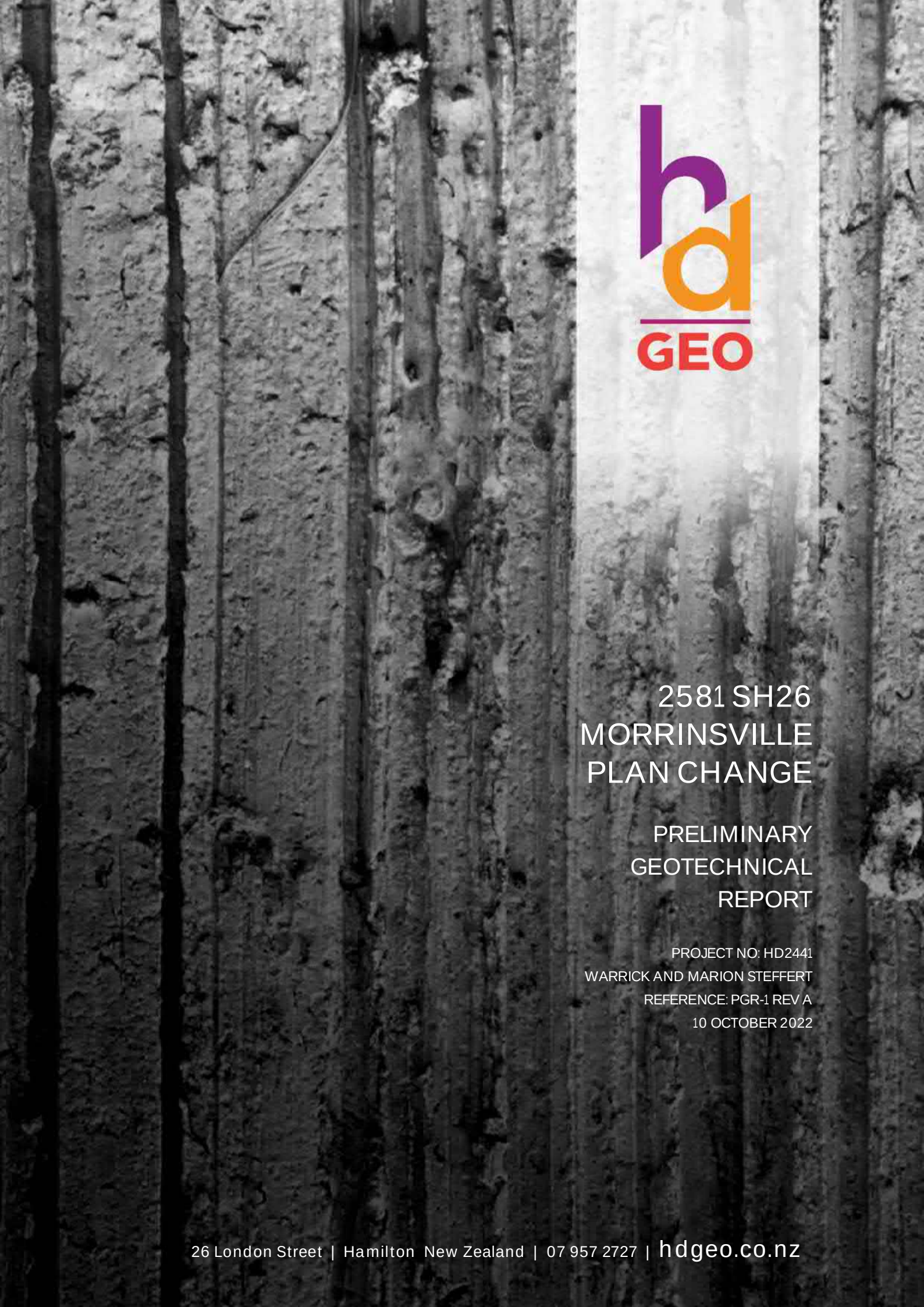


2581 SH26 MORRINSVILLE PLAN CHANGE

PRELIMINARY GEOTECHNICAL REPORT

PROJECT NO: HD2441
WARRICK AND MARION STEFFERT
REFERENCE: PGR-1 REV A
10 OCTOBER 2022

26 London Street | Hamilton New Zealand | 07 957 2727 | hdgeo.co.nz

Executive summary

Introduction

Warrick and Marion Steffert have engaged us to undertake a preliminary geotechnical assessment for their site located at 2581 State highway 26, Morrinsville (legally defined as Lots 1 and 2 DPS 78100). They propose to change the zoning from rural to industrial for future industrial subdivision and development. This report is intended to be submitted to Matamata-Piako District Council in support of the plan change application.

Our scope included

- desktop study of the site to review existing information, including historical aerial images, geology maps, contour maps, and the NZ Geotechnical Database (NZGD)
- hand auger investigation, including ten hand augers (HA) with strength testing, and 4 cone penetration tests (CPTs)
- natural hazards assessment, including preliminary quantitative liquefaction and settlement assessments, and a qualitative slope stability assessment
- preliminary discussion on earthworks and foundations
- identifying further work if required

Our key findings were

- two landform terrains were identified, the elevated hills and the low-lying plains with distinct geologies and geotechnical properties
- the hills terrain generally consisted of stronger, coarser grained materials compared to the plains where sensitive fine-grained material was encountered
- within the transition between the hills and plains terrains a dense layer of river gravel was encountered
- groundwater was encountered between 0.0 and 1.4 m below ground level (bgl) with some standing surface water in the plains. Groundwater was found in the hills at 3.9 m bgl.

Our assessment found that:

- the site is suitable for the proposed land use, subject to further assessment of the geotechnical hazards identified in this report at subdivision stage
- the site's liquefaction performance category was L1 (mild) in the hills and L2 (moderate) in the plains. Vertical settlement from liquefaction was predicted to be between 30 and 70 mm in the plains under Ultimate Limit State (ULS, 1 in 500-year event) conditions.
- a significant consolidation settlement risk was encountered on site in the plains terrain. The depth of settlement prone soils varied across the plains terrain.

Further work is required to:

- define settlement and liquefaction hazard zones within the landform terrains identified
- assess requirements for preloading to induce settlement (or other mitigation) prior to development
- assess slope stability quantitatively once subdivision and earthworks plans are provided
- design pavement thicknesses factoring in the potential soft subgrade and high groundwater levels (by others)

- stormwater design (by others)

Contents

PREPARED BY: George Barker

ENGINEERING GEOLOGIST

George@hdgeo.co.nz

Tel 027 236 0557

REVIEWED BY Andrew Holland, CPEng

TECHNICAL DIRECTOR,
PRINCIPAL ENGINEER

Andrew@hdgeo.co.nz

Tel 022 048 8441

Version	Date	Description	Prepared by	Reviewed by
-	16/09/2022	Initial	GB	AH
A	10/10/2022	Minor rewording	GB	DW

Introduction

We (HD Geo) have been engaged by Warrick and Marion Steffert (the client) to undertake a preliminary geotechnical assessment of Lots 1 and 2 DPS 78100 (the site). The site is located at 2581 State Highway 26, Morrinsville, Waikato. The Stefferts' propose to change the zoning from rural to industrial for future industrial subdivision and development. This report is intended to be submitted to the Matamata-Piako District Council to support a plan change application to rezone the site from rural to industrial. Further testing and assessment is required to inform design and to support subdivision consent. A site plan showing the site is included in Appendix A.

Scope

The scope of our assessment included a:

- desktop study of the site to review existing information, including historical aerial images, geology maps, contour maps, and the NZ Geotechnical Database (NZGD)
- hand auger investigation, including ten hand augers (HA) with strength testing and 4 cone penetration tests (CPTs)
- natural hazards assessment, including preliminary quantitative liquefaction and settlement assessments and a qualitative slope stability assessment
- preliminary discussion on geotechnical hazards, earthworks and foundations including identifying what further work was required

Site description

Lots 1 and 2 DPS 78100 (the site) is located at 2581 State Highway 26, Morrinsville, Waikato. The site is currently used as cattle pasture. A farm track, raised above the natural ground, runs perpendicular from the state highway up to a small shed at the opposite end of the site. Smaller, shorter farm tracks run off this main farm track to provide access to the paddocks.

The site is bounded by agricultural land to the north and east; residential lots to the south and industrial land to the east (under construction).

The site is dominated by two distinct landforms: relatively flat, low-lying plains over the southern two thirds of the site (the 'plains terrain') and gently sloping hills over the northern third of the site (the 'hills terrain').

There are often drainage ditches running perpendicular and parallel to the farm track to re-direct water southwards at the transition between the hills and plains terrains.

The plains terrain is at 29 m above relative level (RL) with the hills terrain increasing in elevation north and westwards to 51 m RL in the north western corner of the site.

Proposed development

A concept plan[1] has been prepared which shows an indicative potential development layout for the site consisting of 30 industrial lots and stormwater and utilities reserves near the southern part of the site. The concept plan shows the lots being serviced by an extension of the road which is being built through the Avenue Business Park site (to the east) and by a new north-south road. We

[1] Tektus Consultants Ltd, Avenue Road Plan Change, Concept Layout Plan (ref: T21098-100-B, dated 31/08/2022

understand the concept plan is indicative and that the final layout for industrial development of the site will be determined at a later date

Desk study

Geological setting

The geology map of the area[2] shows the site is on the boundary between hill terrain to the north of the site, mapped as Walton Subgroup deposits, and the plains to the south of the site, mapped as Hinuera Formation. Walton Subgroup consists of old and often lightly indurated alluvium with primary and reworked, non-welded ignimbrites. The Walton Subgroup is typically mantled by highly weathered volcanic ash (clay and silt of the Hamilton Ash). The Hinuera Formation is described as cross-bedded pumice sand, silt and gravel with interbedded peat.

Aerial photography

We have sourced historic photos of the site from Retrolens[3] and Google Earth[4]. Clear photos were available from 1941, 1963, 1973, 1981, 2008 and 2020. The photos show that there appears to be no significant changes in land use from the site's original use (in 1941) as agricultural land.

Previous reports

We have previously conducted site investigation and assessment for the adjacent industrial subdivision (Avenue Business Park currently under construction) on the eastern boundary of the site[5]. We conducted 12 hand augers and 6 CPTs to assess the ground conditions in this area between 100 and 300 m east of the site. The business park was situated entirely within the plains terrain and encountered:

- loose to dense sand and silty sand to 1.6 m below ground level (bgl)
- very soft/very loose clay and silty clay to 4.9 m bgl that was inconsistent with published geological maps
- interbedded dense/stiff and loose/soft soils to maximum depth of 15.7 m bgl (geology indicated from CPT data)
- groundwater between 1.4 and 2.5 m bgl (summer investigation)

The subsequent assessment highlighted consolidation settlement was a significant hazard across the site.

As part of the earthwork specification for the industrial park[6]; three machine augered boreholes were drilled (TP01 to TP03) within our site to assess how suitable the hills terrain geology was as a source of bulk fill material. Within the proposed plan change site, an area of up to 5.0 m of cut was defined as the "fill removal area" for the adjacent development. This investigation encountered:

- clayey silt and silty clay from 0.2 to 2.3 m bgl – inferred as ash deposits
- silt and sand mixtures to 4.7 m bgl – suitable as fill material
- cobbly gravel between 2.9 and 3.3 m bgl in TP02 only

[2] GNS Science geology viewer https://data.gns.cri.nz/geology/ website accessed 23/08/2022
[3] www.retrolens.co.nz website accessed 23/08/2022
[4] Google Earth Pro application accessed 23/08/2022
[5] HD Geo Ltd Morrinsville industrial subdivision – Preliminary Geotechnical Assessment (ref: HD1310/PGA dated 11/03/2022)
[6] HD Geo Ltd Morrinsville industrial park – Earthworks specification (ref: HD1310-1/EWS-1 dated 07/09/2022)

No strength testing was taken in these augered holes however the gravel layer in TP02 was very dense, causing drill rig refusal before target depth.

Our specification concluded the material from the "fill removal area" was assessed to be suitable for earthworks.

The findings of the previous reports were reviewed and used to assist with this assessment. A copy of the machine augered boreholes is included in Appendix B.

Site investigation

Our site investigation included a site walkover, 10 hand augers and 4 CPTs. Testing locations were initially planned to be spread evenly across the site to broadly characterise the site's ground conditions. However, after an initial site walkover, it was decided to investigate the transition between the hills and plains geology in more detail by concentrating test locations along an approximate cross section traversing from the hills to the plains.

Ground conditions

The materials we encountered on site were consistent with the mapped Walton subgroup for the elevated hills terrain. However, the ground conditions in the plains terrain were not consistent with the mapped Hinuera Formation. The south-eastern corner and the eastern boundary of the plains appears to be more consistent with Holocene River Deposits, described as "Alluvial gravel, sand, silt, mud and clay with local peat".

