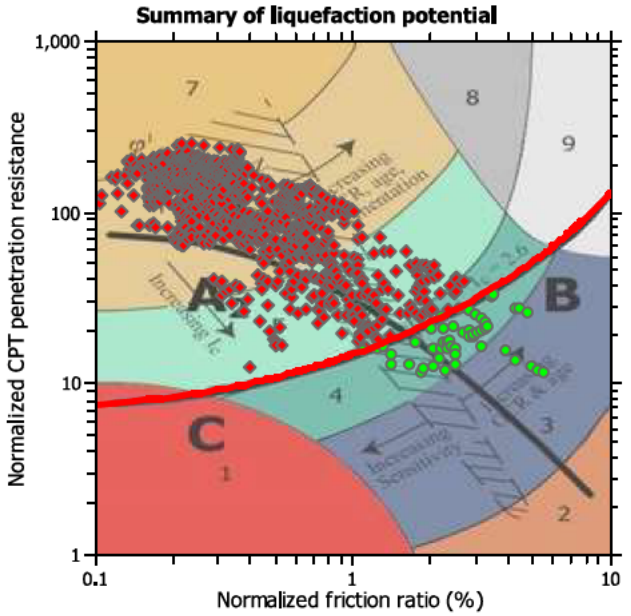
CPT file : CPT03, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

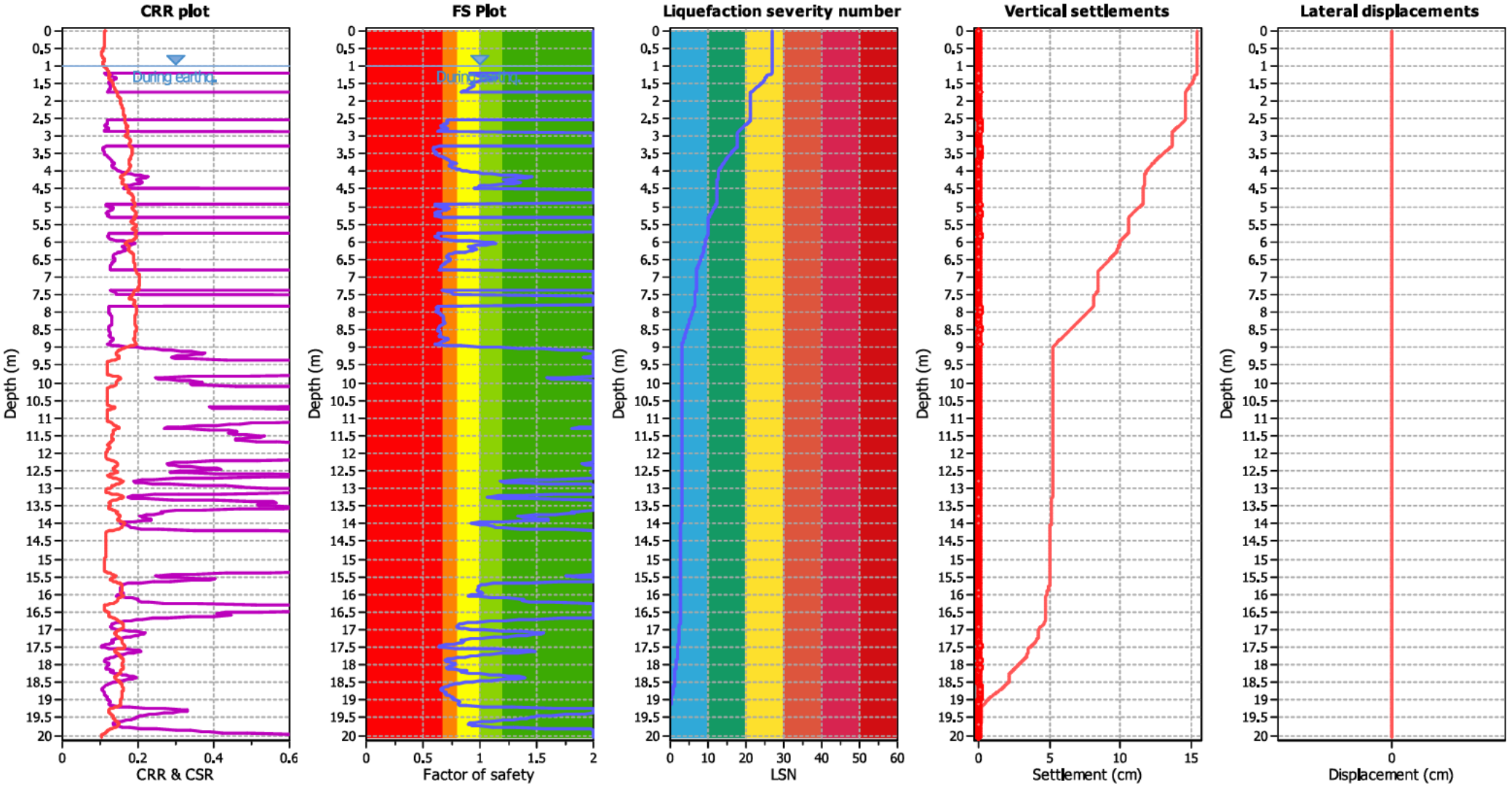






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

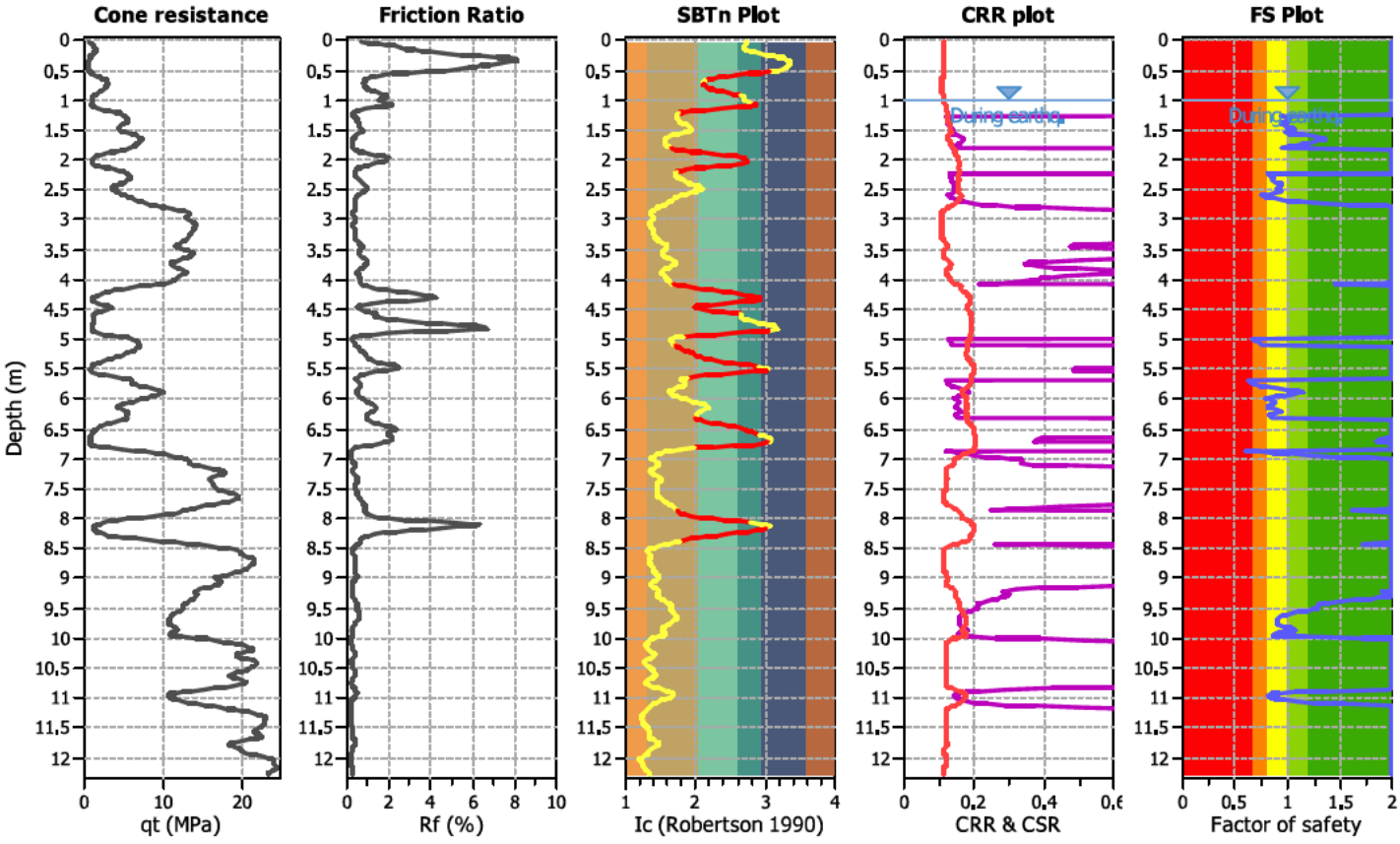
LIQUEFACTION ANALYSIS REPORT

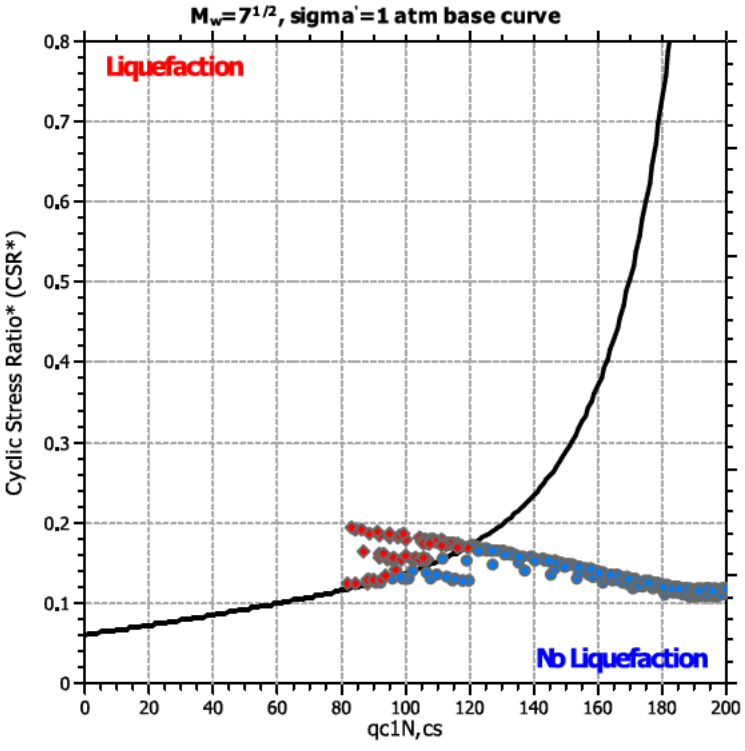
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

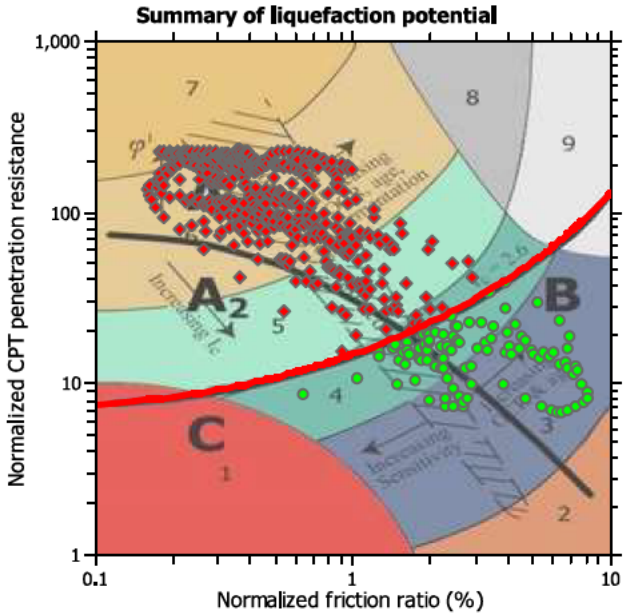
CPT file : CPT04, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