Ground conditions were split between the two geomorphological terrains and are summarised in the tables below:

Table 1: Summary of hills terrain ground conditions

Description	Depth (m bgl)	Density/strength	Notes
Topsoil	0.0 – 0.4	n/a	
Silty Clay (Hamilton Ash)	0.3 – 3.5	Very stiff to hard (100 – 204+ kPa)	
Sand/ silty sand	0.2 – 15.5	Medium dense to very dense 5.0 – 30 MPa	
Sandy silt	15.5 – 19.0+	2.5 – 10 MPa	

Table 2: Summary of the plains terrain ground conditions

Description	Depth (m bgl)	Density/strength	Notes
Topsoil	0.0 – 0.3	n/a	
Coarser grained "crust"	0.2 – 1.6	Loose to very dense sand Very stiff to hard clay	
Finer grained material	0.9 – 15.0	Soft to stiff clay Loose to dense	Poor recovery in boreholes
"Sensitive fine grained" material	• CPT03: 0.0-2.0 • CPT02: 1.5-2.0 and 3.0-3.7 • CPT04: 1.7-2.5 and 3.7-9.2	• Less than 1.0 MPa • Between 0.1 and 0.5 MPa • Less than 1.0 MPa	With organic soils inferred from CPT data only (not confirmed in boreholes)

CPT03, HA06 and HA07, were in the transition between the hills and plains with a very dense layer found at depths ranging between 1.7 and 15.0 m bgl, recovered in shallow hand augers as gravelly sand.

CPTs in the plains geology (CPT02 to 04) encountered layers of "sensitive fine grained" material at varying depths with variable thicknesses. These layers can be susceptible to static consolidation settlement.

Groundwater

Groundwater was encountered in all CPTs and boreholes in the low-lying plains between 0.0 and 1.4 m bgl. Groundwater in the hills was only encountered in CPT01 at 3.9 m bgl. Due to the time of investigation (August 2022) we conclude the recorded groundwater across the site to be temporarily elevated due to high seasonal rainfall. For assessment purposes we have allowed for a groundwater level of 1.0 m bgl in the plains and 4.0 m for the hills.

Geotechnical assessment

This assessment is a collection of general information and advice for the site. The site is geotechnically suitable for the proposed rezoning and land use change (to industrial), subject to the geotechnical recommendations in this report.

Natural hazards

- Earthquake: The site subsoil class is D 'Deep or soft soils'. Design peak ground acceleration for the 1 in 500-year average recurrence interval earthquake event is calculated to be 0.28 g. Earthquake induced liquefaction and/or lateral spread are considered possible (see 'Liquefaction' section below).
- Volcanic, geothermal, or sedimentation activity: The site is not near any known sources of these risks.
- Landslips: See slope stability section

- Erosion: No indications of erosion were observed during the site investigation, and we consider the site to be at low risk of damage due to erosion.
- Flooding: the site lies outside of flood hazard areas[7] however standing surface water was observed during winter investigation in the low-lying plains terrain (See earthworks section below).
- Subsidence is considered possible (See settlement section below).

Liquefaction

We have undertaken a preliminary quantitative liquefaction assessment using CPT data obtained from our previous reports. The assessment has been undertaken in accordance with the NZGS and MBIE guidelines[8]. Outputs from the CPT analysis are included in Appendix B. Outputs from the liquefaction assessment are included in Appendix C.

Assessment inputs

We completed our screening analysis using the proprietary software CLIQ (Geologismiki) and engineering calculations in accordance with the latest NZGS guidelines.

This assessment has implemented Importance Level 2 design earthquake events for the analysis of liquefaction susceptibility as described in the latest MBIE and NZGS guidelines[9]:

- Serviceability limit state (SLS-1): 1 in 25 years
- Intermediate event: 1 in 100 years
- Ultimate limit state (ULS): 1 in 500 years

The same guidelines have been used to assign the input parameters listed below:

- site seismic classification: Class D (deep soil site)
- structure Importance Level[10]: Level 2 (normal importance level)
- peak ground acceleration dependant on earthquake event:

Table 3: Peak ground acceleration (PGA) vs. Importance Level 4 events

Earthquake Event	Return period	PGA
SLS-1	1 in 25 years	0.07
Intermediate	1 in 100 years	0.14
ULS	1 in 500 years	0.28

- earthquake magnitude: 5.9
- design life of structure: 25 years
- groundwater depth: 1.0 m bgl for the plains and 4.0 m bgl for the hills
- analysis depth: Limited to 10 m[11]

Site specific 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 site's overall susceptibility to

[7] Matamata- Piako district council (MPDC) district plan flood hazard map (https://webmap.mpdc.govt.nz/PublicPortalFull/) accessed 07/09/2022

[8] Ministry of Business Innovation and Employment (MBIE) / New Zealand Geotechnical Society (NZGS). Module 3: Identification, assessment and mitigation of liquefaction hazards. Dated November 2021.

[9] Ministry of Business Innovation and Employment (MBIE) / New Zealand Geotechnical Society (NZGS). Module 1: Overview of the guidelines. Dated November 2021.

[10] NZS 1170.0:2002. Structural Design Actions – *General Principles. SANZ*

[11] See Site specific Liquefaction susceptibility section

liquefaction including liquefaction potential index (LPI), liquefaction severity number (LSN), ground surface settlement and lateral spreading.

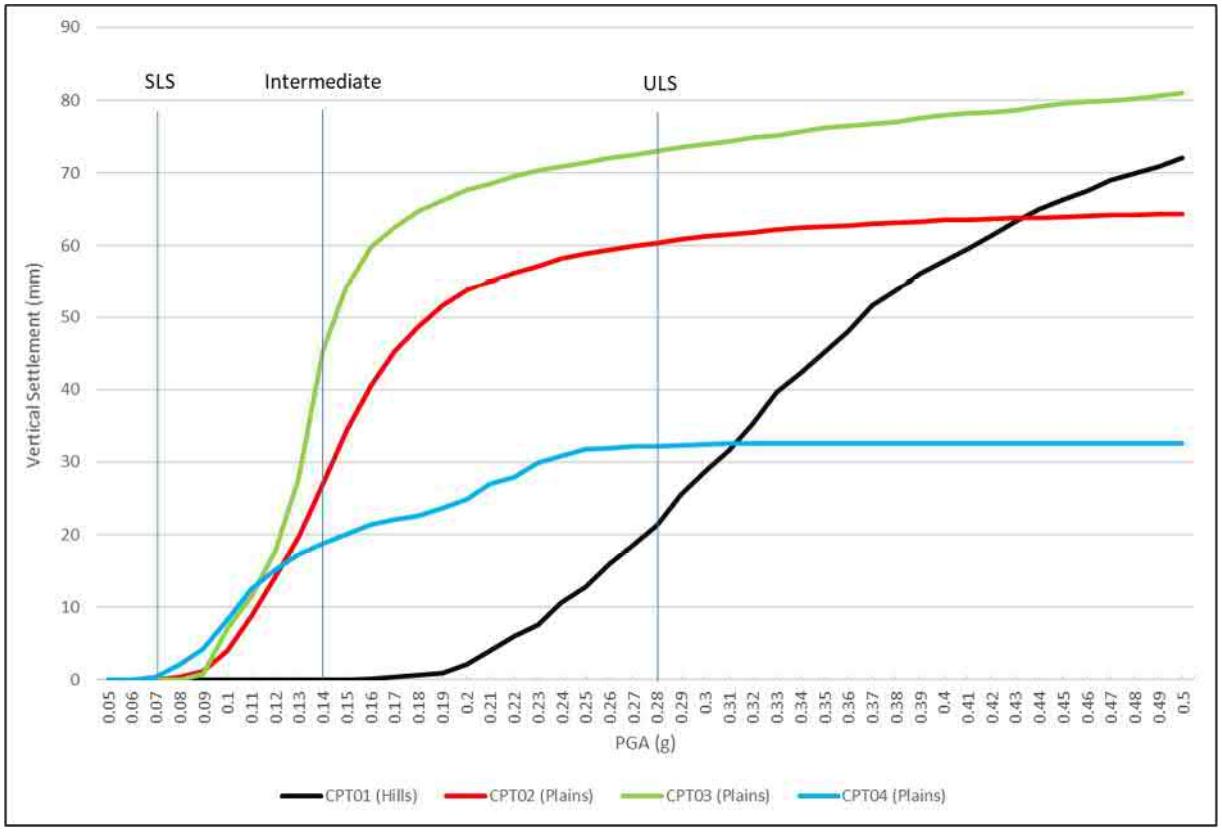
CPTs were assessed under ULS conditions with the analysis limited to 10 m depth for the screening assessment in accordance with the guidelines. Beneath 10 m, the effects of liquefaction may contribute to global settlements however are unlikely to have significant surface expression.

Overall Site liquefaction assessment result

Liquefaction was not triggered in the SLS event but was triggered well before the ULS event.

By plotting predicted vertical settlement with peak ground acceleration (PGA), we can assess that the majority of liquefaction is induced at lower accelerations in the plains terrain than the hills terrain. The CPTs within the plains show that liquefaction is triggered between a 1 in 50 and 1 in 100 -year earthquake event (PGA between 0.09 and 0.14). In contrast, the hills terrain CPT shows liquefaction triggering at approximately the 1 in 250-year event (0.21g).

Figure 1: Vertical settlement vs Peak Ground Acceleration (PGA), vertical lines show the acceleration for each assessment event.



The marked difference in liquefaction response between the hills and plains is due to differences in geology. CPT01 indicates a layer of non-liquefiable clay above dense sand deposits that are less susceptible to liquefy, reducing the likelihood of surface expression in the hills.

The figure above shows the variability of the site's liquefaction response. CPT04, while located in the plains terrain, shows significantly less liquefaction potential than CPT02 and CPT03 due to thinner layers of liquefiable material (more clay dominated soil profile).

A detailed description of the events and their assessed liquefaction risk is presented below. CLiq outputs for the ULS event are attached in Appendix C.

Serviceability Limit State (SLS-1) 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 (a 1 in 25 year earthquake) there is no liquefaction damage expected at the site.

Intermediate Earthquake

Following the latest guidelines[9], an intermediate event is used to define if liquefaction is triggered between the SLS and ULS events. Our assessment showed that under intermediate conditions the different terrains behaved differently. The hills terrain expressed no liquefaction at the intermediate event whereas in the plains terrain, liquefaction was triggered. Our assessment of the plains terrain at an intermediate event (1:100 years) indicated:

- 18 to 45 mm of predicted vertical settlement
- liquefaction Potential Index (LPI) between 0 and 2 (low risk)
- liquefaction Severity Number (LSN) between 2 and 13 (little to minor expression of liquefaction expected)
- thin liquefiable layers were identified across the entire soil profile from 2.0 to 10.0 m bgl
- no lateral spreading risk indicated

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 liquefaction hazard is fully triggered in the plains and only partly triggered in the hills.

Under ULS conditions, our assessment indicated:

Table 4: ULS earthquake event liquefaction assessment summary

Assessment output	Hills (CPT01)	Plains (CPT02, 03 and 04)
Predicted vertical settlement	20 mm	30 -70 mm
LPI	0 (low risk)	3 – 10 (low to high risk)
LSN	3 (no surface expression)	11 – 19 (minor expression)
Liquefiable layers identified	5.5 to 6.0 m bgl	•1.0 to 1.5 m CPT04 •1.7 to 5.5 m CPT02 & 03 (thin layers) •5.2 to +7.2 m CPT02 •7.5 to 9.0 m CPT04 & 03
Lateral spreading	Less than 100 mm displacement predicted	N/A (level ground)

Lateral displacement was only predicted in the hills terrain, however, given the geology (very old, strong clay layers, lateral spreading is unlikely to be a significant risk. Stability in seismic conditions will be needed during design.

Site performance level

Our assessment indicates that the site has a split performance level between the hills and plain terrains. The hills terrain has a level of L1 (mild anticipated liquefaction effects) in accordance with

Table 5.1 of the latest MBIE and NZGS guidelines[12]. The L1 performance level is defined as having negligible ground deformation and small settlements.

The plains terrain has a performance level of L2 (moderate anticipated liquefaction effects) in accordance with the guidelines. The L2 performance level is defined as having limited thickness of liquefiable material, minor ground expression of liquefaction causing small differential settlements.

We recommend further liquefaction assessment is carried out during the design phase to further define the risk and to guide foundation recommendations.

Slope stability

Historic and recent images were used to identify whether features indicating slope instability are present at the site or surrounding areas. Aerial images dating back to 1941 indicate that there has been minimal change to the geomorphology of the area. No features indicating historic or recent large-scale instability at the site or surrounding area were observed during the desk study.

There was no evidence of large-scale instability encountered during the site walkover. Observed instability in the area was minor soil creep on the steeper slopes.

Considering the above, we assess the existing slopes in their current condition are stable.

The transition from the hills to plains terrain is typically gentle (less than 15 degrees) but can be up to 26 degrees in places (e.g. between HA07 and HA08). As of writing there are no development plans that show finished surface levels and care needs to be taken when altering natural slopes. If slopes are altered to ease gradients and form level platforms, buttressing fills and/or retaining walls may be required to ensure slope stability.

Detailed investigation and assessment will be required once the proposed subdivision finished levels are provided any restrictions or stabilisation work needed to meet stability requirements.

During and after development, water should be controlled to avoid ponding above slopes or concentration of water flow towards these slopes. All stormwater and wastewater generated by the development should be directed away from the slopes.

Settlement

The shallow boreholes in the plains encountered soft soils at approximately 2.0 m bgl (recorded as core loss or poor recovery in logs). The CPTs indicated the plains to be underlain by soft deposits up to 9.2 m bgl behaving as “organic soils” and “sensitive fine grained” material.