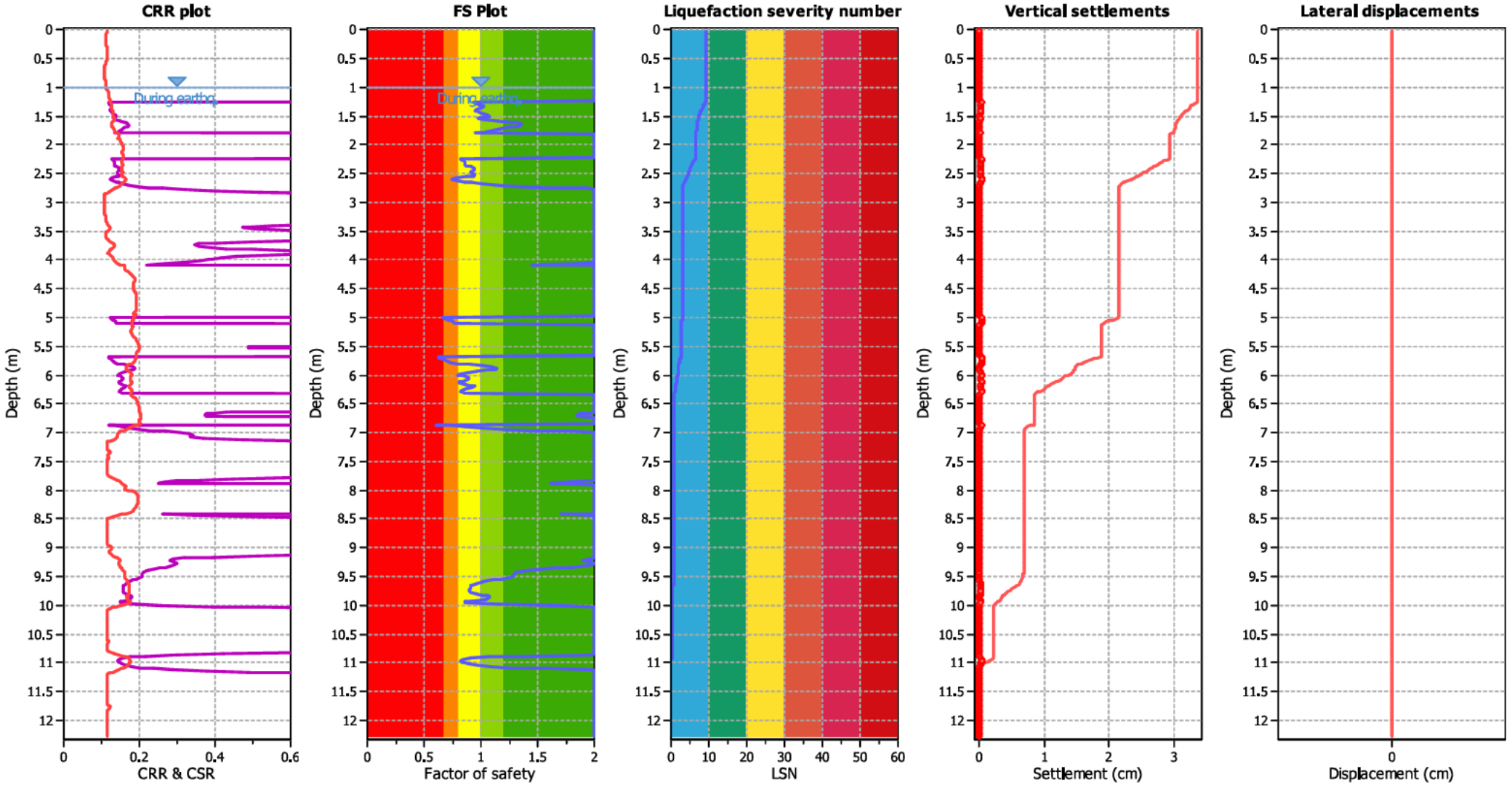






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

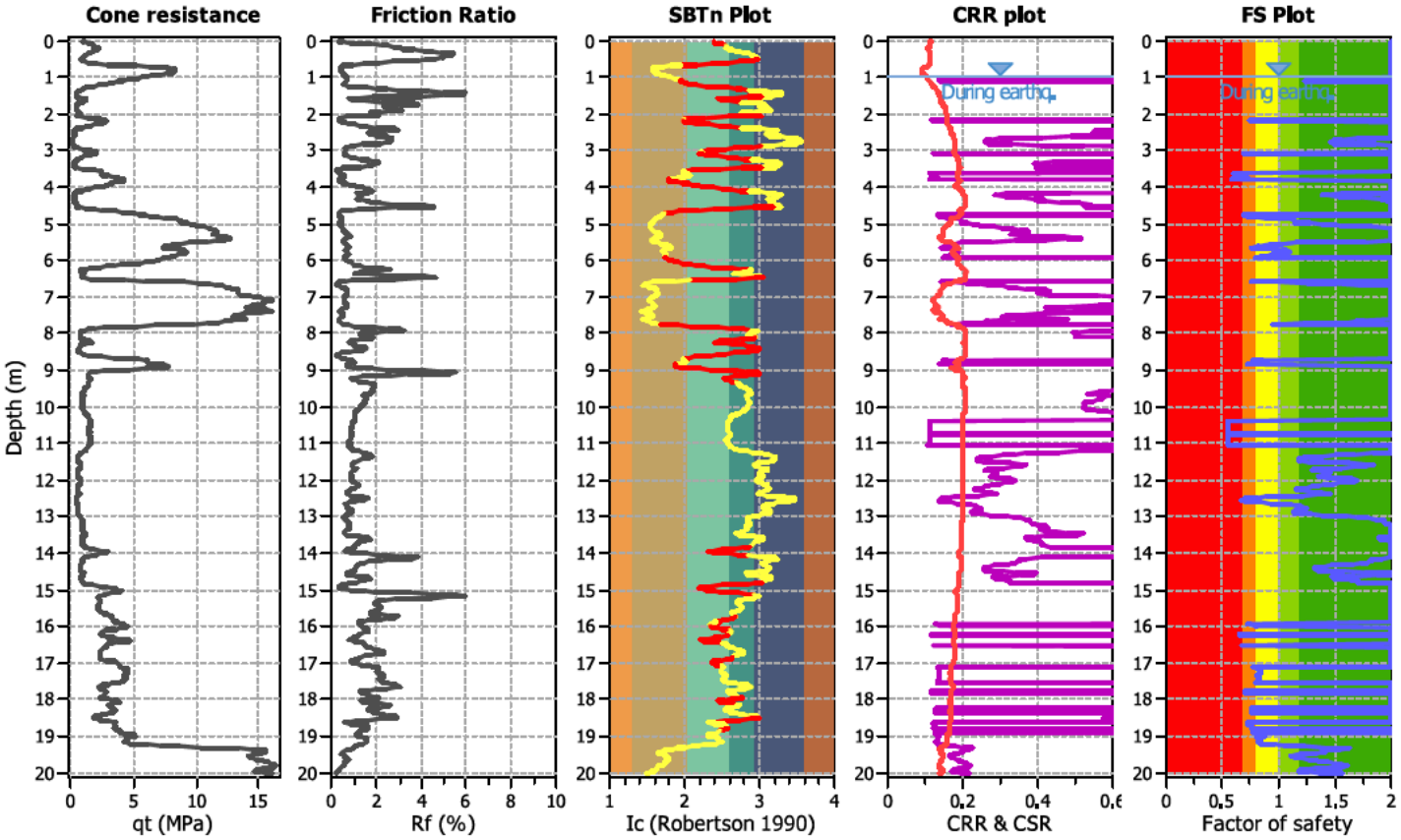
LIQUEFACTION ANALYSIS REPORT

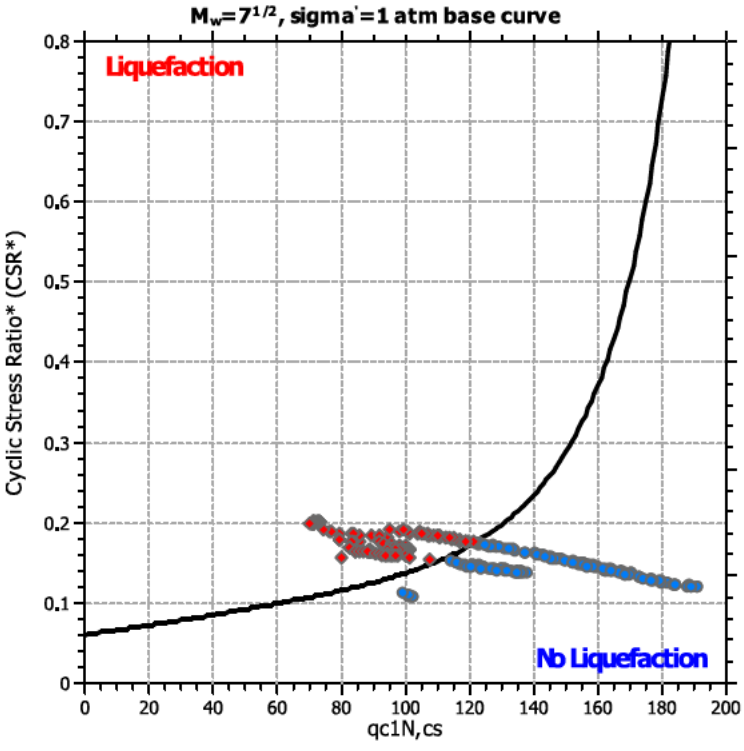
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

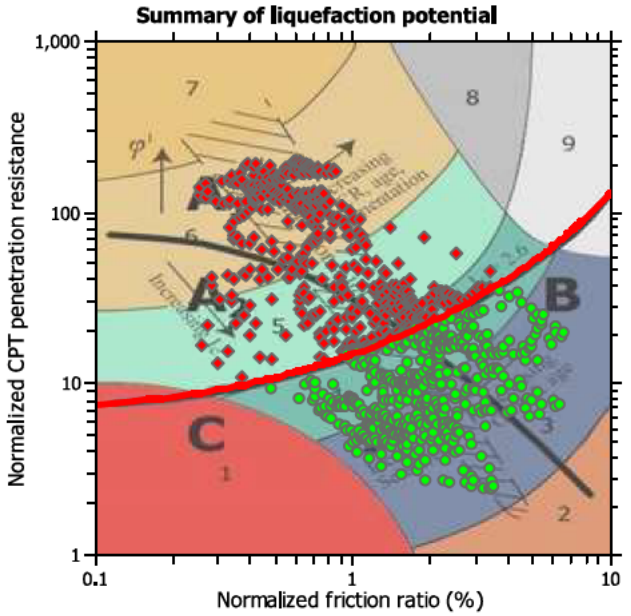
CPT file : CPT05, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