We completed a settlement screening analysis using proprietary software, CPet (Geologismiki), considering a widespread slab foundation geometry (assuming 20 x 20 m slab dimensions typical for an industrial development) with a structural load and foundation embedment (20 to 40 kPa and 0.0 m respectively).

[12] Module 3: Identification, assessment and mitigation of liquefaction hazards. Prepared by Ministry for the Environment and Ministry of Business, Innovation and Employment, dated November 2021.

Given the inputs above, static settlement ranged between the CPT locations as detailed in the table below:

Table 5: summary of predicted consolidation settlement with a 20x20 m slab

CPT location	20 kPa	30 kPa	40 kPa
CPT01 – Hills	9 mm	15 mm	21 mm
CPT02 – Plains	46 mm	68 mm	91 mm
CPT03 – Plains	367 mm	551 mm	735 mm
CPT04 – Plains	107 mm	178 mm	246 mm

Excessive total and differential static settlements are expected to be likely in the plains area of the site. This amount of settlement is unlikely to be acceptable for the proposed building type.

The majority of the predicted settlement at the CPT02 and 03 locations were within 2.0 m of the surface whereas CPT04 had potential settlement at depths up to 9.5 m bgl.

We recommend further investigation of the potential consolidation settlements across the low-lying terrain once site earthwork concepts have been developed. Mitigation measures will require further assessment and design (see discussion section below).

Expansive soils

During investigation, material encountered was described with variable plasticity (low to high), with ash soils at the top of the hills terrain and clays in the plains terrain the typically described as low to moderate plasticity. High plasticity soils have the potential to change in volume ('shrink and swell') in response to moisture content changes, typically with a seasonal periodicity if close to the surface.

Based on the soil's plasticity and the Waikato Soil's clay minerology, we expect the subgrade across the proposed development 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 by ground improvement or deepened foundations at building consent stage.

Earthworks

There is no current design for cut to fill at the site, however we would expect that there is likely to be significant cuts in the hills and filling in the plains to ease grades on the site and form level building platforms.

The soils encountered in the hills terrain and the upper granular deposits in the plains are likely to be suitable earthwork materials. It is likely that the materials will be wet of optimum moisture content and conditioning will be required. Laboratory testing of the materials and an earthworks specification will be required.

Due to the localised ponding of surface water observed on site, lots may need to be elevated with bulk earth fill so that the base of foundations are above winter groundwater levels. In the plains terrain widespread standing surface water was observed in low lying areas (ground water level of 0.0 m bgl).

Further assessment is required to understand how groundwater could affect earthworks and the subdivision design.

Pavements

The concept plan[1] shows that access will be obtained from Avenue Road North via an extension of the road which is being built through the Avenue Business Park site. A north-south road is also shown through the plan change site. Although the pavement design has not been completed (so subgrade levels are not known), it is likely the pavement subgrade will be founded on soft materials with a potential settlement risk. Specific pavement investigation, design and specification is required prior to construction.

Foundations

Plains terrain foundations

Based on the ground conditions encountered during the site investigation; the potential of consolidation settlement and the potential for liquefaction deformations in a large earthquake, the plains area of the site is not expected to achieve competent bearing capacity and standard shallow foundations are not considered suitable.

Due to the anticipated consolidation settlement, mitigation measures will need to be implemented. Measures could include pre-loading and specifically designed shallow foundations, or a raft foundation supported by piles to a stiff founding layer at depth.

Hills terrain foundations

The hills terrain has a lower liquefaction and settlement risk, and with competent bearing capacity standard shallow foundations are likely to be suitable. However due to the site's proposed industrial use, foundations will likely require specific foundation design.

For both terrains, further testing and assessment are required to provide inputs for foundation design prior to building consent.

Discussion

After preliminary assessment, the site has highly variable geology with differing geotechnical risks.

Hills terrain

The hills terrain is stable in its current state with low liquefaction and settlement hazards. To create flat and level lots, earthworks and retaining walls will likely be required. Up to 5.0 m of cut is proposed as a source of fill for an adjacent subdivision, this area is marked out in our site investigation plan described as "fill removal area" in Appendix B. Currently there are no details as to how these cut slopes will be supported in the long term however these slopes should be stable for short term rural use (pasture) with the intent that these slopes will be reworked to be stable for industrial use subject to final subdivision design and further geotechnical assessment.

Global slope stability analysis and retaining wall design will likely be required once earthworks plans have been provided.

Plains terrain

The plains terrain exhibits a range of geotechnical hazards including an elevated liquefaction risk and significant consolidation settlement predicted compared to the hills. Geotechnical properties also vary within the plains between test locations. Different test locations have layers of settlement potential at different depths (CPT02 and CPT03 are shallow, CPT04 is deep) which may guide the mitigation methods for different areas of the plains terrain. In the area of CPT02 and CPT03, shallow excavation and replacement with bulk earth fill could be appropriate to mitigate the settlement risk

but the area around CPT04 may require remediation such as pre-loading to induce settlement in the deeper layers before development.

From reviewing our previous reports from the adjacent lot, the blue grey clay and sensitive fine-grained materials encountered on site in shallow boreholes (HA01 and HA05) and deep investigation (CPT04) respectively may indicate the presence of buried lacustrine (lake) deposits below a 'crust' of denser river deposits (sand and silt). Understanding the extent of these lake deposits is critical for defining the site's geotechnical hazard areas, especially consolidation settlement.

The variable settlement risk from the differing geology within the plain terrain could also affect pavement construction and services installation. This risk can be mitigated through investigation, assessment and design (such as raising pavement levels above seasonal groundwater highs and elevate the pavement and lots away from settlement prone layers) or mitigated through hard engineering methods (preloading along the pavement alignment as used in the adjacent Avenue Business Park subdivision). Specific testing and design will be required to develop remediation methods and determine the final pavement requirements.

Hills to plains transition

In between the two terrains, we encountered dense gravel layers which could indicate the presence of buried river terrace gravels. The location and depth of these layers is highly variable and may not be consistent across the site.

The surface water drainage trenches within this area indicate groundwater springs are likely and care needs to be taken when altering natural slopes. Natural groundwater flow paths may destabilise temporary and permanent cut slopes so planning drainage to de-water these potential springs will need to be considered during design.

Further work

The land is suitable for the proposed rezoning and land use change (to industrial); however further investigation, assessment and design will be required to better define the extent of the geotechnical hazards within the different terrains once subdivision plans have been developed. Further geotechnical work could include:

- further investigation to define settlement and liquefaction hazard zones within the landform terrains identified
- assess site suitability for preloading to induce settlement prior to development
- quantitative slope stability assessment once subdivision and earthworks plans are provided
- pavement design factoring in the potential soft subgrade, risk of consolidation settlement, and high groundwater
- geotechnical assessment report, summarising results for design and subdivision consent application

Limitation

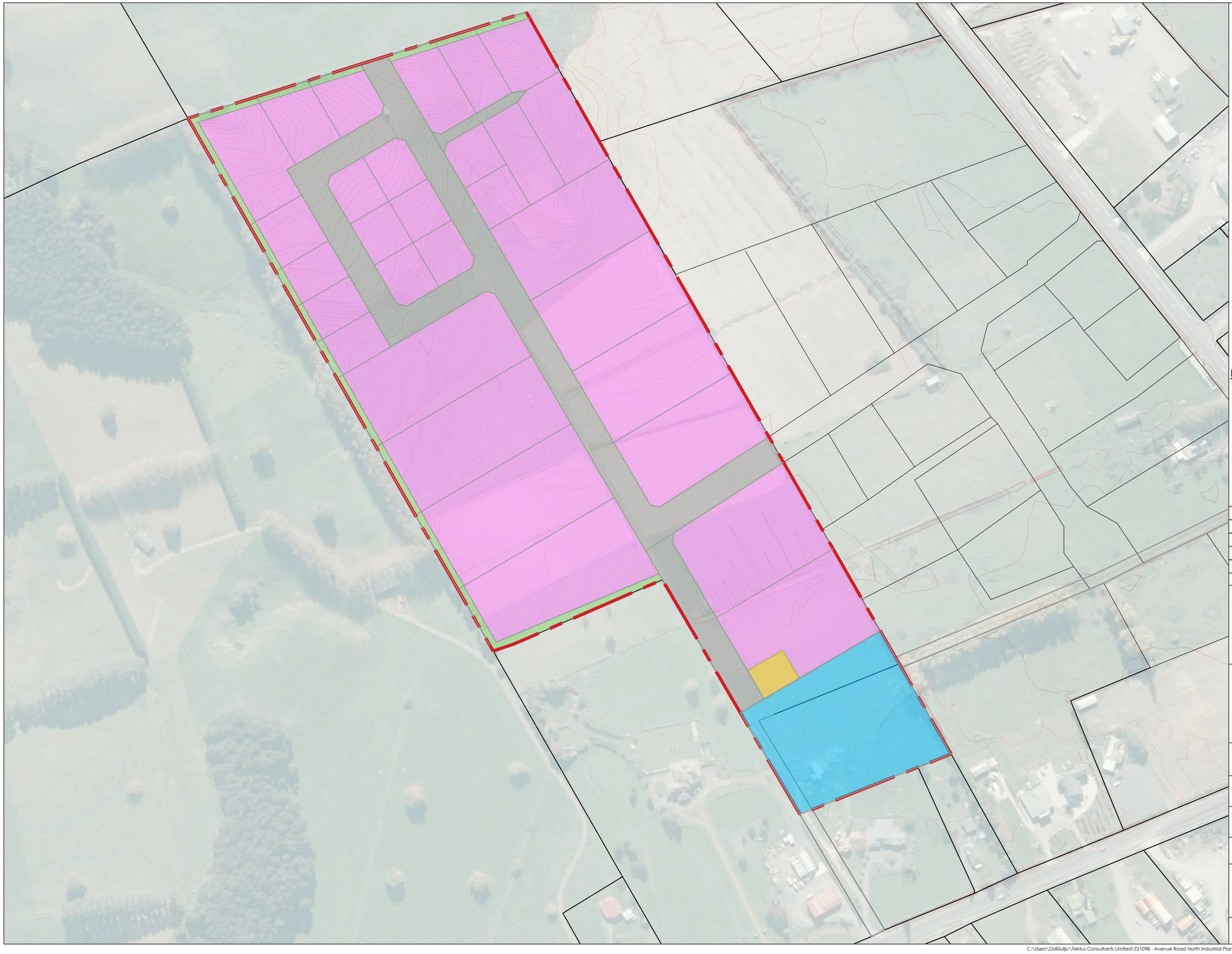
This report has been prepared for our client, Warrick and Marion Steffert, their professional advisers, and the relevant local authority for the purposes detailed above and may not be relied on by any other party for any other purposes. This report contains a preliminary assessment to establish suitability for subdivision based on a site walkover and testing in discrete locations. Further testing and assessment is required during the development of the site. Inferences about the conditions at

the site have been made based on the testing undertaken and our understanding of the geological environment in which the site lies.

We recommend that HD Geo is engaged to undertake further testing and assessment for subdivision resource consent, and to observe works during the site preparation.

APPENDIX A – CONCEPTPLANS

PLOTTED: 31/08/2022 11:27:11 am



NOTES:

LEGEND

- EXISTING PROPERTY BOUNDARY
- PROPOSED INDUSTRIAL ZONE
- EXISTING MAJOR CONTOUR (2m)
- EXISTING MINOR CONTOUR (0.5m)
- PROPOSED INDUSTRIAL AREA
- ROAD/ACCESS RESERVE
- STORMWATER MANAGEMENT RESERVE
- LANDSCAPE BUFFER (5m)
- UTILITY RESERVE

B	FOR DISCUSSION	DS	31.08.2022
A	FOR DISCUSSION	DS	25.07.2022
REVISION DETAILS:		BY:	DATE:

TEKTUS CONSULTANTS

CLIENT:

WARWICK AND MARION STEFFERT

SITE: AVENUE ROAD PLAN CHANGE

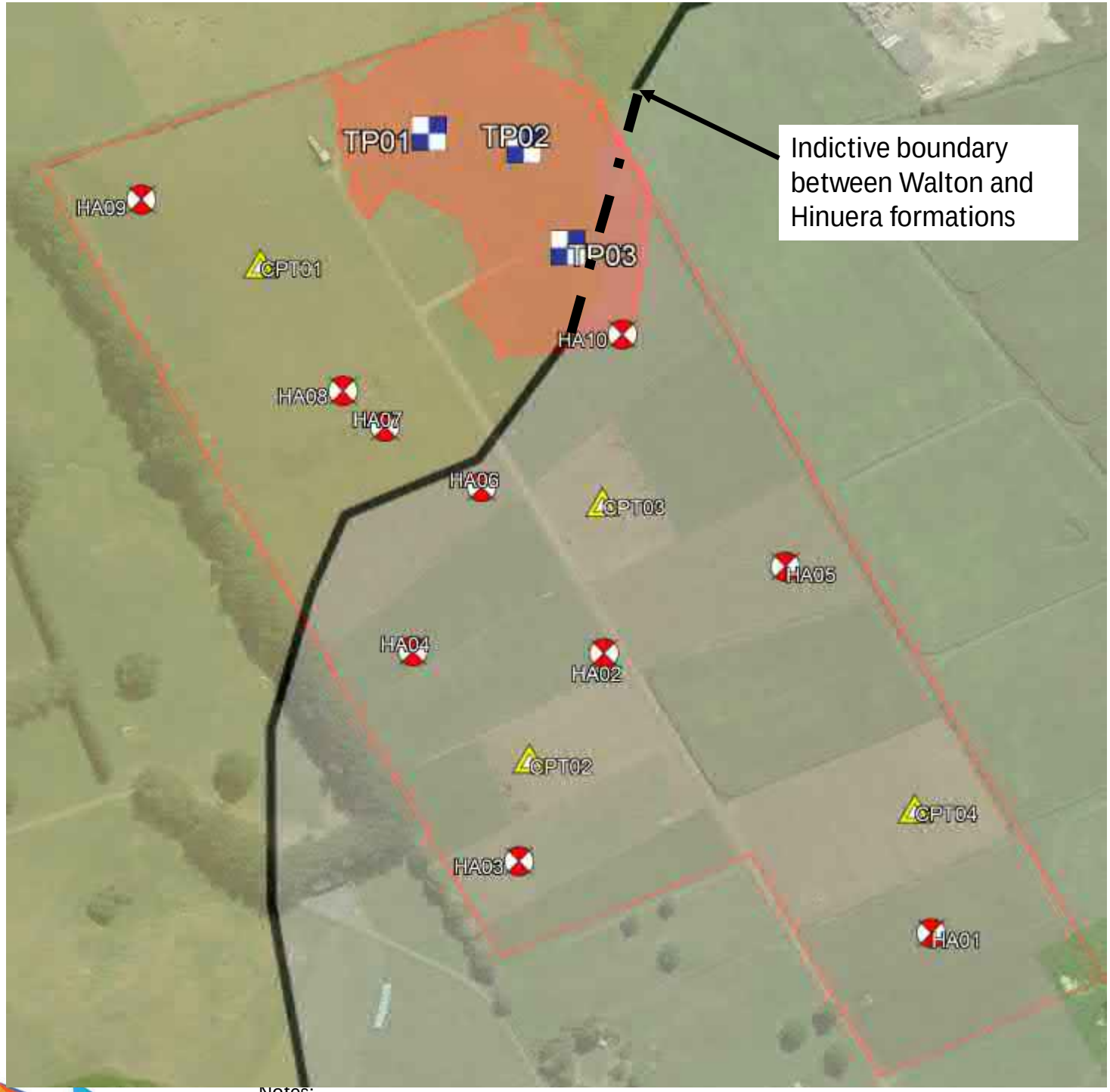
TITLE: CONCEPT LAYOUT PLAN

SUBTITLE:

DRAWN:	REVIEWED:	APPROVED:
DS		
NORTH:	SCALE AT A3: 1:2500	DATE: 31.08.2022
	STATUS: FOR INFORMATION	
PROJECT NO: T21098	DRAWING NO: 100	REVISION: B

C:\Users\DaliSuljic\Tektus Consultants Limited\T21098 - Avenue Road North Industrial Plan Change - Documents\Drafts\CAD\T21098.AVENUE - Concept Plan.dwg

APPENDIX B – SITE INVESTIGATION DATA



Notes:
1. Image overlay taken from Google Earth Pro and GNS science Geology viewer

LEGEND

- Hand Auger (HA)
- Cone Penetrometer test (CPT)
- Test Pit (TP)
- "Fill removal area"

PROJECT: 2581 SH26 Plan change

PROJECT No: HD2441

CLIENT: Warwick & Marion Steffert

TITLE: Site investigation plan

SCALE: N/A

Drawing No: 01

Drawing By: GB

Rev	Initials	Date
0	GB	03/08/2022
1	GB	09/09/2022

INVESTIGATION LOG

Job No.:	HD2441
Client:	Warrick and Marion Steffert
No.:	HA01
Project:	2581 SH26 Morrinsville PGR
Location:	South east corner
Date:	22.08.22
Co-ordinates:	1821566mE, 5828797mN
Logged By:	SW
Elevation:	Ground
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	Silty TOPSOIL; dark blackish brown. Moist to wet.	0.2
Holocene River Deposits	SAND, with some silt; light grey. Loose to dense; saturated; well graded; sand, fine to coarse, pumice.	1.0
	SAND; light grey streaked orange. Dense; saturated; sand, fine to medium, pumice.	1.2
	Sandy SILT; light grey. Loose; saturated; sand, fine to medium.	
	EOH: 1.30 m	1.3

Legend

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows
0.0–0.2	1, 1
0.2–0.4	2, 4
0.4–0.6	4, 4
0.6–0.8	10, 15
0.8–1.0	16, 10
1.0–1.2	15, 8
1.2–1.4	2, 1
1.4–1.6	1, 2
1.6–1.8	1, 2
1.8–2.0	1, 2
2.0–2.2	2, 2
2.2–2.4	2, 2
2.4–2.6	2, 2
2.6–2.8	2, 3
2.8–3.0	3, 3
3.0–3.2	3, 5

Vane Shear Strength (kPa) (Vane: 1710)

Depth (m)	Peak	Remoulded
0.4–0.6	15	15
0.6–0.8	15	15
0.8–1.0	UTP	-
1.0–1.2	UTP	-
1.2–1.4	198	18

Water: 0.2 m

Photo

Remarks

End of borehole at 1.3 meters_ target depth not achieved. repeated hole collapse.

Shear Vanes
- Peak
- Remoulded

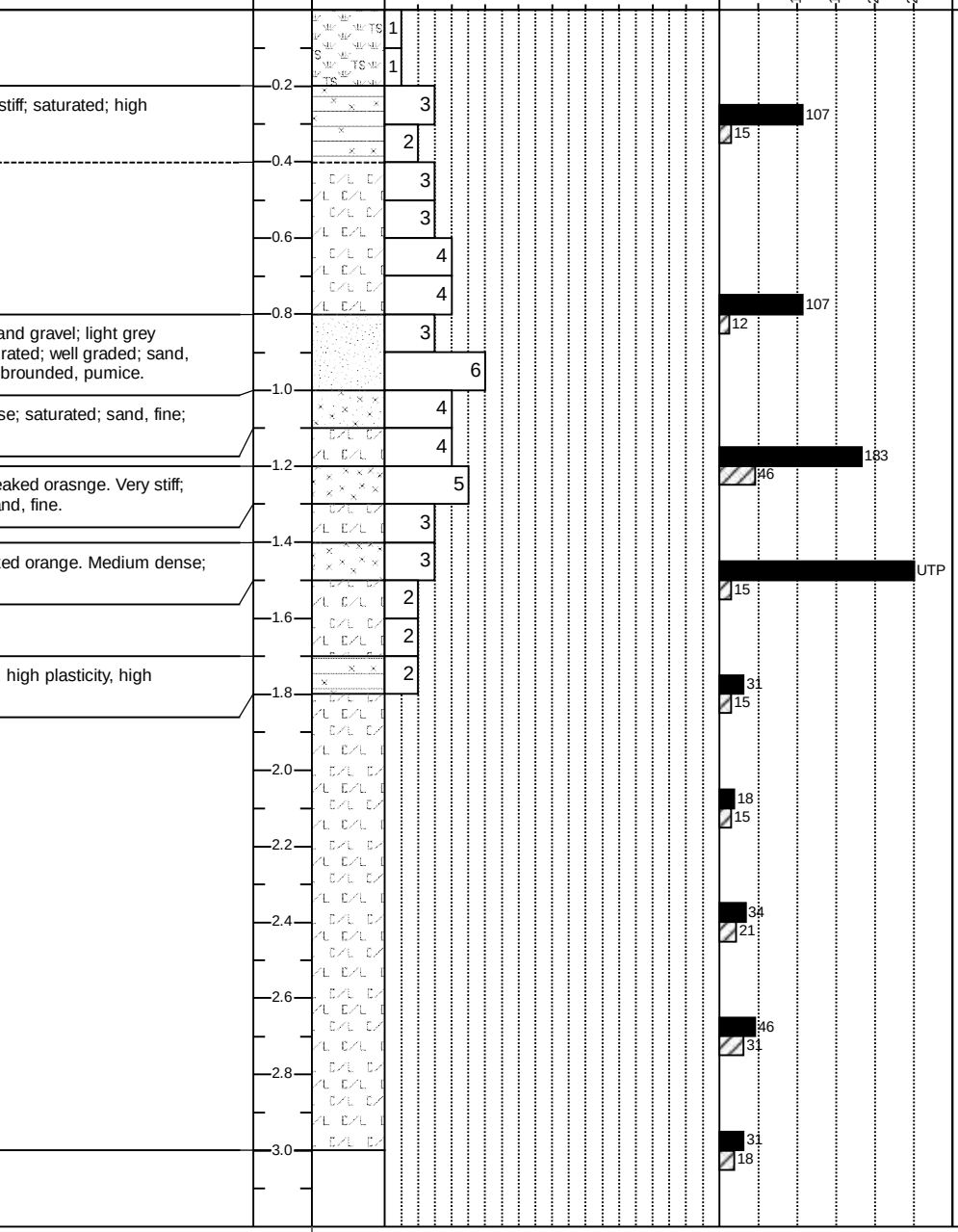
Water
- Standing Water Level
- Out flow
- In flow

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

INVESTIGATION LOG

Job No.:	HD2441
No.:	HA02
Client:	Warrick and Marion Steffert
Project:	2581 SH26 Morrinsville PGR
Location:	Central plains
Co-ordinates:	1821412mE, 5828935mN
Elevation:	Ground
Date:	22.08.22
Logged By:	SW
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	Silty TOPSOIL; greyish black. Moist.	0.2
Holocene River Deposits	Silty CLAY; light greyish brown. Very stiff; saturated; high plasticity, high dilatency, sensitive.	0.4
No Recovery		0.6
		0.8
Holocene River Deposits	SAND, with minor silt, with trace clay and gravel; light grey streaked orange. Medium dense; saturated; well graded; sand, fine to coarse, pumice; gravel, fine, subrounded, pumice.	1.0
HRD / NR	Sandy SILT; light brown. Medium dense; saturated; sand, fine; tree roots.	1.2
HRD / NR	SILT, with minor sand; light brown streaked orasnge. Very stiff; saturated; high dilatency, sensitive; sand, fine.	1.4
HRD / NR	SILT, with trace sand; light blue streaked orange. Medium dense; saturated; sand, fine.	1.6
HRD	Silty CLAY; light blue. Firm; saturated; high plasticity, high dilatency, moderately sensitive.	1.8
No Recovery	Soft to firm, insensitive.	2.0
		2.2
		2.4
		2.6
		2.8
	EOH: 3.00 m	3.0



Photo

Remarks

End of borehole at 3.0 meters_ target depth achieved.

NR = No Recovery
HRD = Holocene River Deposits

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

INVESTIGATION LOG

Client:	Warrick and Marion Steffert
Project:	2581 SH26 Morrinsville PGR
Location:	South west corner
Co-ordinates:	1821369mE, 5828837mN
Elevation:	Ground

Job No.: HD2441
No.: HA03
Date: 22.08.22
Logged By: SW
Checked By: AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	Silty TOPSOIL; greyish black. Moist.	0.2
Holocene River Deposits	Sandy SILT; light grey. Loose; saturated; sand, fine.	0.4
	SAND; light greyish brown. Loose; saturated; well graded; sand, fine to coarse, pumice.	0.8
	Silty CLAY; light grey. Very stiff to firm; saturated; high dilatency, high plasticity, extra sensitive to moderately sensitive.	1.2
No Recovery		2.0
HRD	SILT; bluish grey. Firm; saturated; high dilatency, moderately sensitive.	2.2
No Recovery		2.8
HRD	SAND, with trace gravel; bluish grey. Loose to medium dense; saturated; poorly graded; sand, medium to coarse; gravel, fine, subrounded, pumice.	
NR		
HRD	Silty CLAY, with minor sand; bluish grey. Loose; saturated; high dilatency; sand, fine.	3.0
	EOH: 3.00 m	3.4

Legend

Scala Penetrometer (Blows / 100 mm)

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

Vane Shear Strength (kPa) Vane: 1710

Depth (m)	Peak	Remoulded
0.2–0.4	61	18
0.4–0.6	107	18
0.6–0.8	122	15
1.0–1.2	31	12
1.8–2.0	46	18
2.8–3.0	UTP	-
3.0	UTP	-

Water: 0.2 m

Photo

Remarks

End of borehole at 3.0 meters_ target depth achieved.