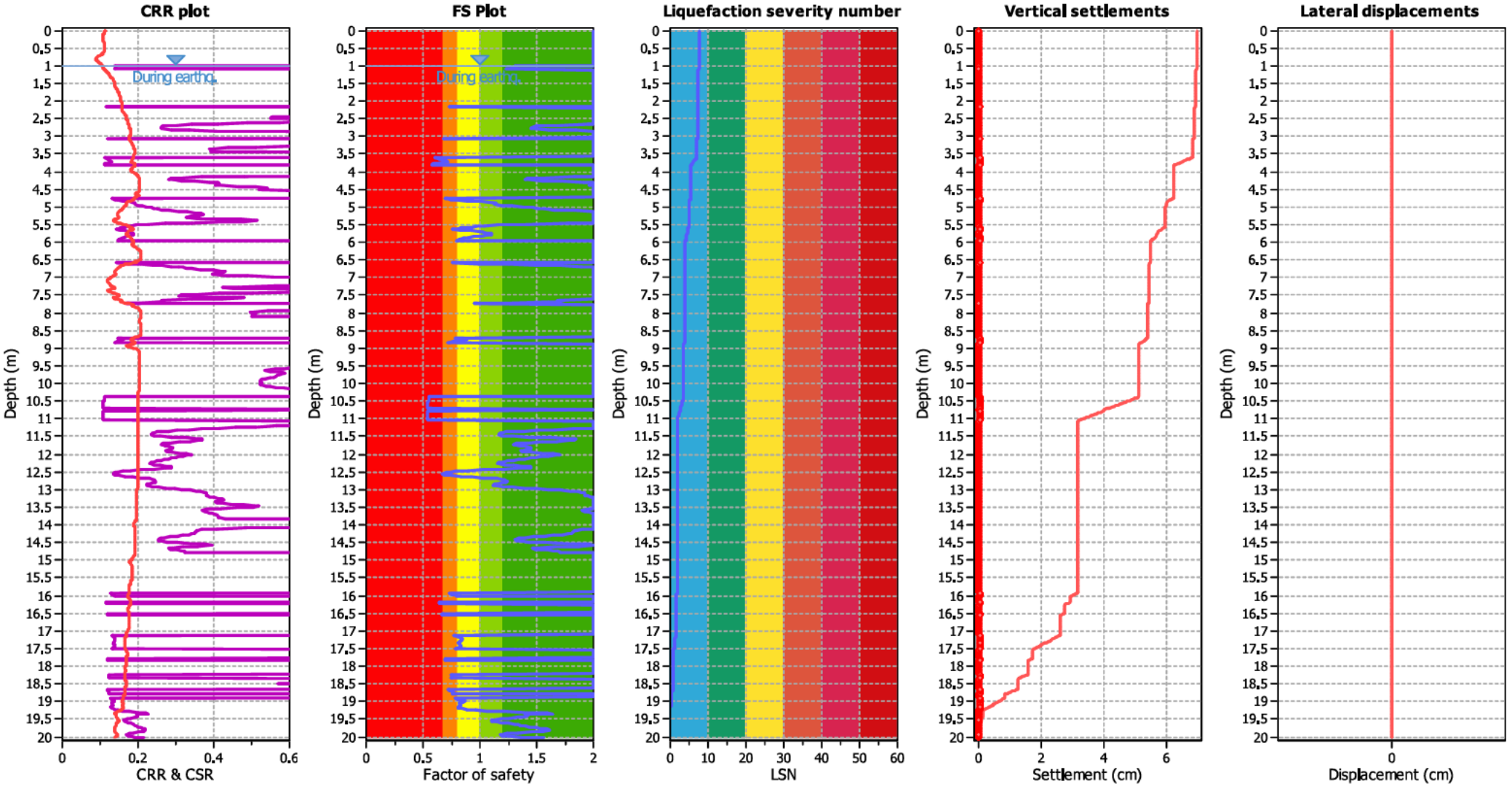






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

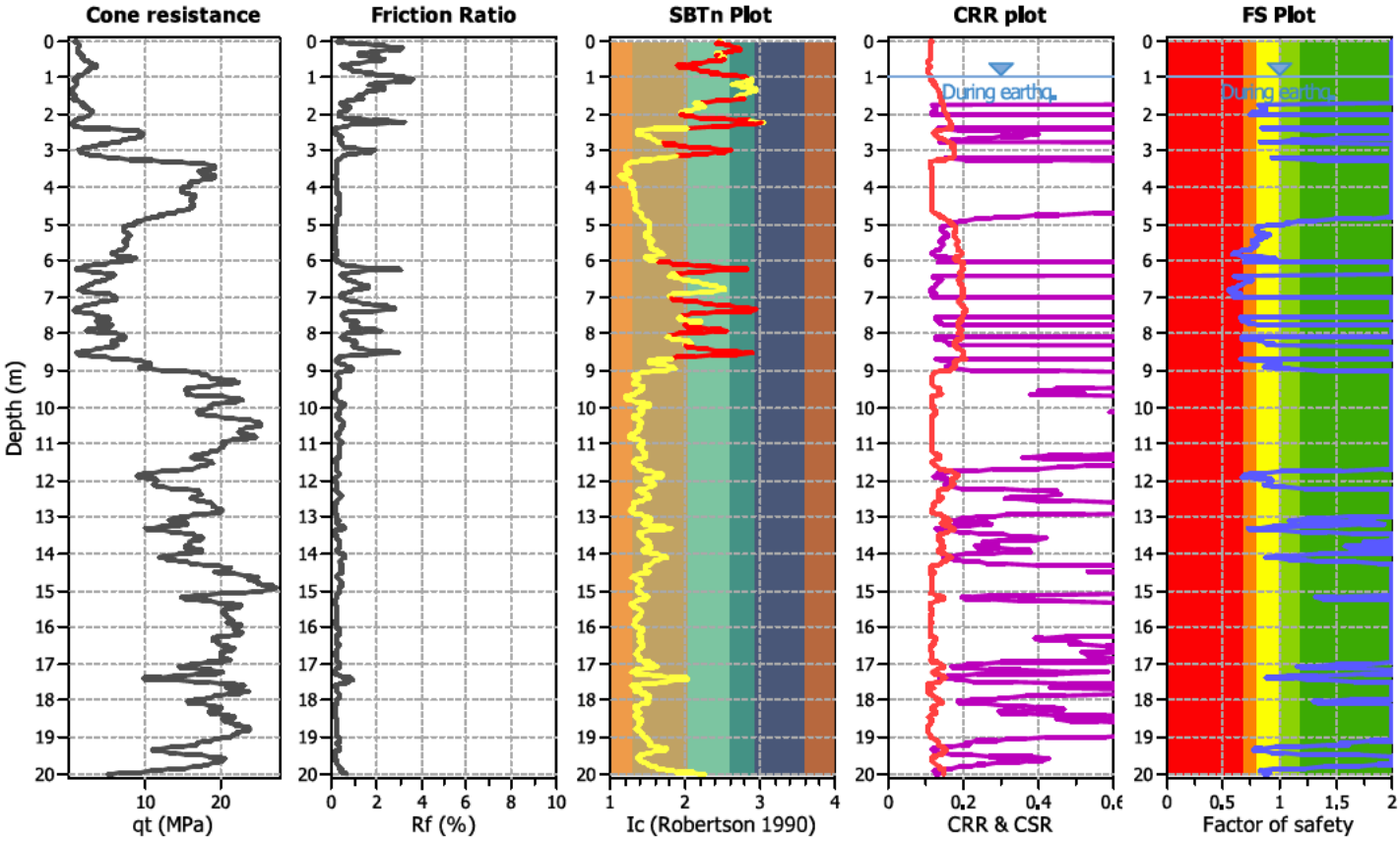
LIQUEFACTION ANALYSIS REPORT

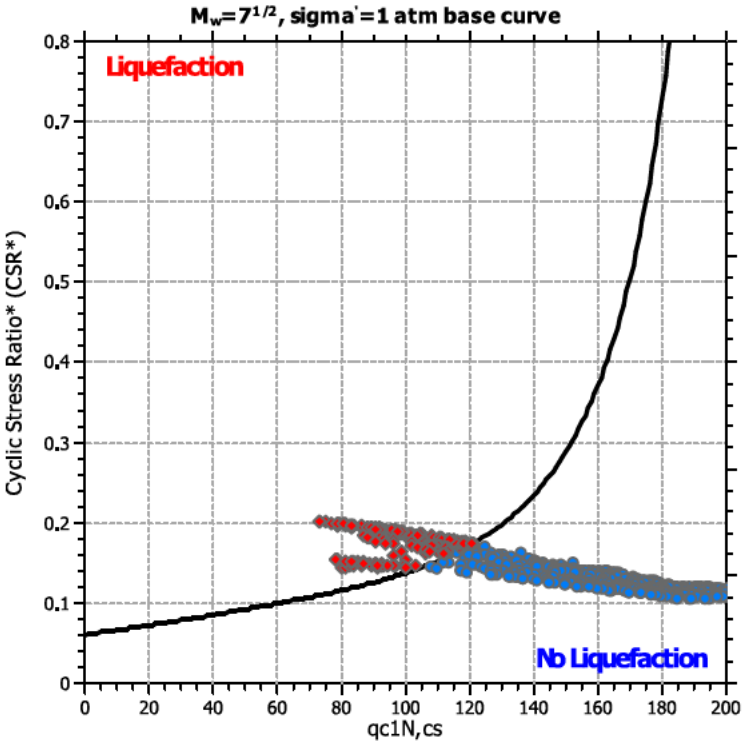
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

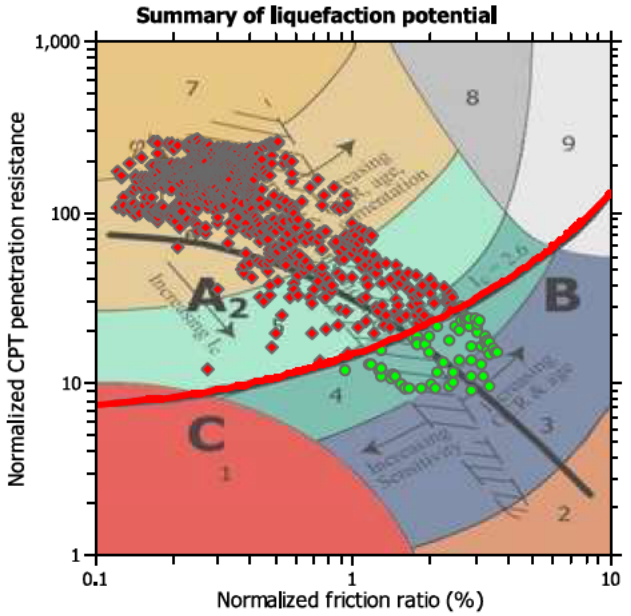
CPT file : CPT06, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