NR = No recovery
HRD = Holocene River Deposits

Shear Vanes
- Peak
- Remoulded

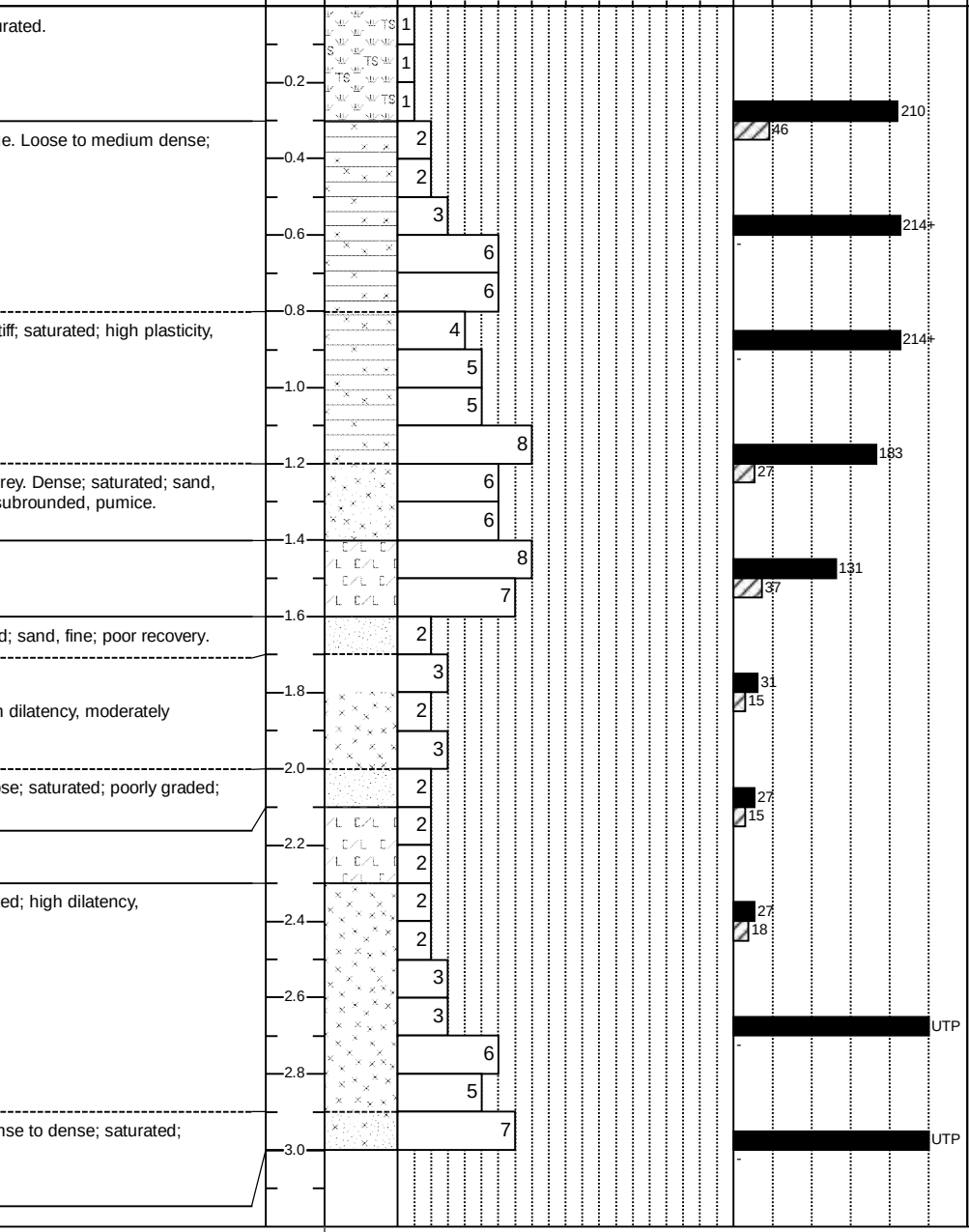
Water
- Standing Water Level
- Out flow
- In flow

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

INVESTIGATION LOG

Job No.:	HD2441
No.:	HA04
Client:	Warrick and Marion Steffert
Project:	2581 SH26 Morrinsville PGR
Location:	West central plains
Co-ordinates:	1821320mE, 5828938mN
Elevation:	Ground
Date:	22.08.22
Logged By:	SW
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL; light broiwn. Moist to saturated.	0.2
Holocene River Deposits	Silty CLAY; light grey streaked orange. Loose to medium dense; saturated; low to moderate plasticity.	0.4
		0.6
		0.8
Holocene River Deposits	Silty CLAY; light grey. Hard to very stiff; saturated; high plasticity, sensitive.	1.0
		1.2
Holocene River Deposits	Sandy SILT, with trace gravel; light grey. Dense; saturated; sand, fine to coarse, pumice; gravel, fine, subrounded, pumice.	1.4
No Recovery		1.6
Holocene River Deposits	SAND; light brown . Loose; saturated; sand, fine; poor recovery.	1.8
	SILT; light grey. Firm; saturated; high dilatency, moderately sensitive; poor recovery.	2.0
	SAND, with some silt; light grey. Loose; saturated; poorly graded; sand, medium to coarse.	2.2
No Recovery		2.4
Holocene River Deposits	SILT; light grey. Firm to hard; saturated; high dilatency, insensitive; limited recovery.	2.6
		2.8
	Silty SAND; bluish grey. Medium dense to dense; saturated; sand, fine.	3.0
	EOH: 3.00 m	



Photo

Remarks

End of borehole at 3.0 meters_ target depth achieved.

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.:	HD2441
No.:	HA05
Client:	Warrick and Marion Steffert
Project:	2581 SH26 Morrinsville PGR
Location:	East central plains
Co-ordinates:	1821501mE, 5828974mN
Elevation:	Ground
Date:	22.08.22
Logged By:	SW
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL; dark greyish brown. Moist.	0.2
Holocene River Deposits	Sandy SILT; light brown. Medium dense; saturated; sand, fine to medium, pumice.	1.5 m:
No Recovery		2.8
HRD	Silty CLAY, with minor sand; bluish grey. Loose; saturated; high plasticity; sand, fine.	3.0
No Recovery		
	EOH: 3.00 m	

Legend: TS

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Scala Penetrometer	Vane Shear Strength (kPa)
0.2	1, 1, 1	214
0.4	3, 2	
0.6	3, 4	159 / 37
0.8	4, 4	
1.0	5, 5	143 / 27
1.2	7, 5	156 / 31
1.4	5, 3	
1.6	2, 2	46 / 15
1.8	2, 2	46 / 15
2.0	2, 2	76 / 15
2.2	1, 1	
2.4	2, 3	
2.6	3, 4	
2.8	2, 2	61 / 31
3.0	2, 2	34 / 12

Water: 0.2 m

Photo

Remarks

End of borehole at 3.0 meters_ target depth achieved.

Shear Vanes
- Peak
- Remoulded

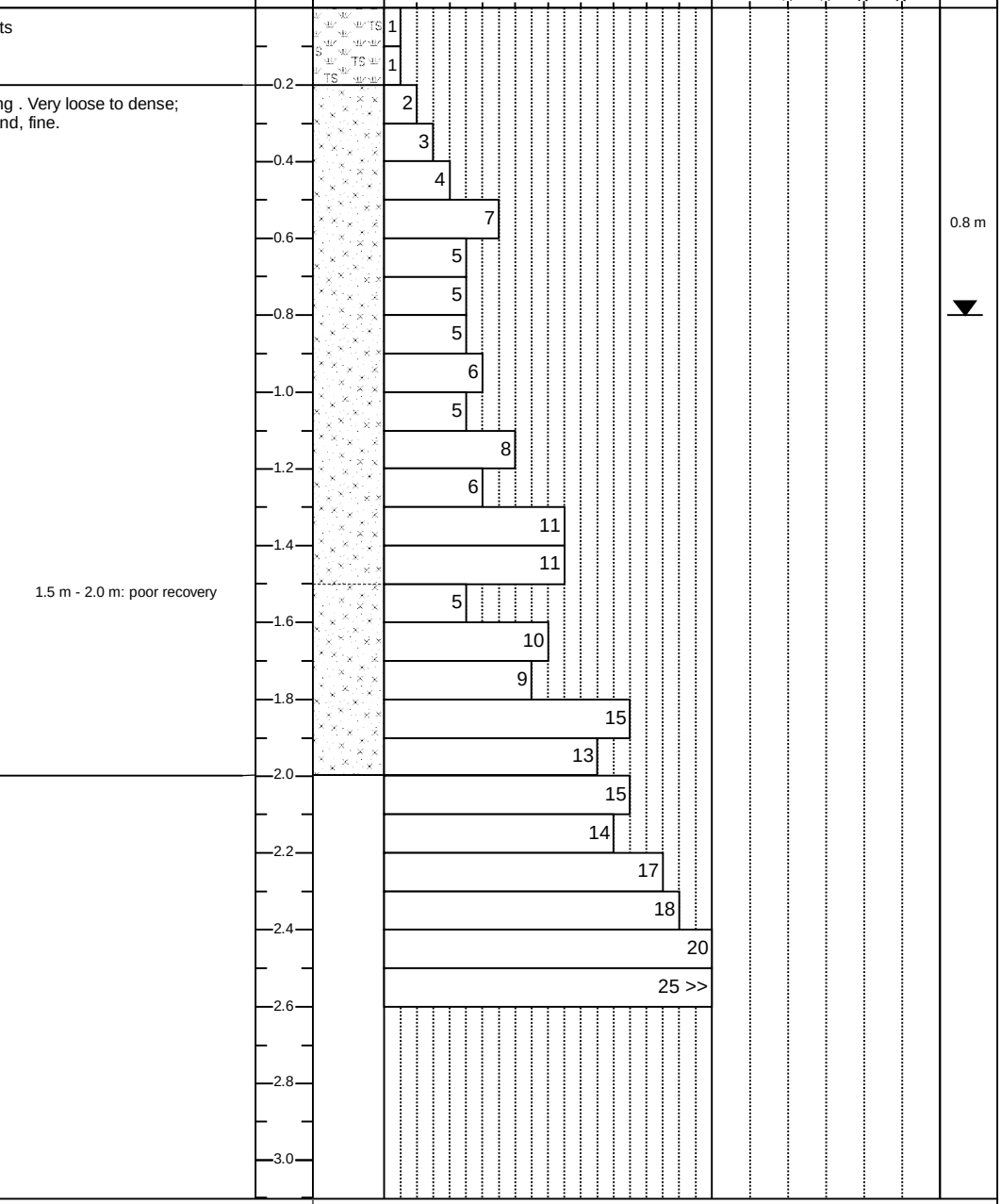
Water
- Standing Water Level
- Out flow
- In flow

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

INVESTIGATION LOG

Job No.:	HD2441
Client:	Warrick and Marion Steffert
No.:	HA06
Project:	2581 SH26 Morrinsville PGR
Location:	Hill- Plain transition, plain
Date:	08.08.22
Co-ordinates:	1821349mE, 5829008mN
Logged By:	GB
Elevation:	Ground
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL. Dark brown silt with rootlets	0.0
Holocene River Deposits	Sandy SILT; white with orange staining . Very loose to dense; moist to saturated; high dilatency; sand, fine.	0.2
	1.5 m - 2.0 m: poor recovery	0.4
		0.6
		0.8
		1.0
		1.2
		1.4
		1.6
		1.8
	EOH: 2.00 m	2.0
		2.2
		2.4
		2.6
		2.8
		3.0



Photo

Remarks

End of Hole 2.0 m - target depth not reached due to borehole collapse. DCP unable to penetrate 2.7 m

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.:	HD2441
Client:	Warrick and Marion Steffert
No.:	HA07
Project:	2581 SH26 Morrinsville PGR
Location:	Hill-plain transition, middle terrace near water trench
Date:	08.08.22
Co-ordinates:	1821295mE, 5829033mN
Logged By:	GB
Elevation:	Ground
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL. Dark brown silt with rootlets	0.2
Holocene River Deposits	Sandy SILT. Stiff; wet to saturated; moderate dilatency, moderately sensitive to sensitive; sand, medium to coarse; poor core recovery.	1.2
	SILT & SAND. Loose to medium dense; saturated; high dilatency; sand, fine to coarse.	1.8
	Dense to very dense granular material; unable to penetrate with hand auger. No sample recovery due to groundwater	
	EOH: 1.90 m	

Legend

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.2	2, 2
0.4	2, 2, 2
0.6	2, 3
0.8	4, 3
1.0	2, 3
1.2	3, 3, 2
1.4	3, 3
1.6	4, 5
1.8	10, 25 >>

Vane Shear Strength (kPa) — Vane: 2284

Depth (m)	Peak	Remoulded
0.2	67	15
0.6	73	20
1.0	58	20

Water: 1.2 m

Photo

Remarks

End of Hole 1.9 m - unable to penetrate dense material

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

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

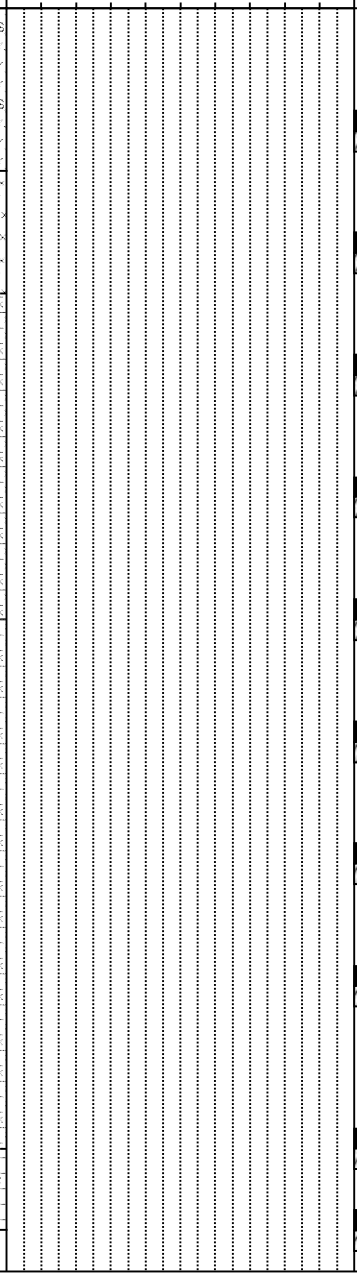
INVESTIGATION LOG

Job No.:	HD2441
Client:	Warrick and Marion Steffert
No.:	HA08
Project:	2581 SH26 Morrinsville PGR
Location:	Hill-plain transition, Hill
Date:	08.08.22
Co-ordinates:	1821280mE, 5829051mN
Logged By:	GB
Elevation:	Ground
Checked By:	AM