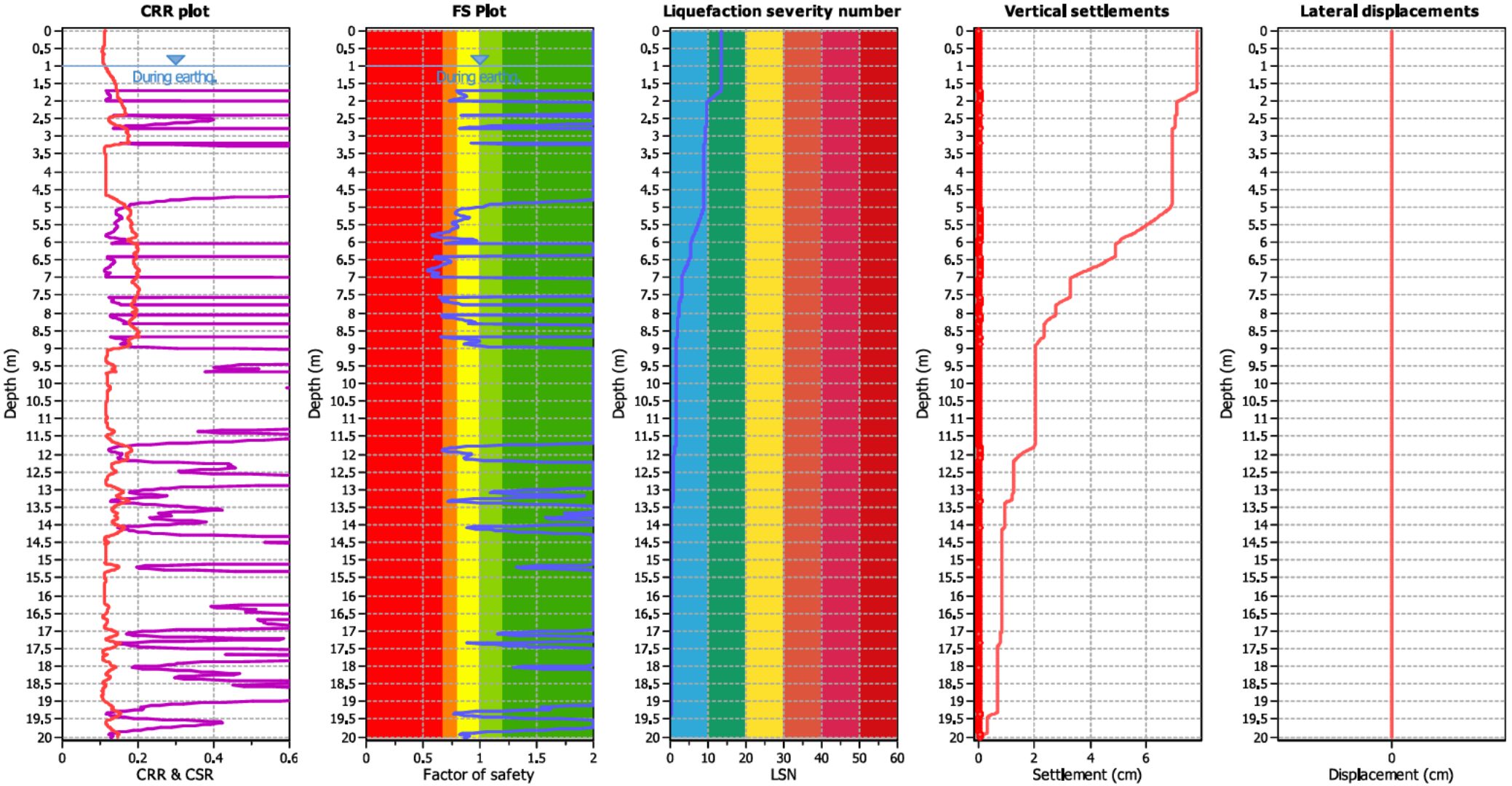






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

HD geo

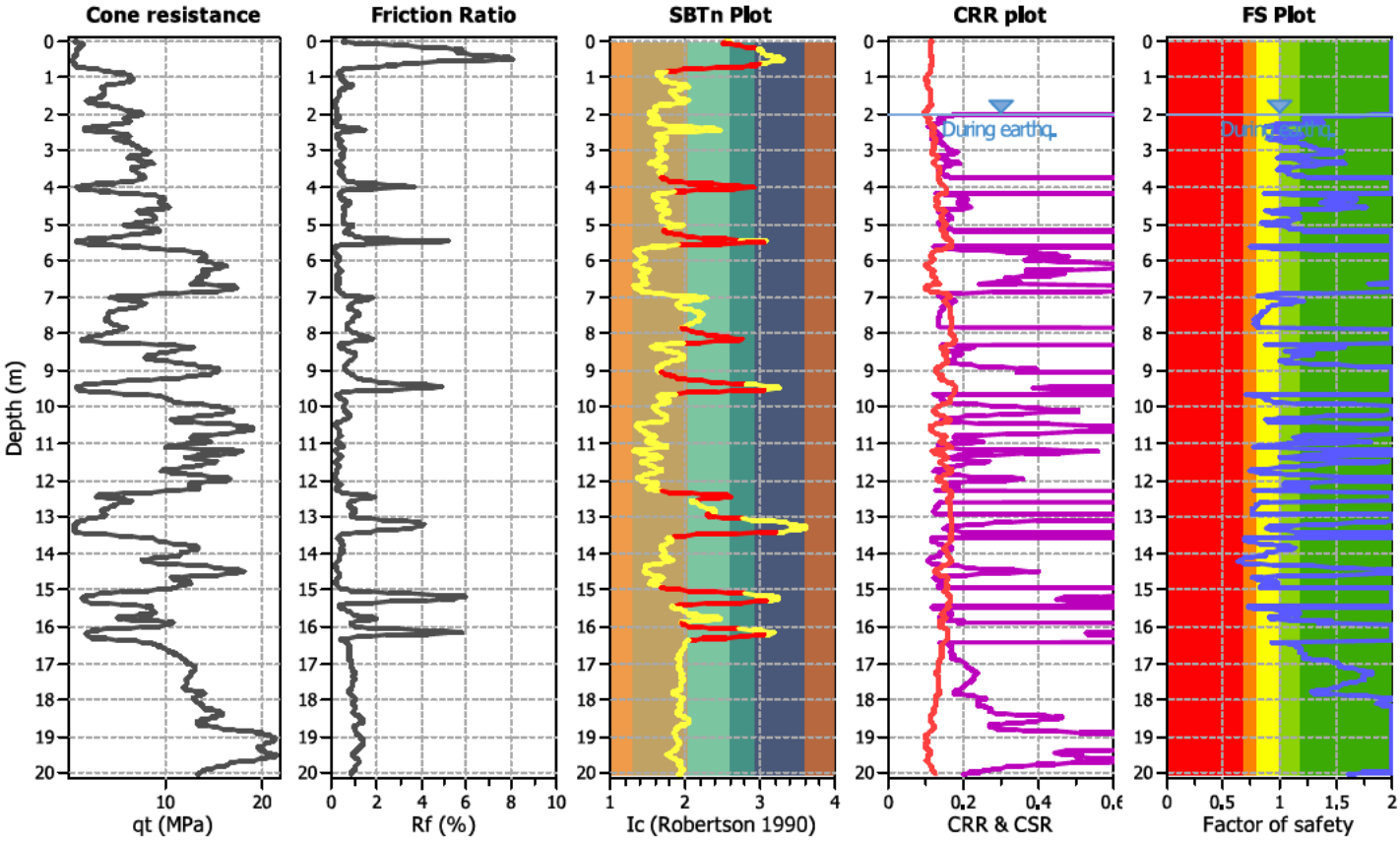
LIQUEFACTION ANALYSIS REPORT

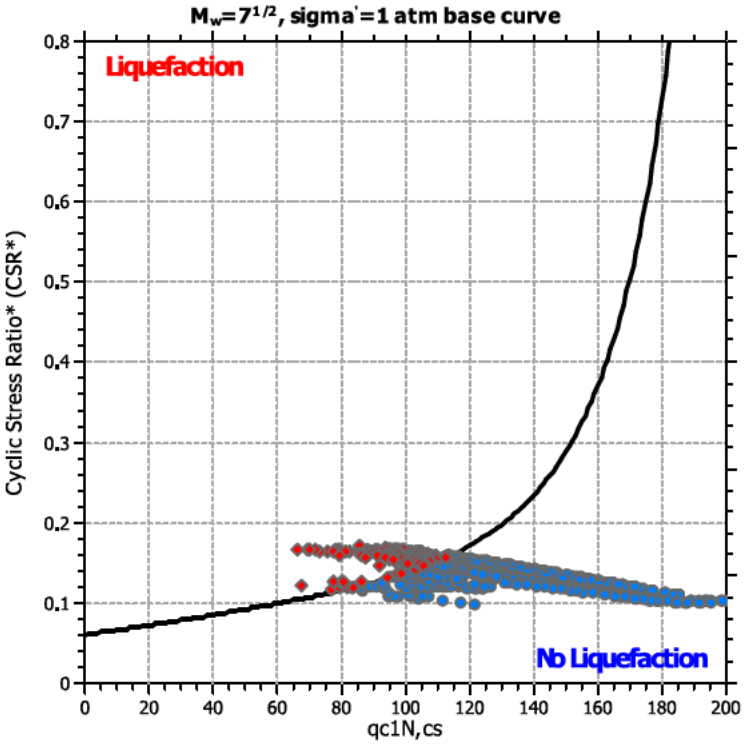
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

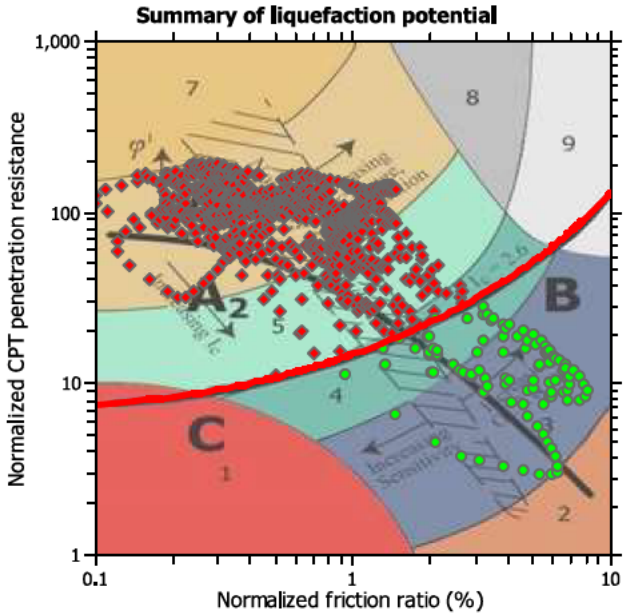
CPT file : CPT01, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

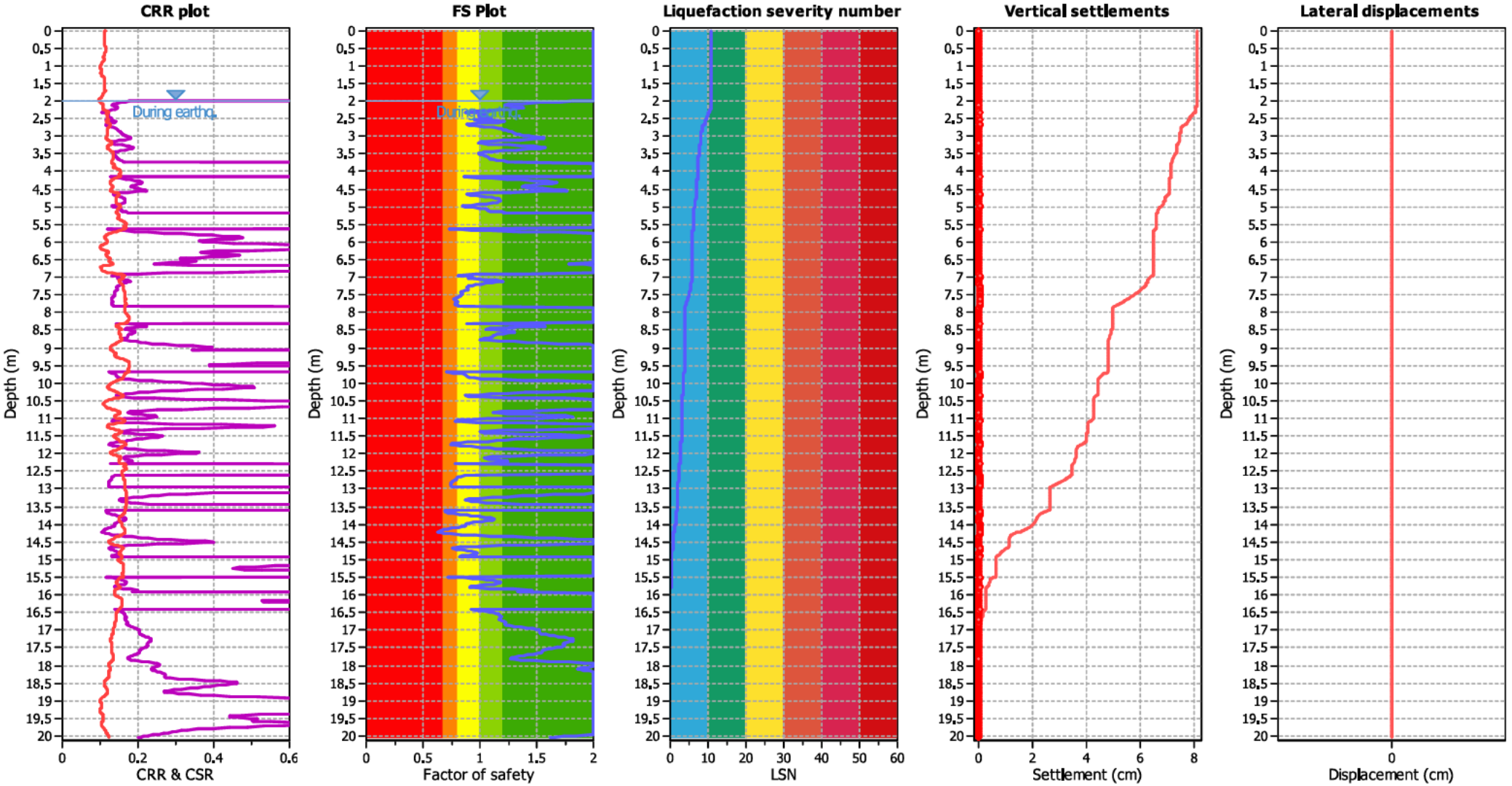






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

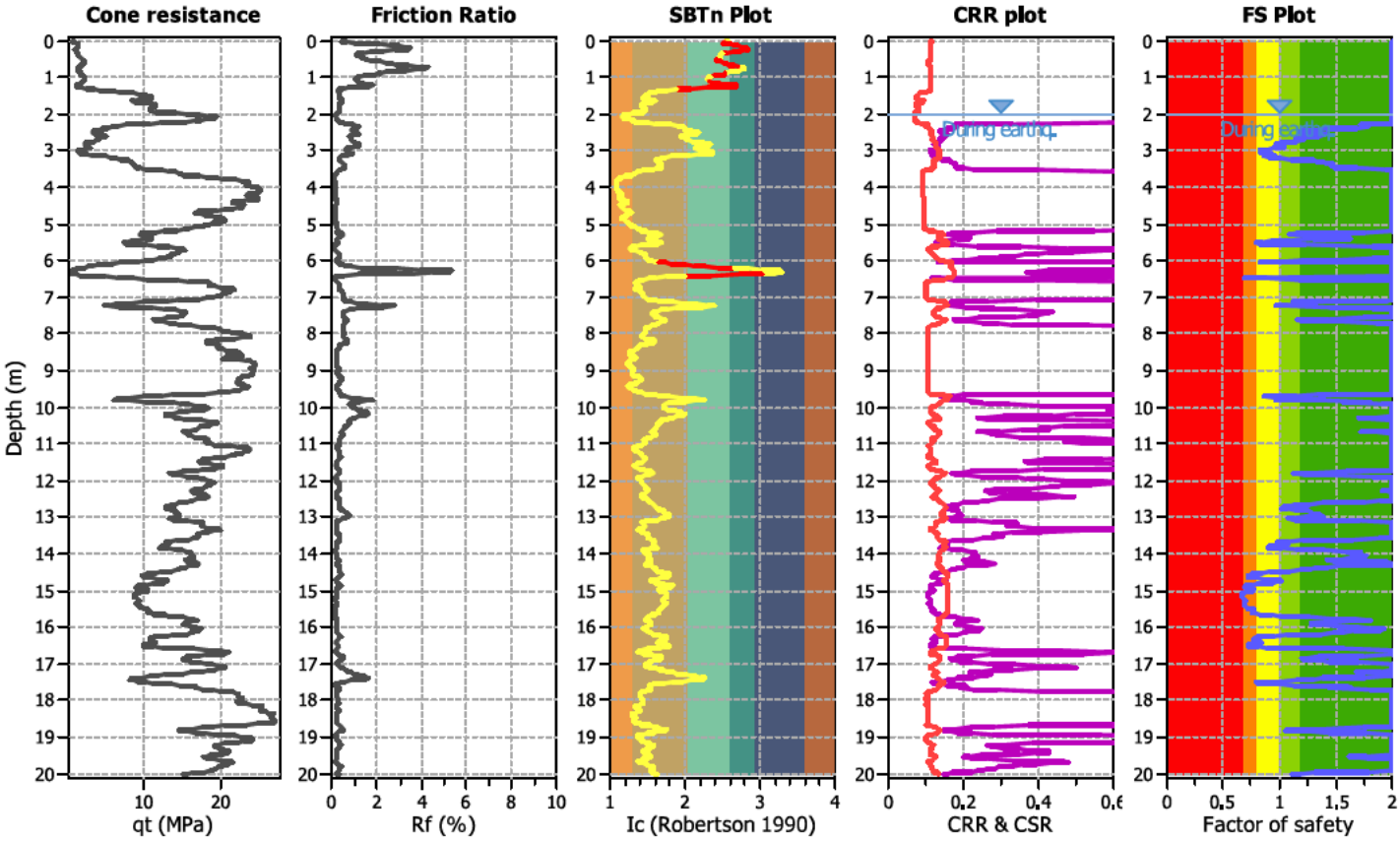
LIQUEFACTION ANALYSIS REPORT

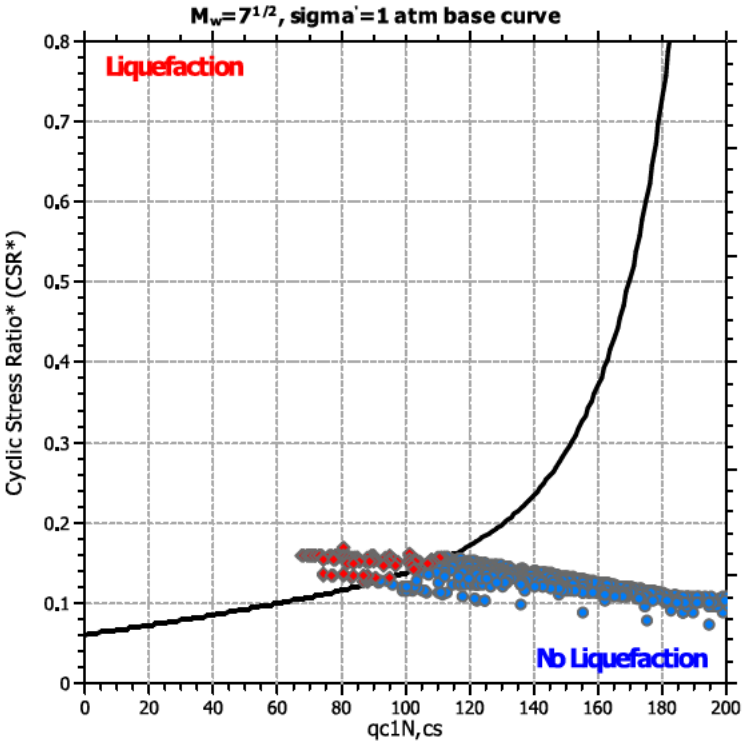
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