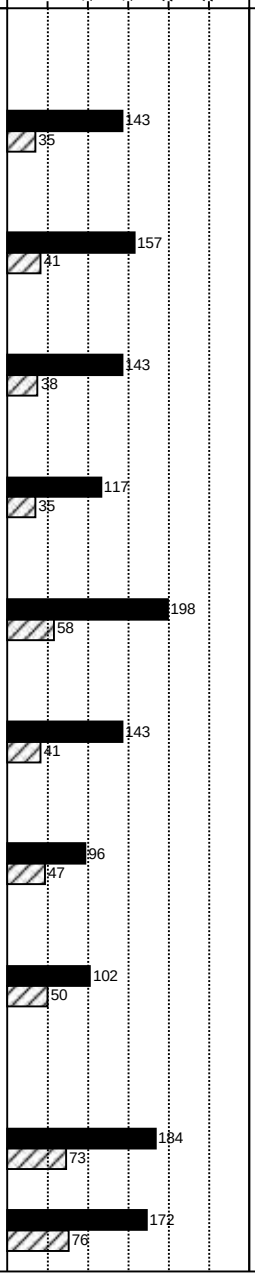
Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL. Brown silt with rootlets	0.4
Undifferentiated airfall ash	SILT; dark brown. Very stiff; moist; low plasticity, sensitive.	0.8
	Clayey SILT; brown. Very stiff to hard; moist; moderate plasticity, moderately sensitive.	1.4
	Clayey SILT, with some sand; light brown speckled black . Stiff to very stiff; moist; moderate plasticity, moderately sensitive; sand, fine to medium, quartz.	2.8
	Silty CLAY, with minor sand; grey . Very stiff; moist; moderate plasticity, moderately sensitive; sand, fine.	3.0
	EOH: 3.00 m	

Legend

Scala Penetrometer (Blows / 100 mm)



Vane Shear Strength (kPa) Vane: 2284



Water: Groundwater Not Encountered

Photo

Remarks

End of Hole 3.0 m - target depth achieve

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.:	HD2441
Client:	Warrick and Marion Steffert
No.:	HA09
Project:	2581 SH26 Morrinsville PGR
Location:	NW corner , top of hill
Date:	08.08.22
Co-ordinates:	1821196mE, 5829158mN
Logged By:	GB
Elevation:	Ground
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa) Vane: 2284	Water
Topsoil	TOPSOIL. Brown silt with rootlets	0.2	TS			
Undifferentiated airfall ash	Silty CLAY, with trace sand; dark brown speckled black. Very stiff to hard; moist; low plasticity, insensitive to moderately sensitive; sand, fine to medium, quartz; trace rootlets.	0.4			134 / 47	Groundwater Not Encountered
		0.6			102 / 41	
		0.8			204+ / -	
	Sandy SILT; light brown . Moist; low dilatency; sand, fine to medium, quartz.	1.0				
	Clayey SILT, with some sand, with trace gravel; light brown. Very stiff to hard; moist; low plasticity, insensitive to sensitive; sand, fine to coarse; gravel, fine.	1.2			190 / 47	
		1.4			204+ / -	
		1.6				
		1.8			192 / 50	
		2.0			137 / 38	
		2.2				
		2.4			149 / 32	
	Silty CLAY, with trace sand; brown. Very stiff; wet; moderate plasticity, moderately sensitive to sensitive; sand, fine.	2.6			143 / 23	
		2.8				
	EOH: 3.00 m	3.0			149 / 35	

Scala Penetrometer (Blows / 100 mm): 2 4 6 8 10 12 14 16 18

Vane Shear Strength (kPa): 50 100 150 200 250

Photo

Remarks

End of Hole 3.0 m - target depth achieved

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.:	HD2441
No.:	HA10
Client:	Warrick and Marion Steffert
Project:	2581 SH26 Morrinsville PGR
Location:	Hills-plains transition
Co-ordinates:	1821425mE, 5829087mN
Elevation:	Ground
Date:	22.08.22
Logged By:	SW
Checked By:	AM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL; dark blackish brown. Moist; trace rootlets.	0.2
Holocene River Deposits	Silty SAND; light brown. Loose to dense; moist; poorly graded; sand, fine to medium.	0.4 / 0.6 / 0.8 / 1.0 / 1.2 / 1.4 / 1.6 / 1.8 / 2.0 / 2.2
	EOH: 2.10 m	

Legend: TS

Scala Penetrometer (Blows / 100 mm)

2 4 6 8 10 12 14 16 18

2, 4, 3, 6, 7, 10, 9, 10, 10, 12, 12, 12

Vane Shear Strength (kPa) Vane: 1710

50 100 150 200 250

214+, 214+, 214+, UTP, UTP, UTP, UTP

Water

Groundwater Not Encountered

Photo

Remarks

End of hole at 2.1 meters target depth not achieved. borehole kept squeezing closed.

Shear Vanes
- Peak
- Remoulded

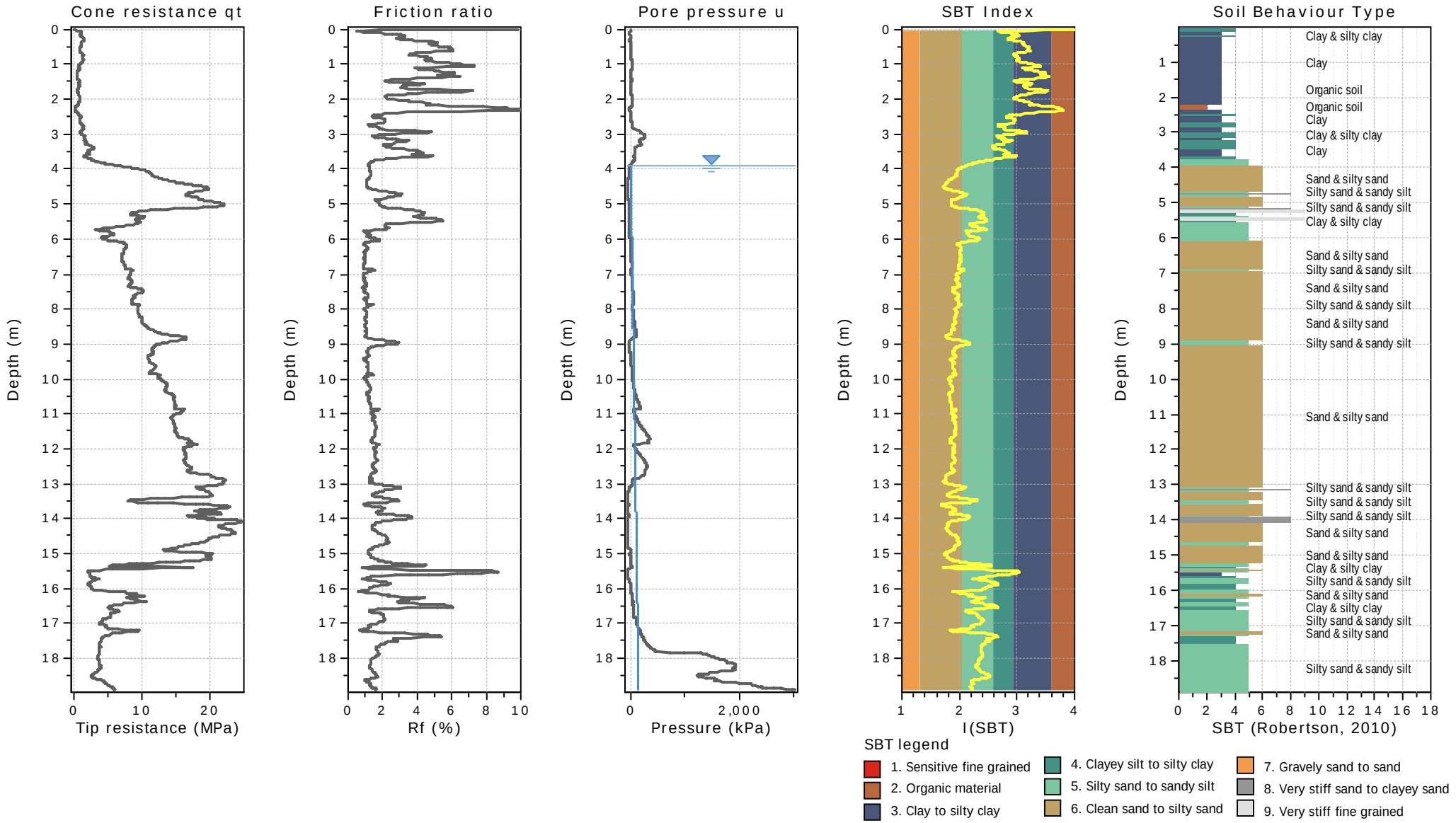
Water
- Standing Water Level
- Out flow
- In flow

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

HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

CPT: CPT01
Total depth: 18.89 m, Date: 23/08/2022
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

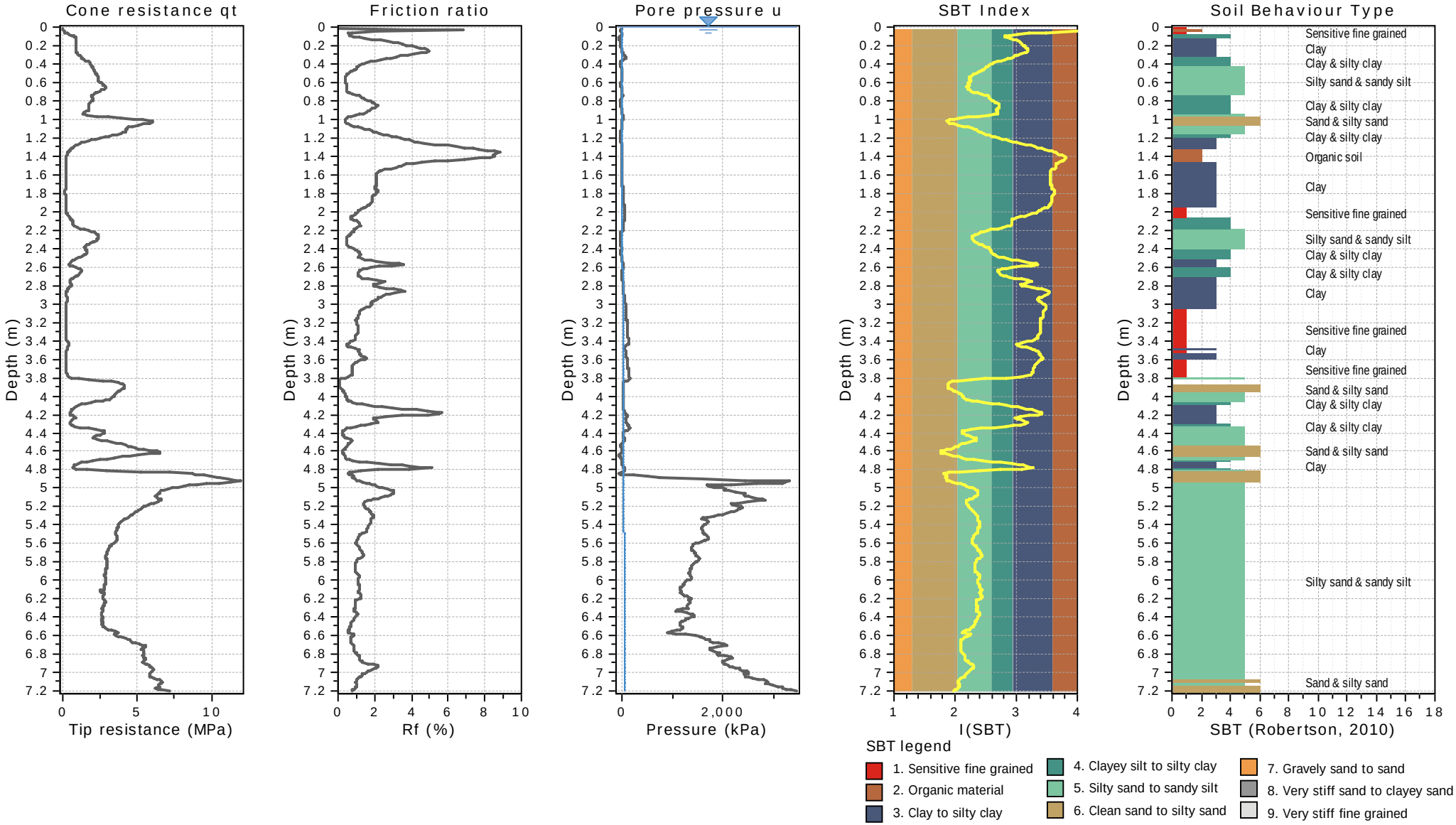
Project:
Location:



HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

CPT: CPT02
Total depth: 7.20 m, Date: 23/08/2022
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

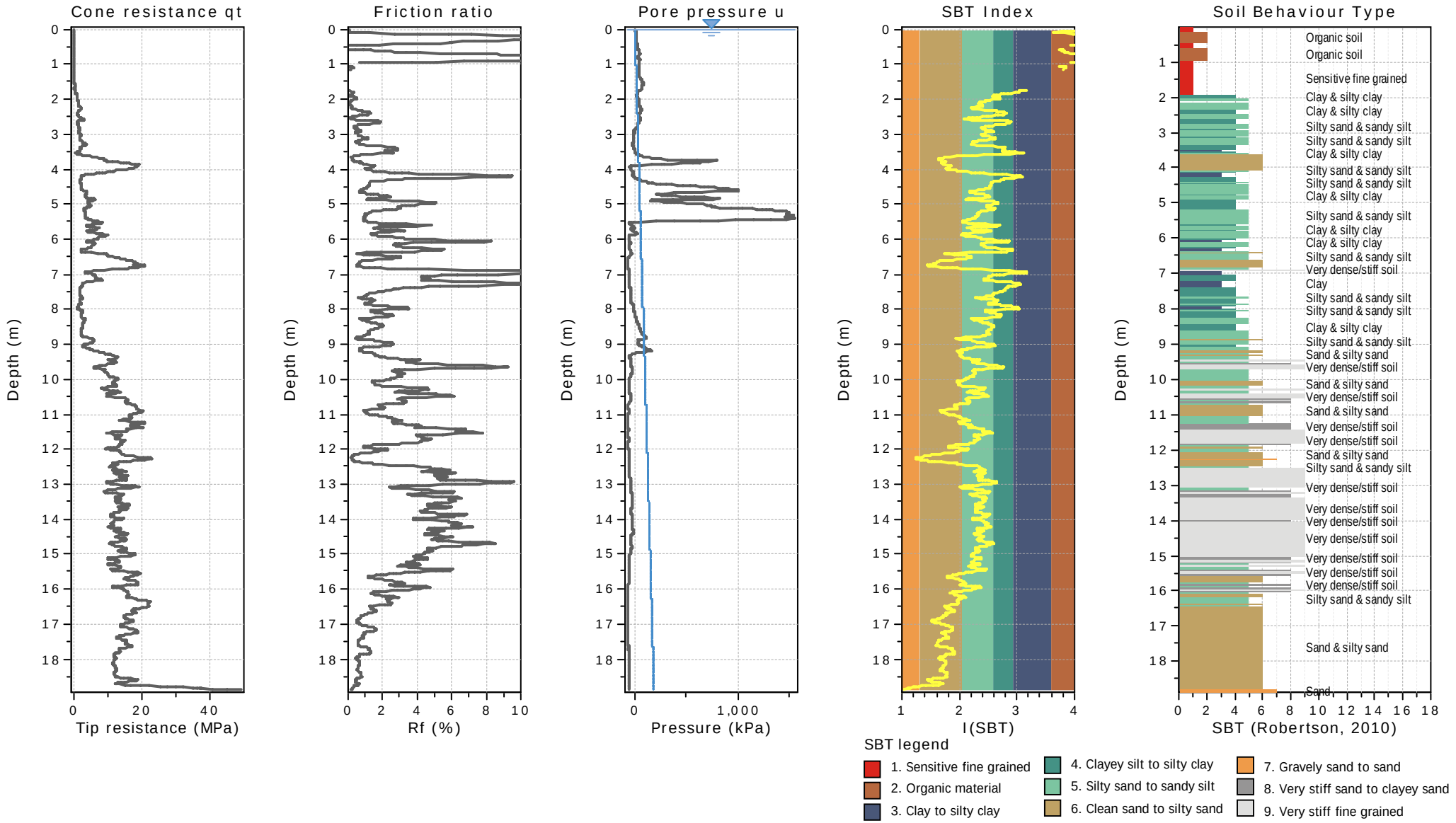
Project:
Location:



HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

CPT: CPT03
Total depth: 18.87 m, Date: 23/08/2022
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

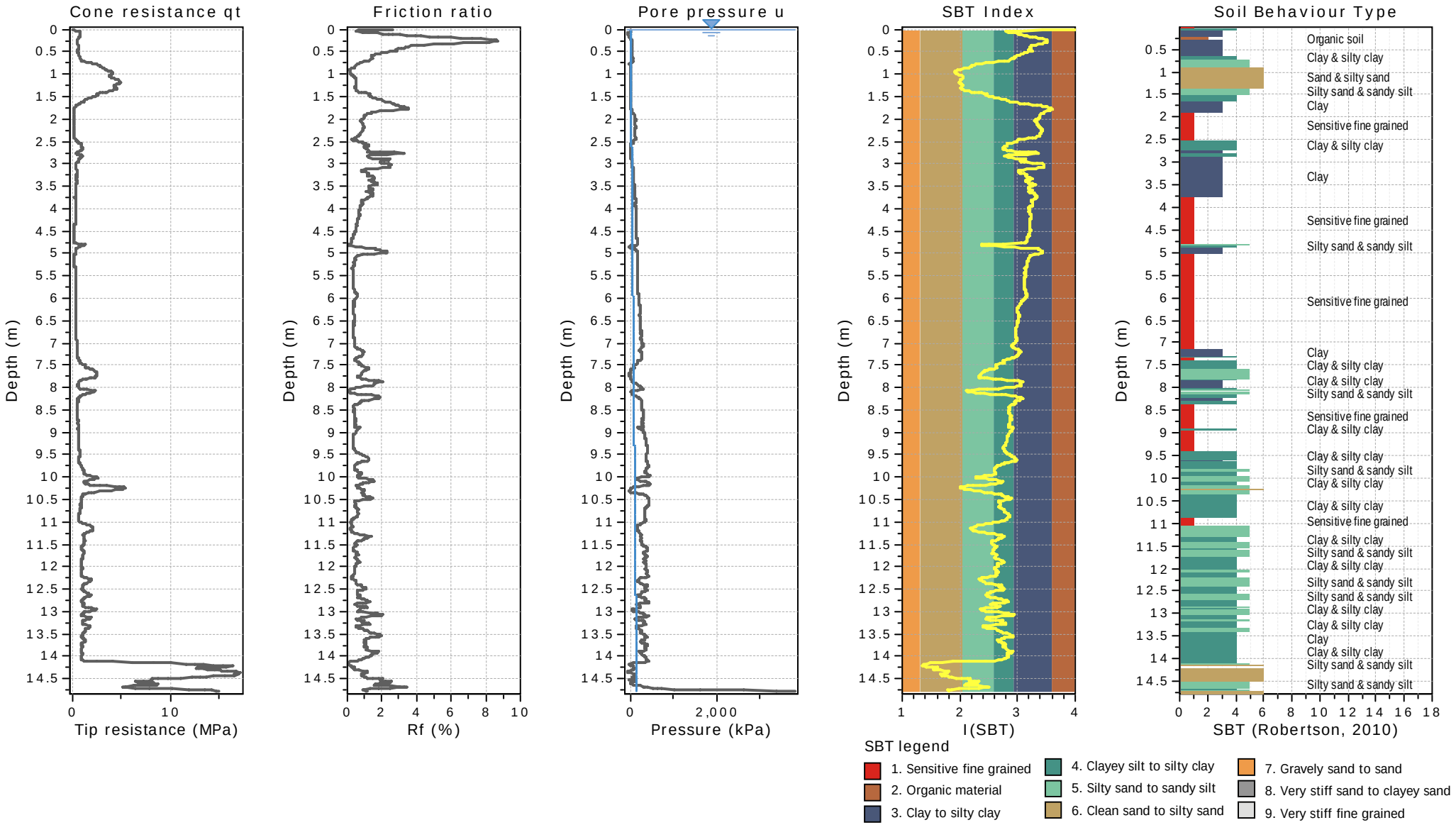
Project:
Location:



HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

CPT: CPT04
Total depth: 14.78 m, Date: 23/08/2022
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:



APPENDIX C – LIQUEFACTION OUTPUTS

HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

LIQUEFACTION ANALYSIS REPORT

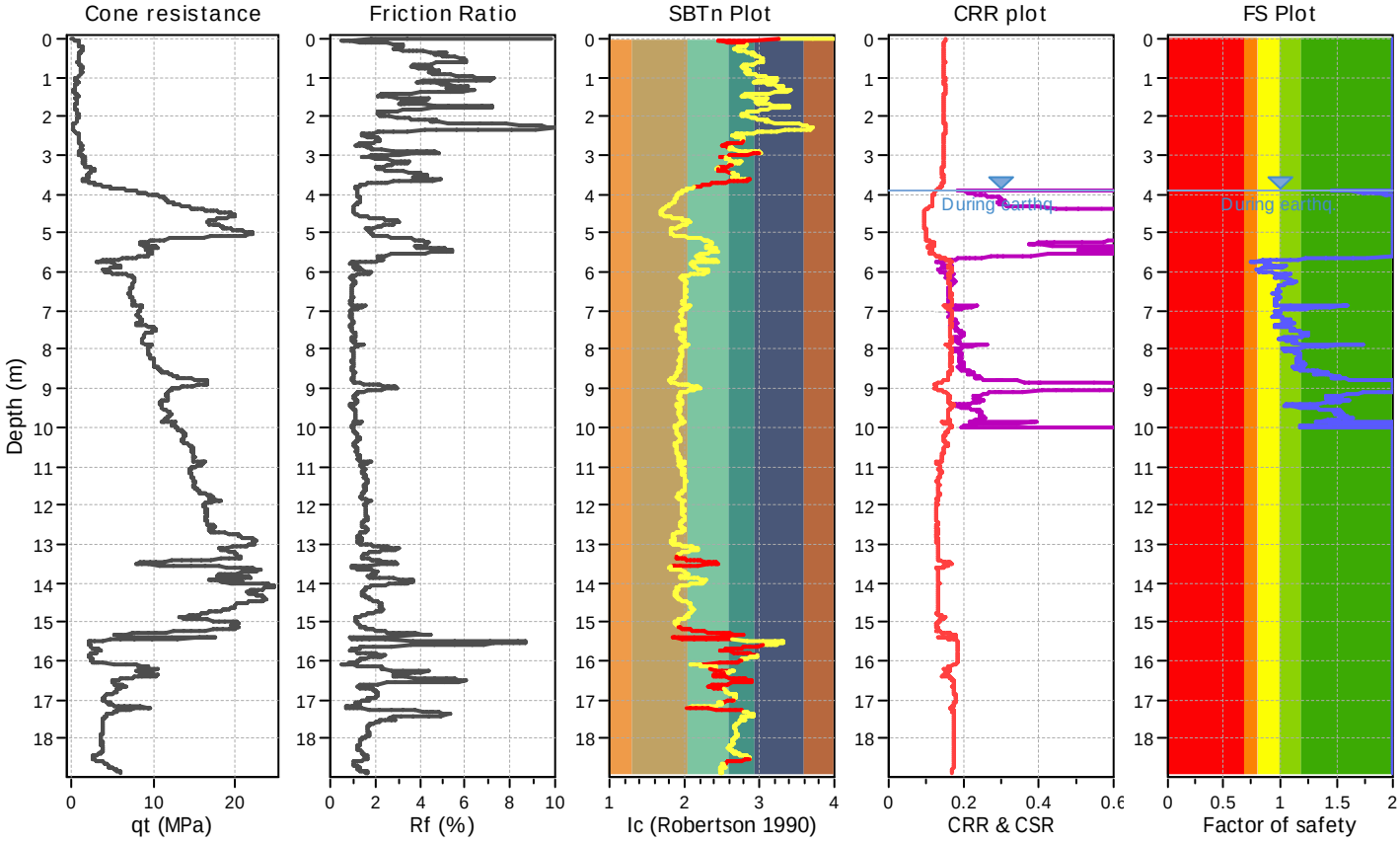
Project title :