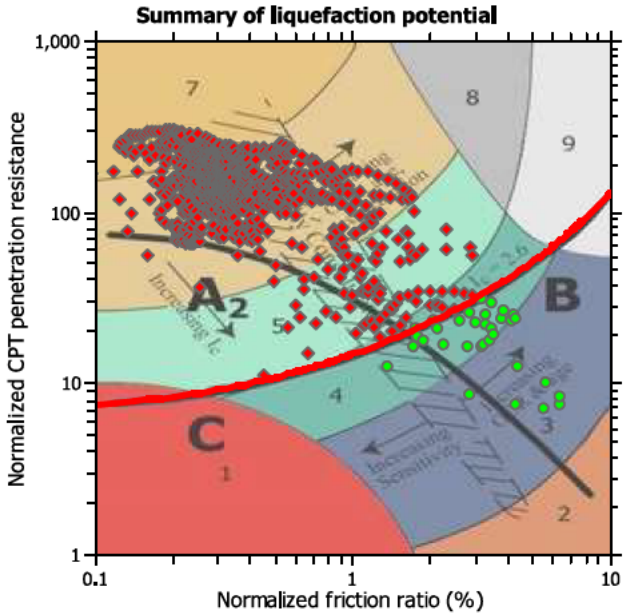
CPT file : CPT02, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

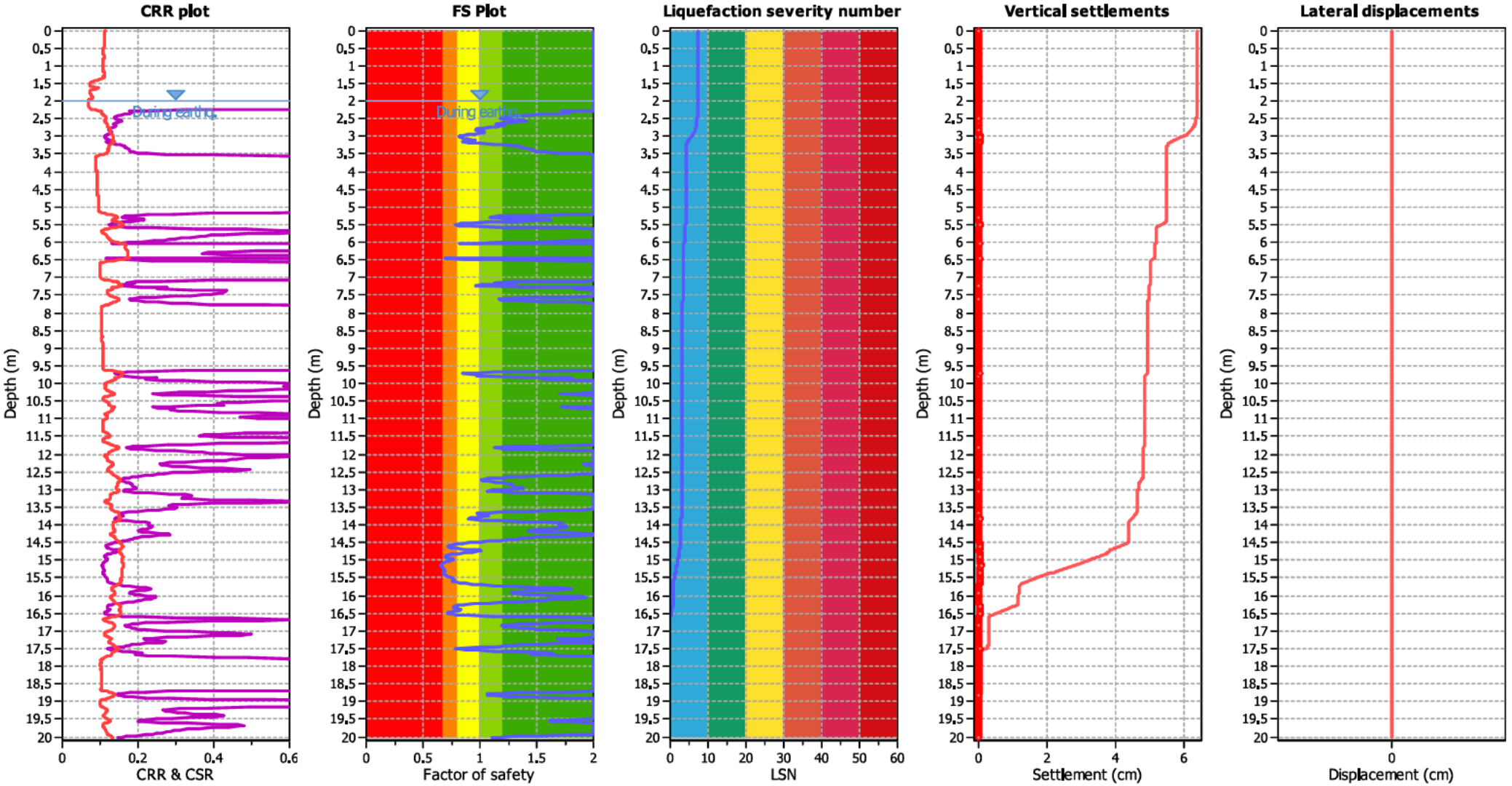






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

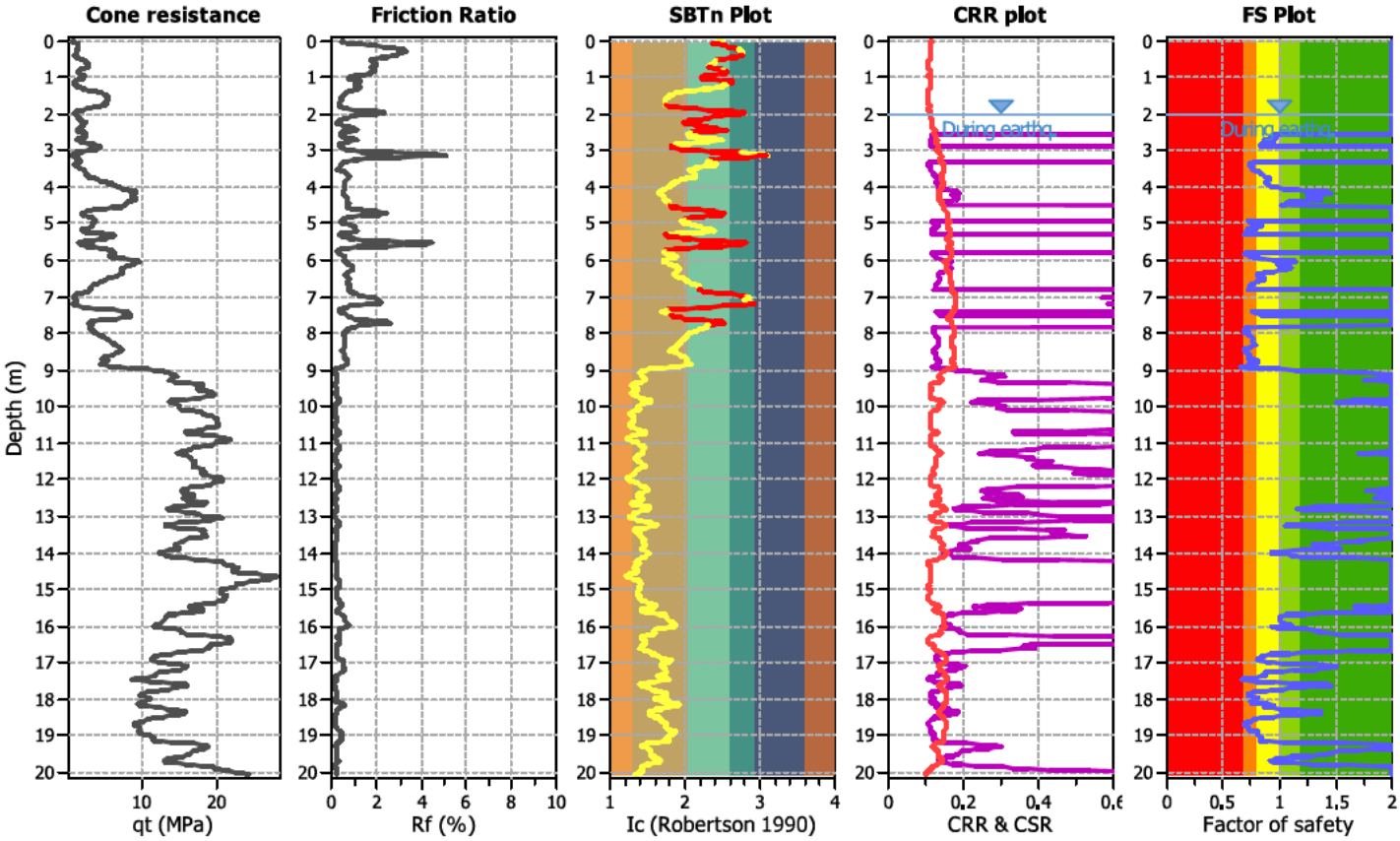
LIQUEFACTION ANALYSIS REPORT

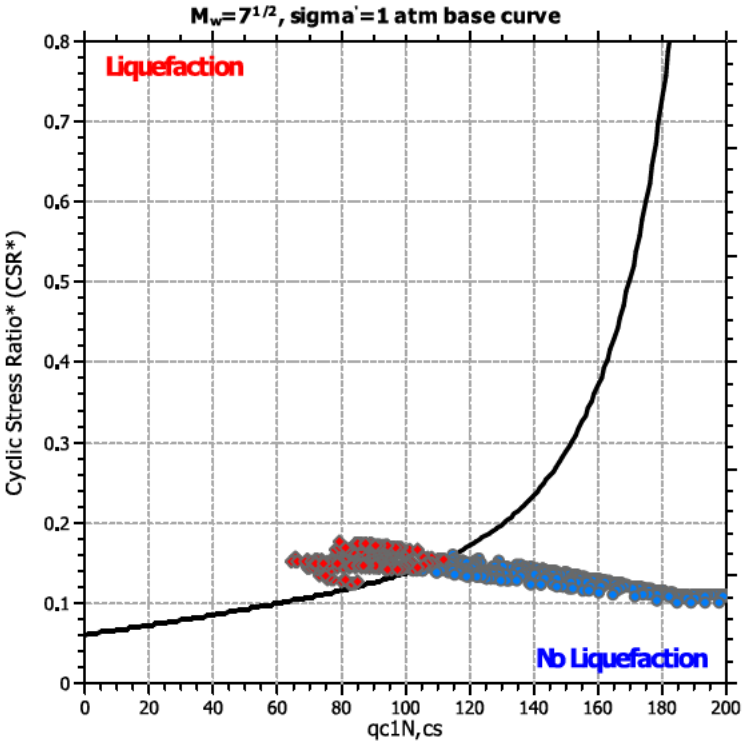
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

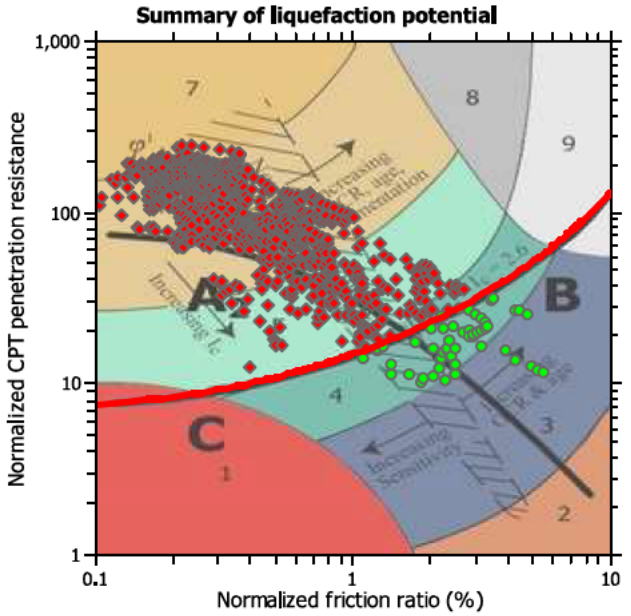
CPT file : CPT03, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

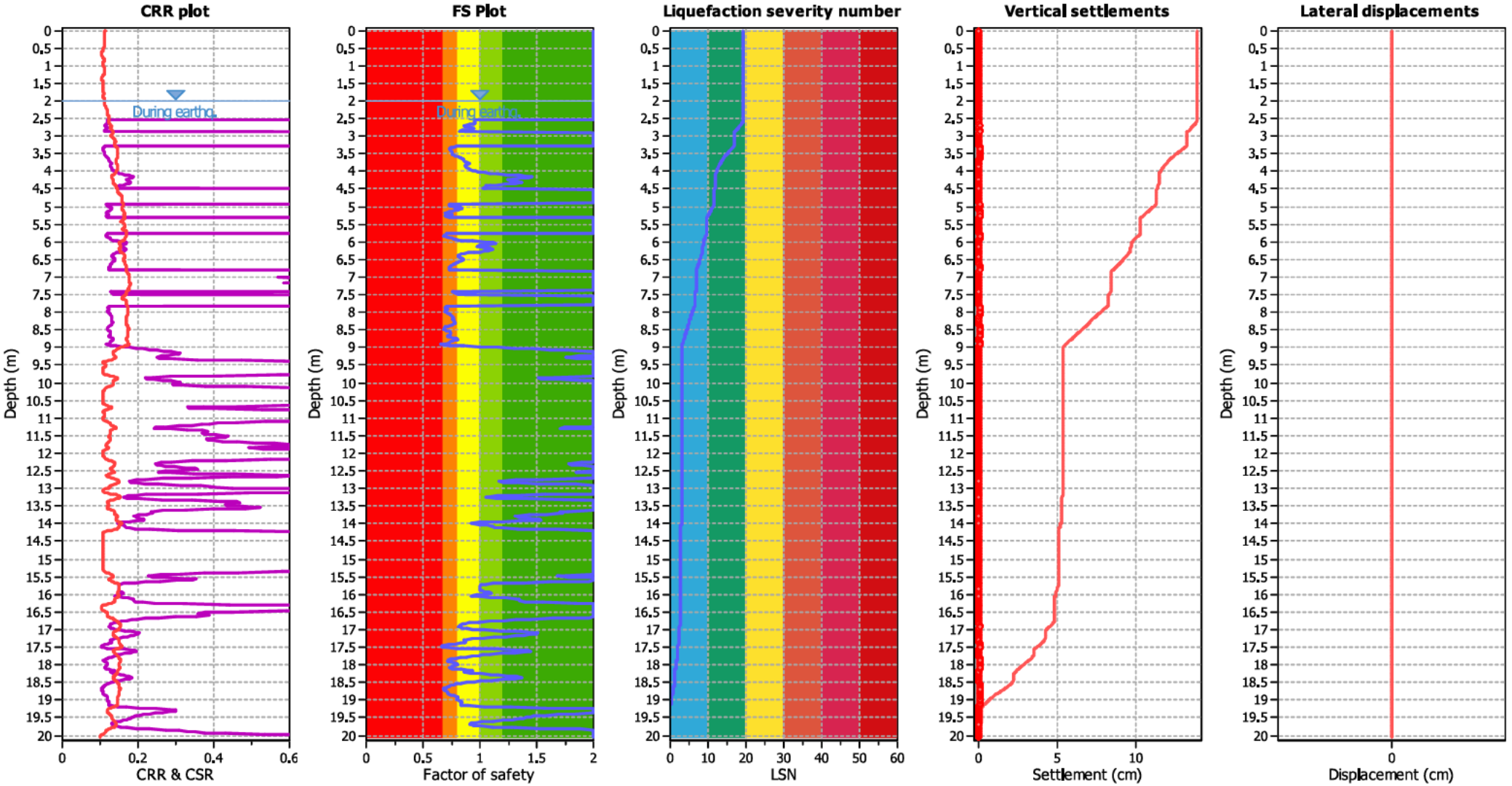






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

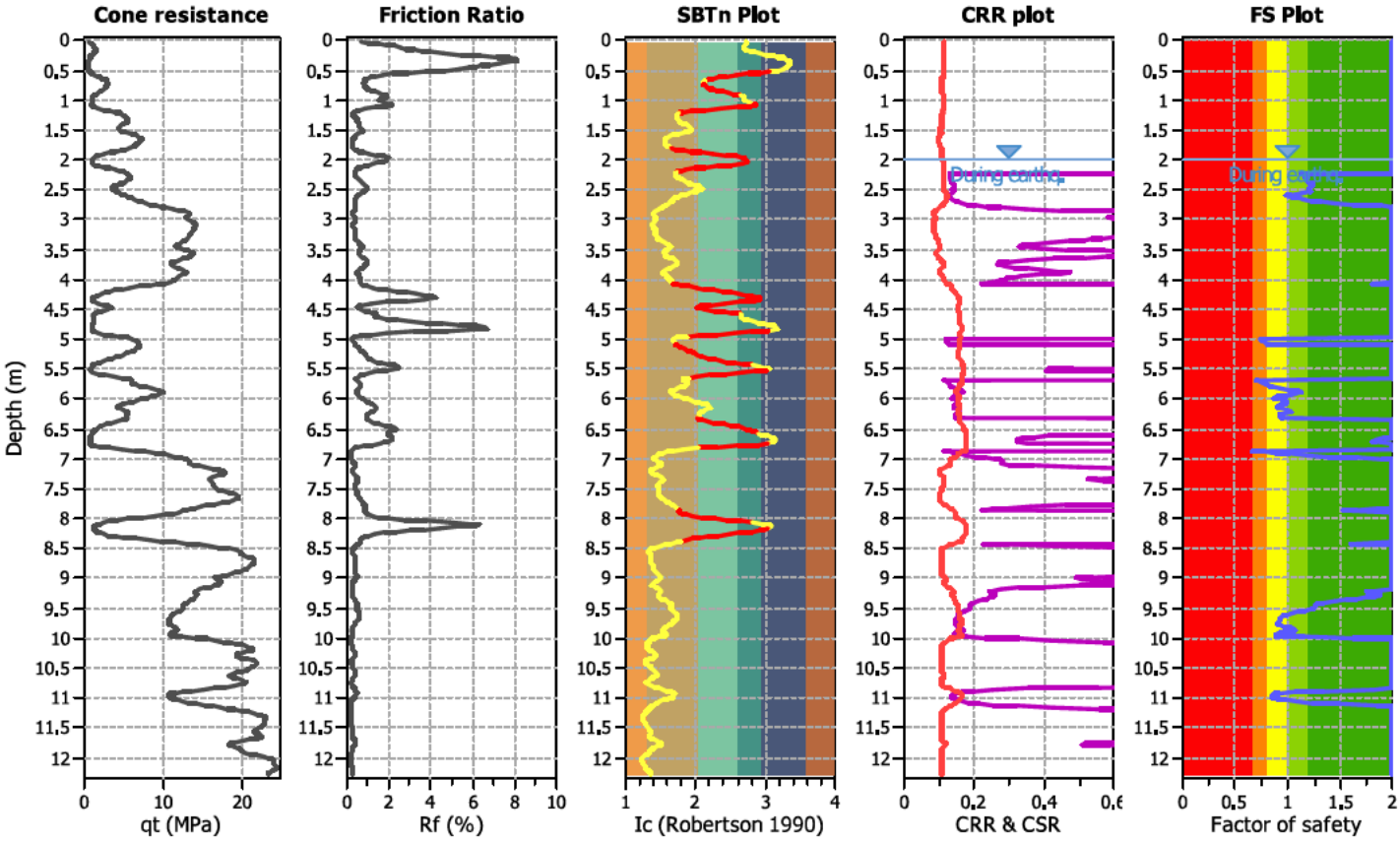
LIQUEFACTION ANALYSIS REPORT

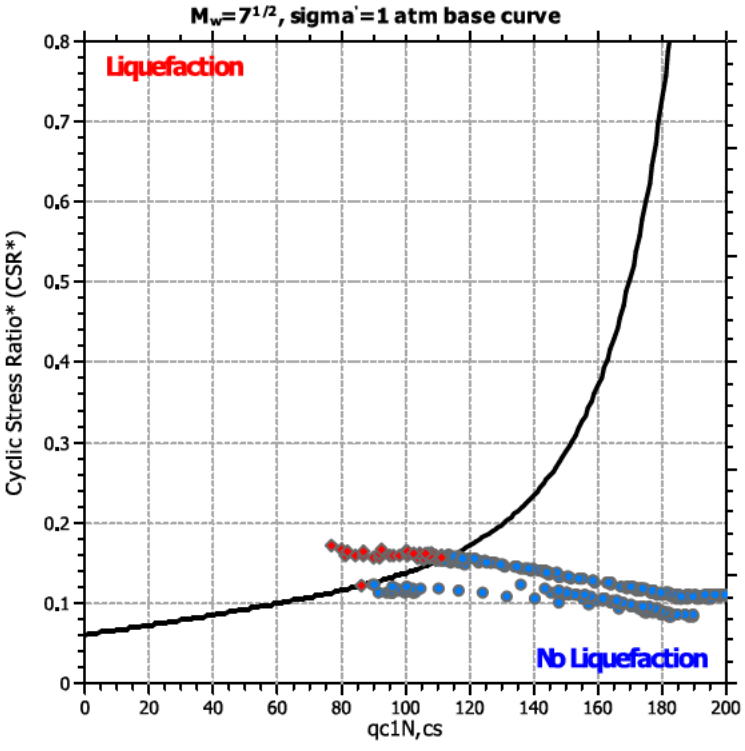
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

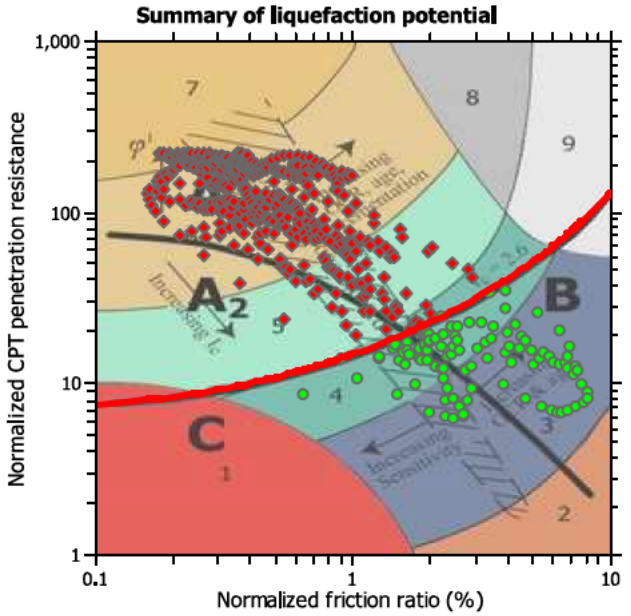
CPT file : CPT04, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

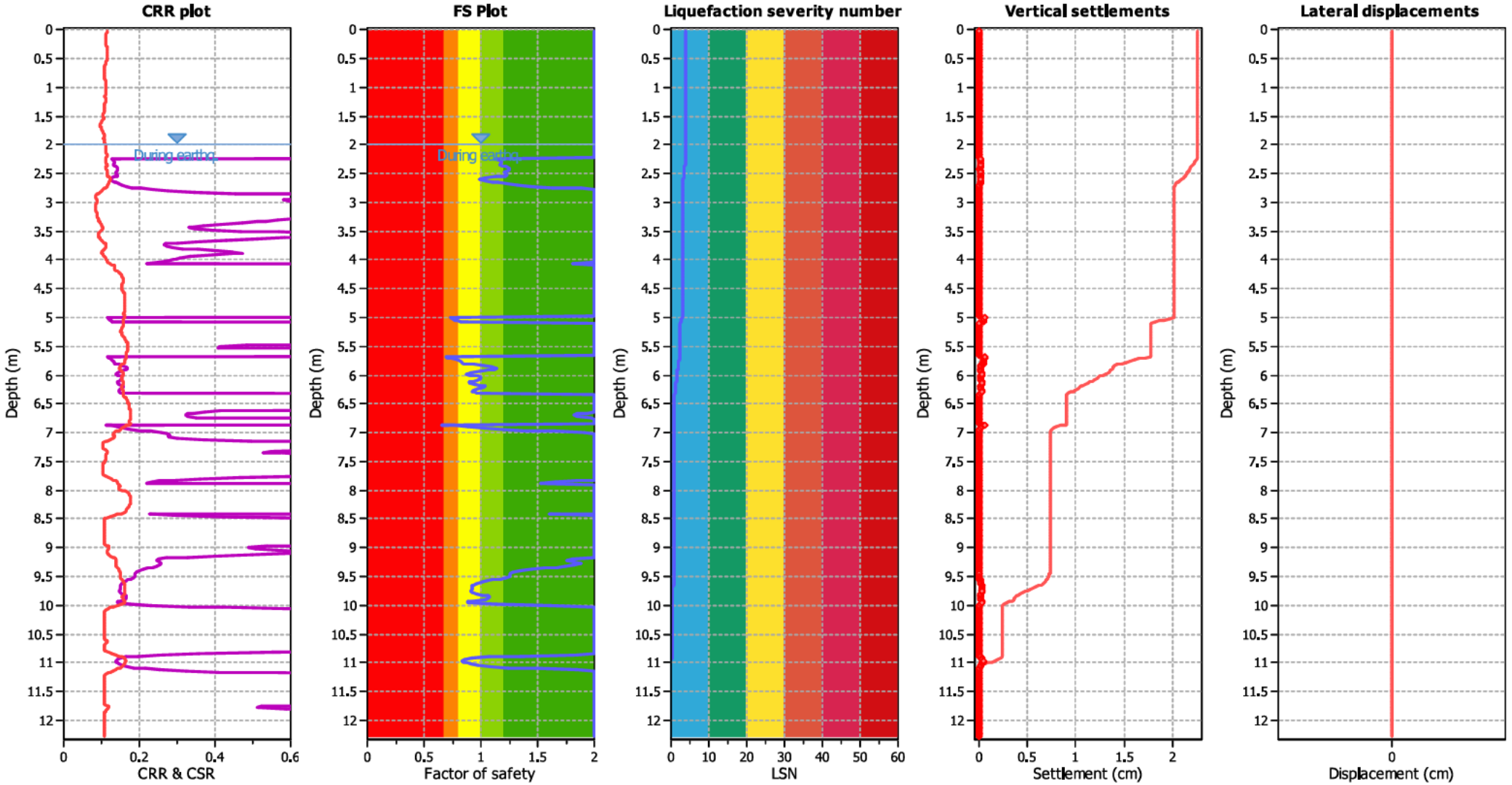






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

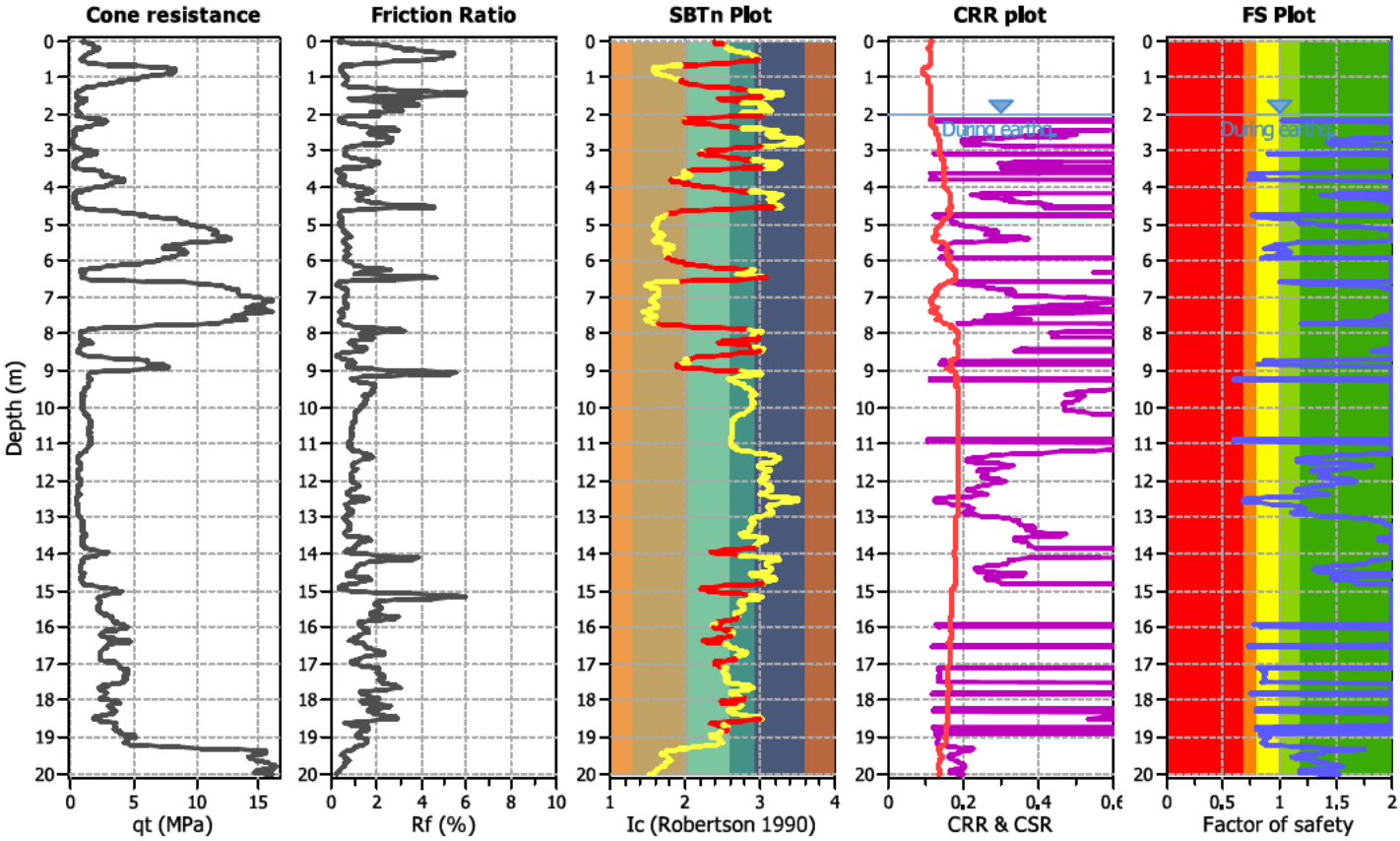
LIQUEFACTION ANALYSIS REPORT

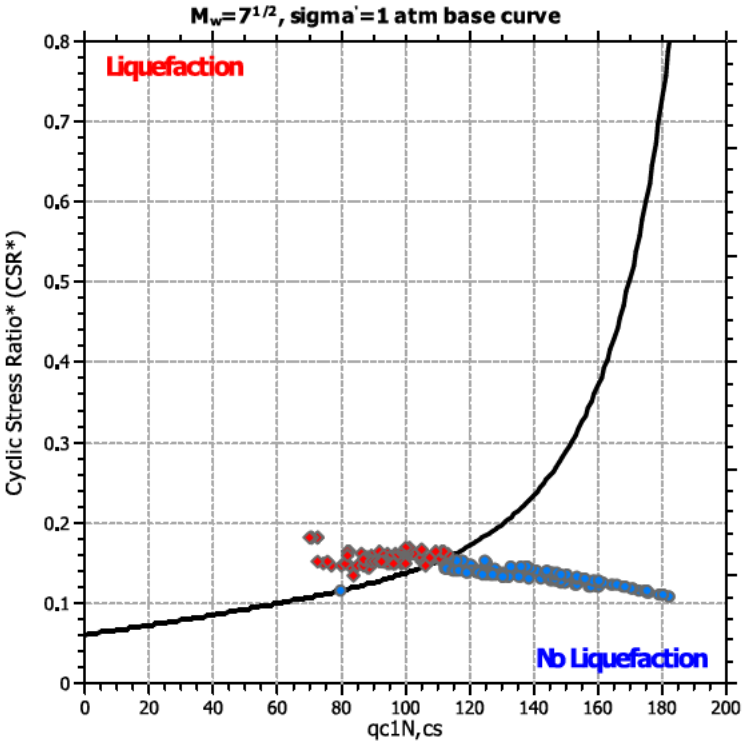
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

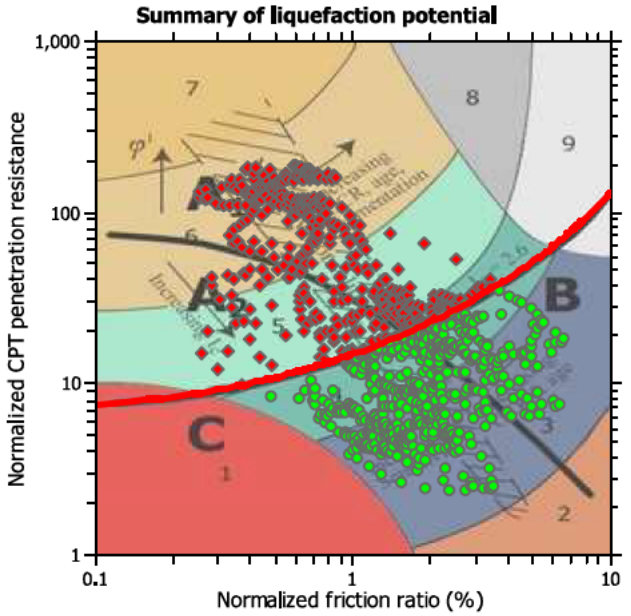
CPT file : CPT05, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

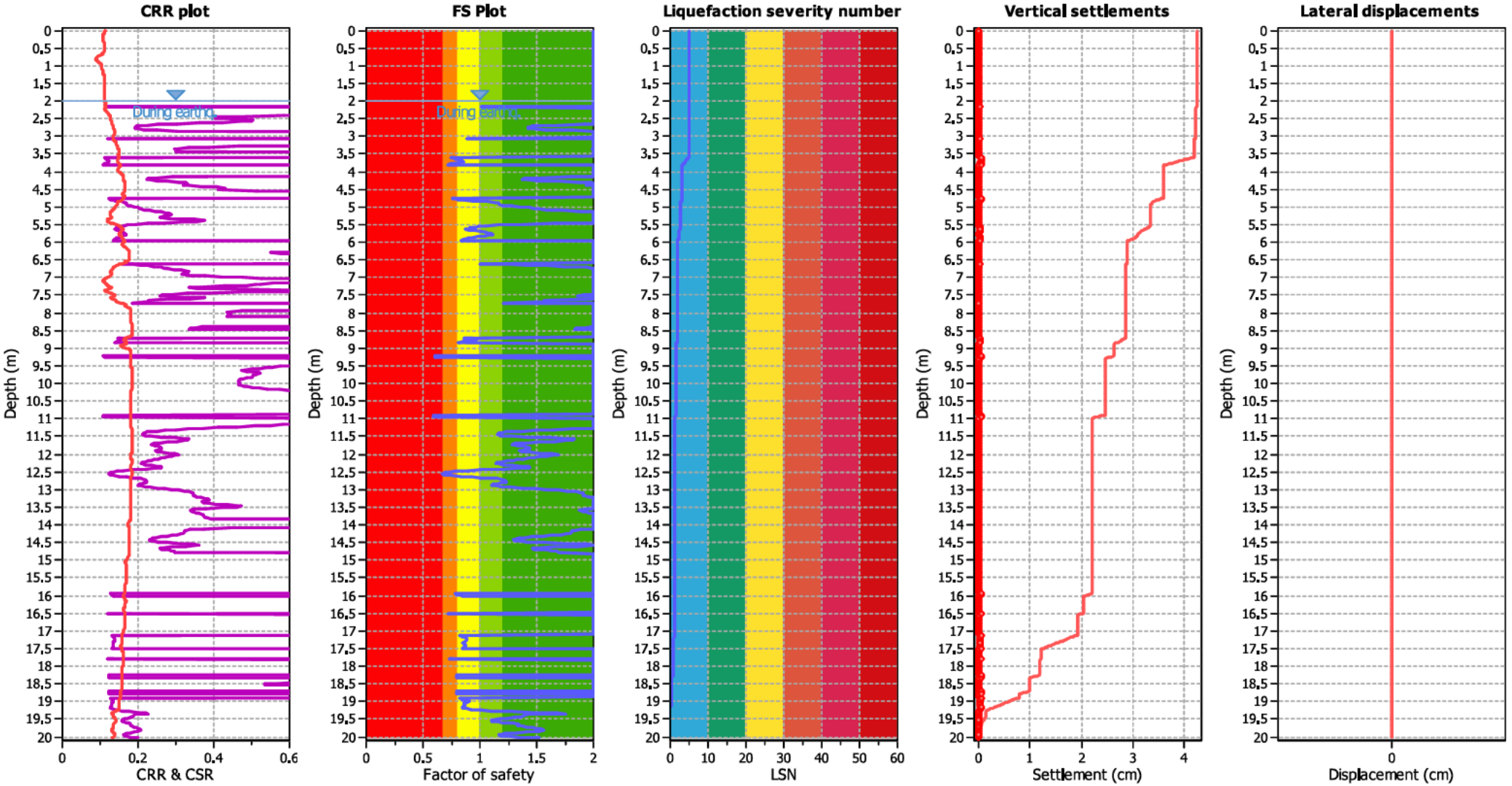






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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

LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

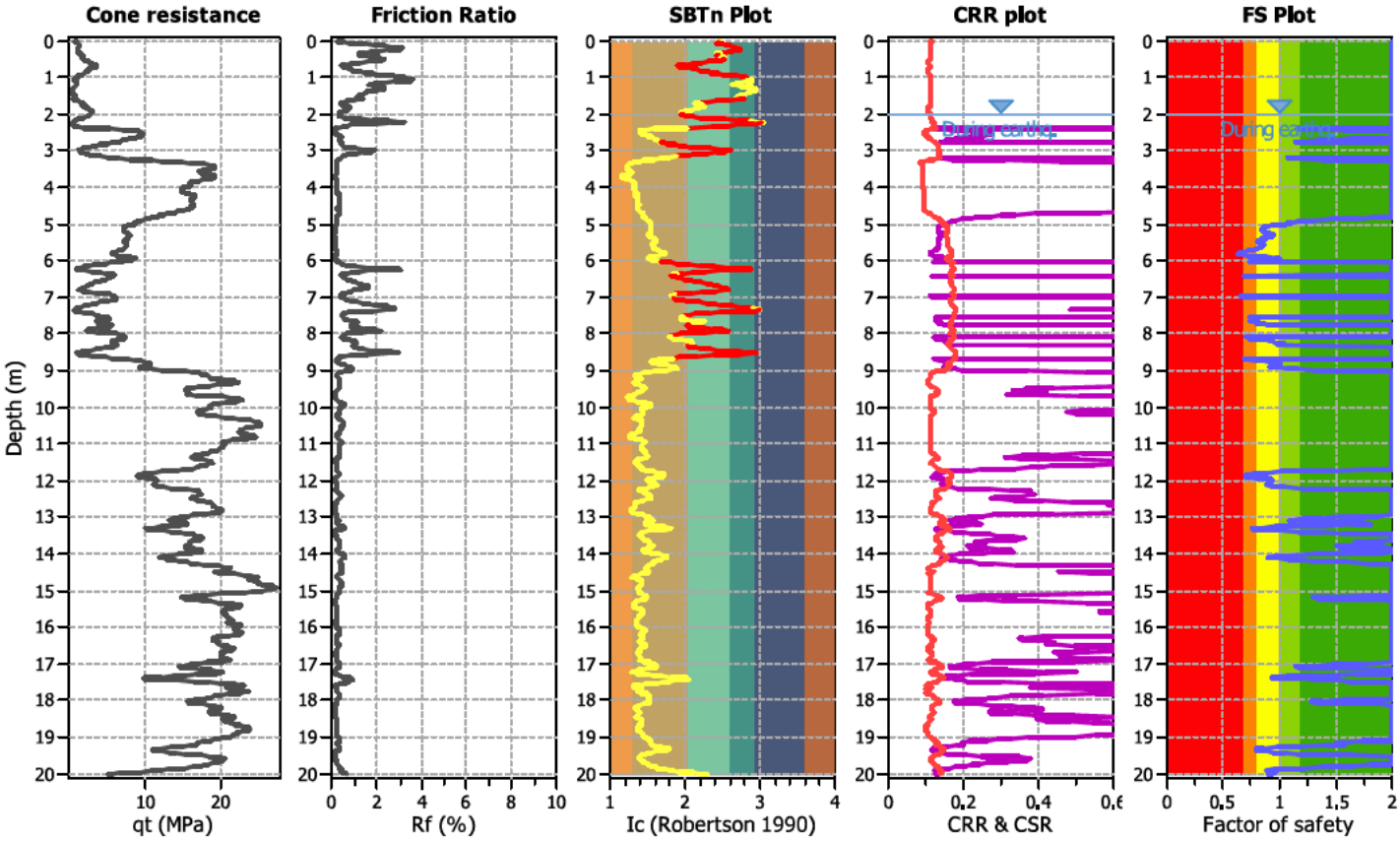
LIQUEFACTION ANALYSIS REPORT

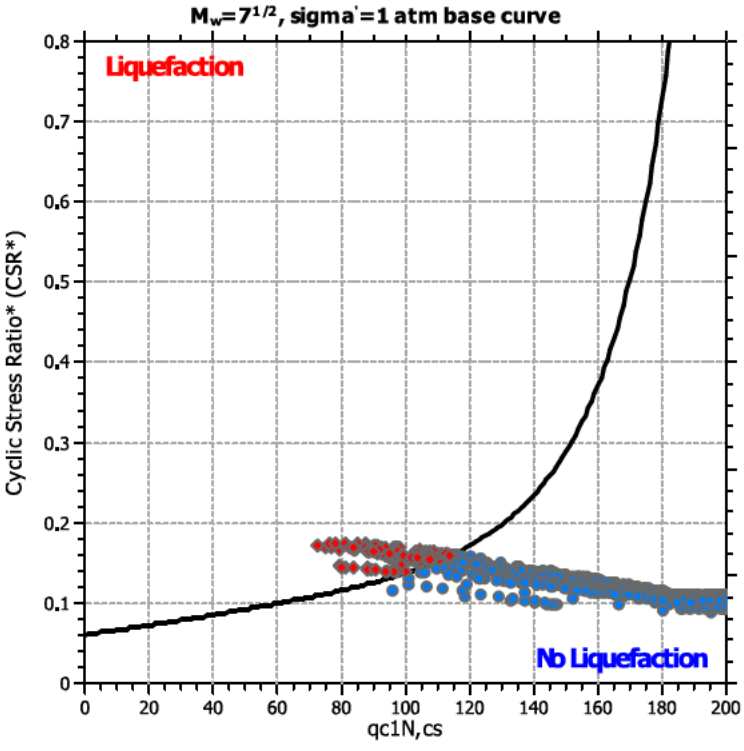
Project title : HD1996 - Te Kowhai Properties **Location : Te Kowhai**

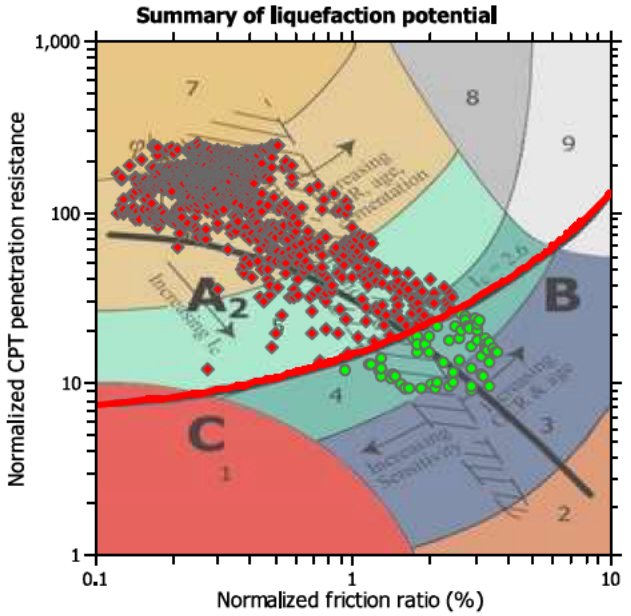
CPT file : CPT06, 268 Te Kowhai Road, Te K

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:	Sand & Clay
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:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.21	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

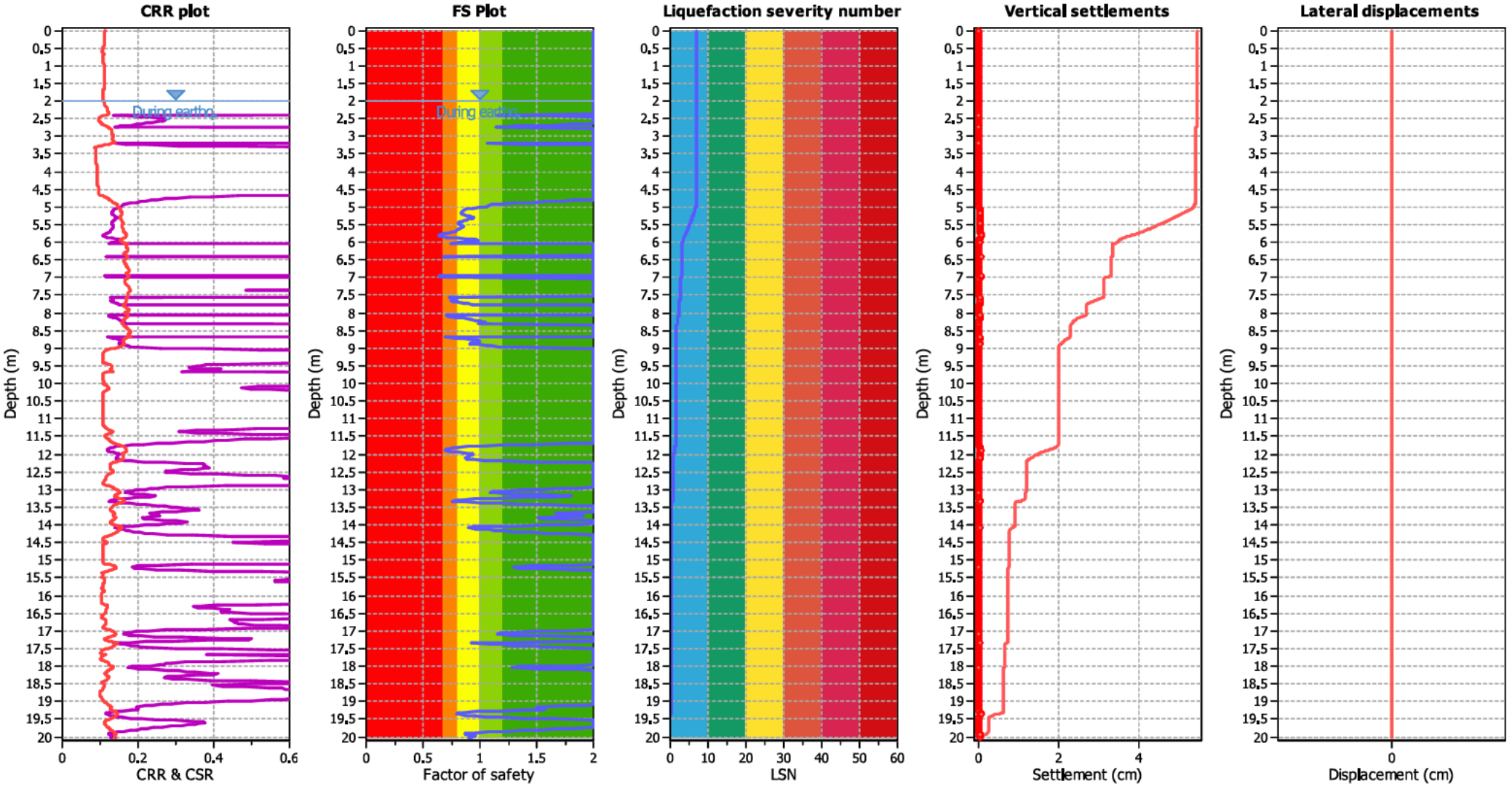






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.21	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
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LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

APPENDIX D – HISTORICAL IMAGERY

Figure 1. Aerial imagery from 1979. Site location in red.

Figure 2. Aerial imagery from 1995. Site location in red.

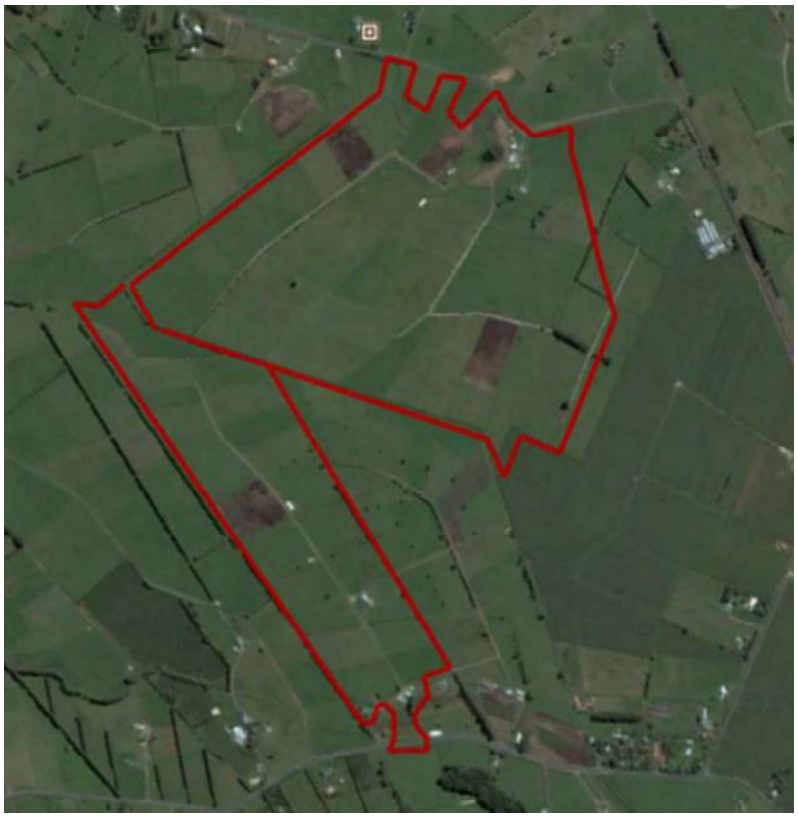

Figure 3. Aerial imagery from 2001. Site location in red.

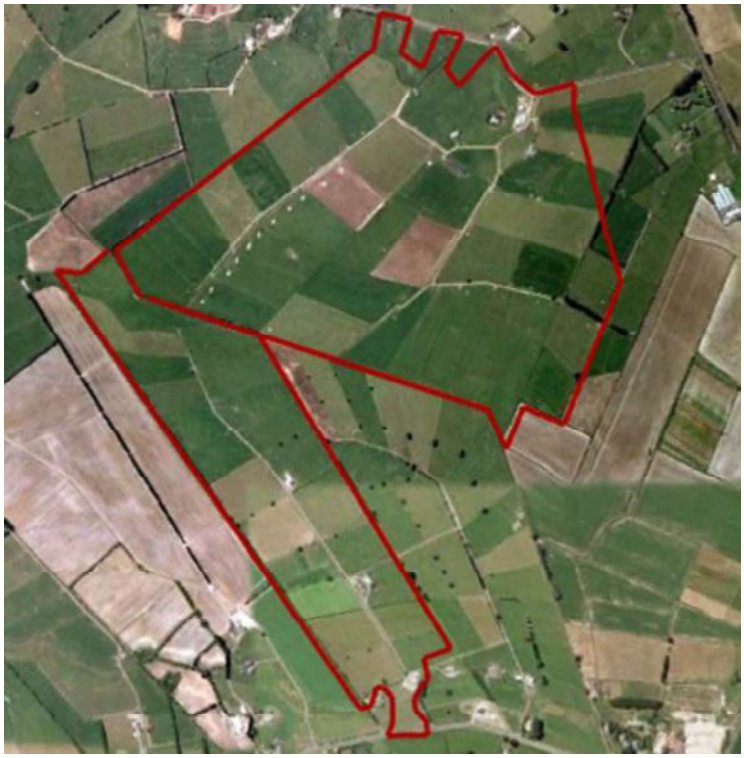

Figure 4. Aerial imagery from 2004. Site location in red.

Figure 5. Aerial imagery from 2012. Site location in red.

Figure 6. Aerial imagery from 2020. Site location in red.