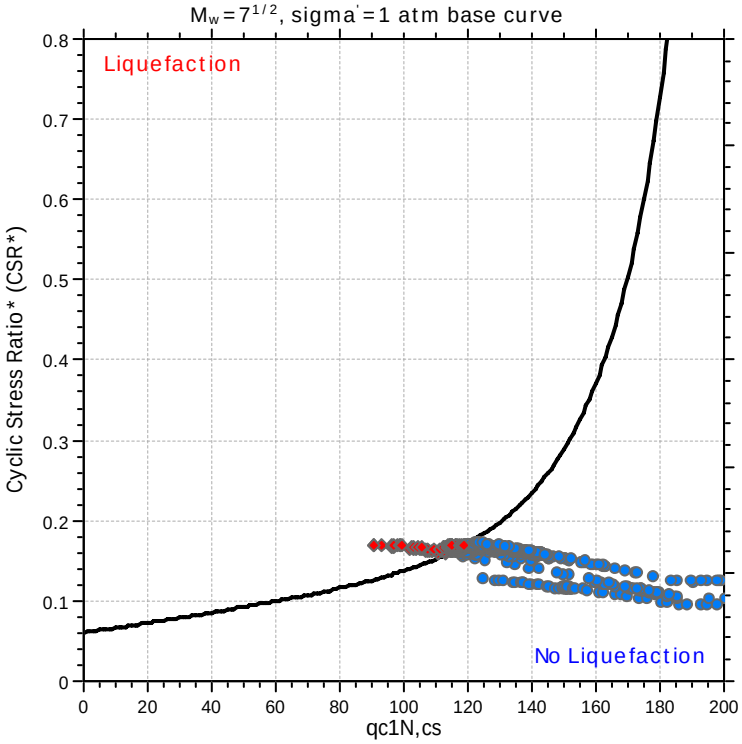
Location :

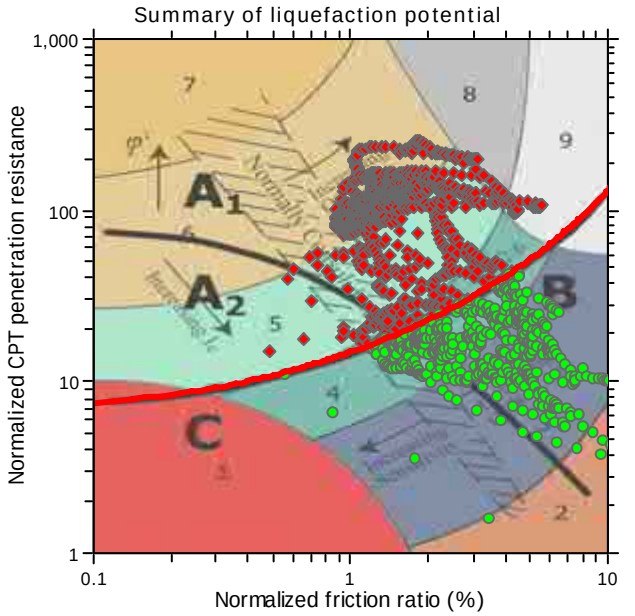
CPT file : CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.90 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.90 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

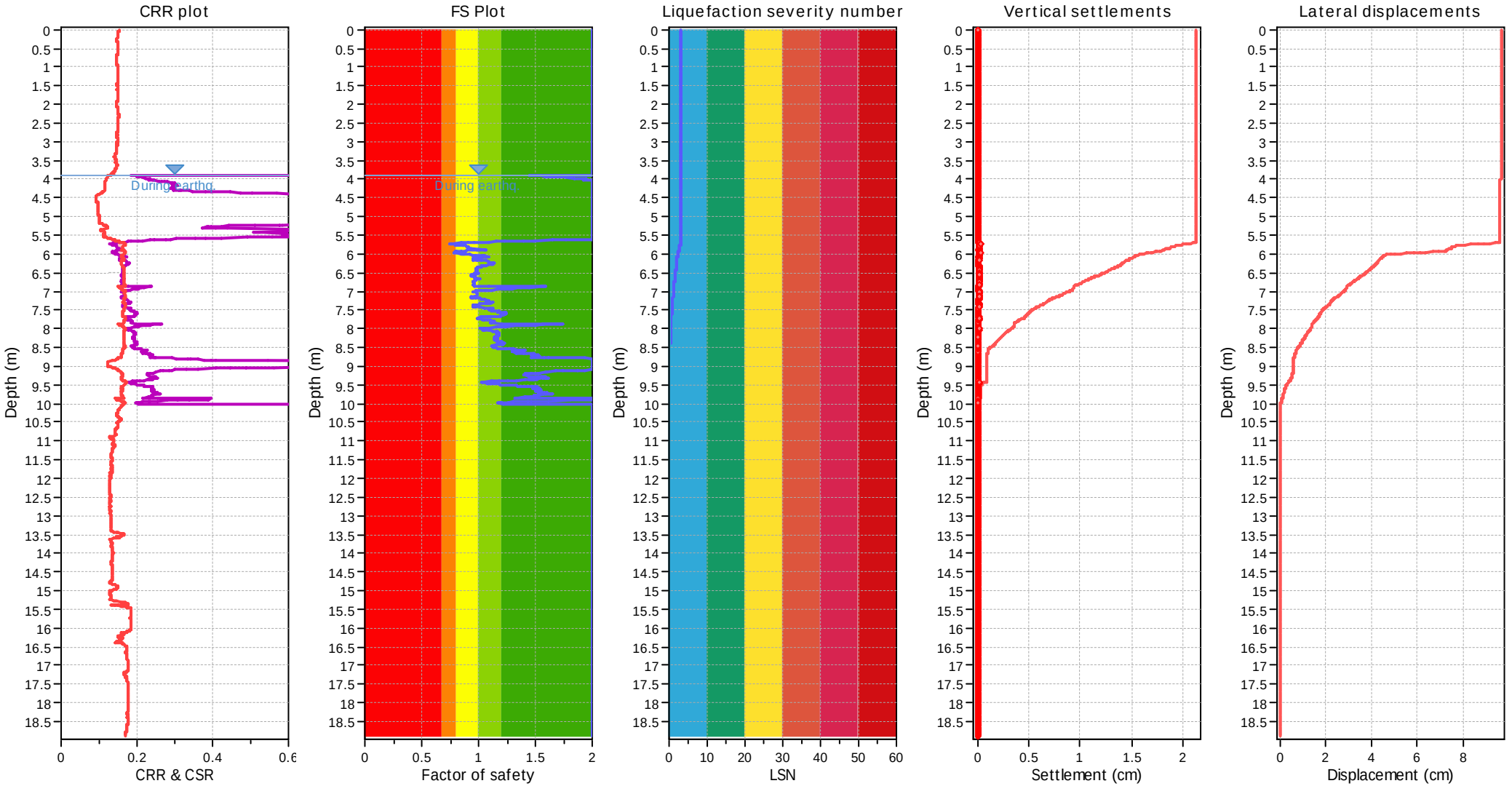






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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.):	3.90 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:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.90 m	Fill height:	N/A	Limit depth:	10.00 m

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
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

LIQUEFACTION ANALYSIS REPORT

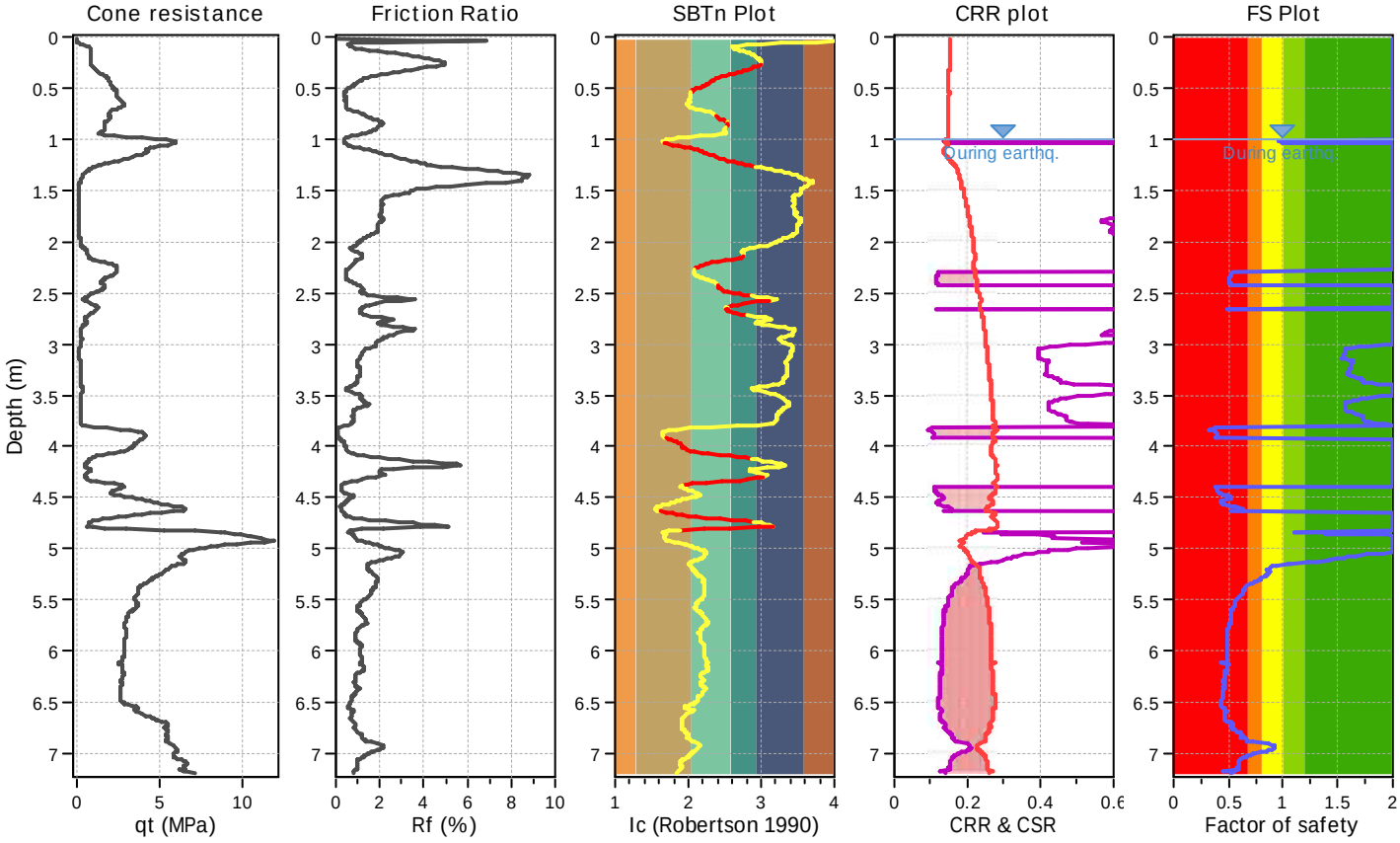
Project title :

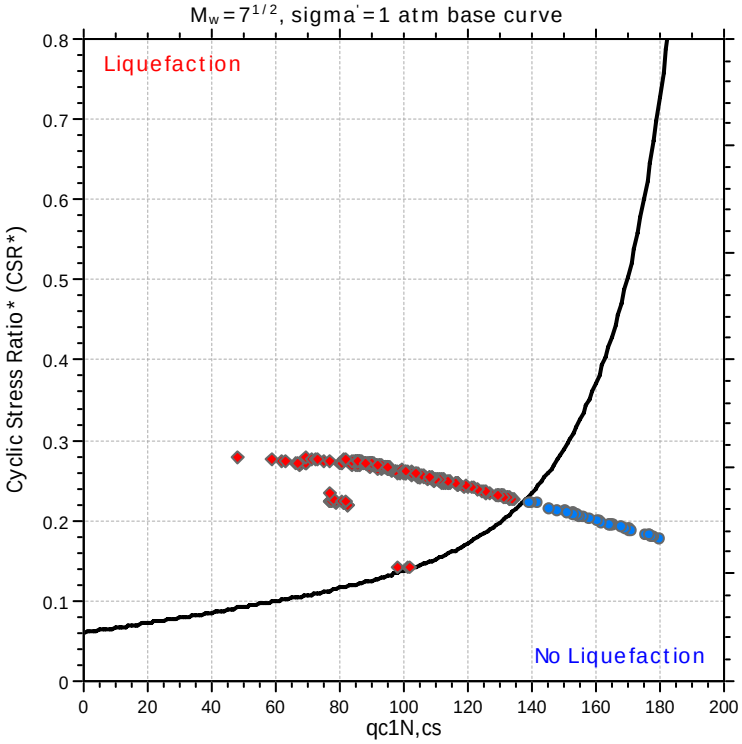
Location :

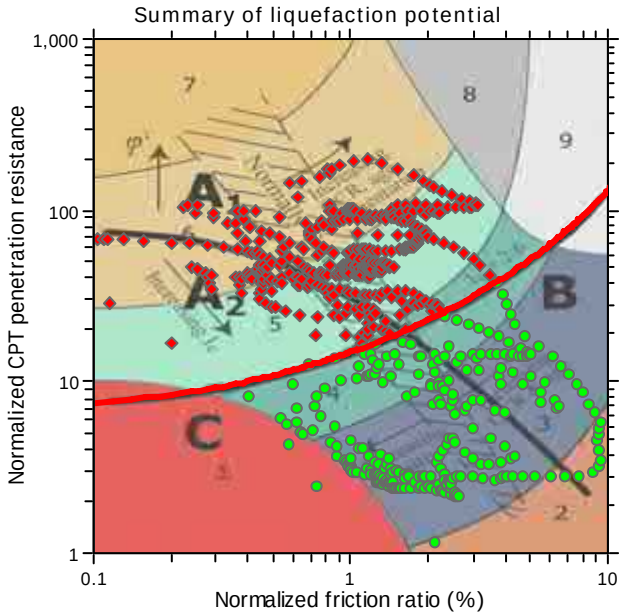
CPT file : CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 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:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

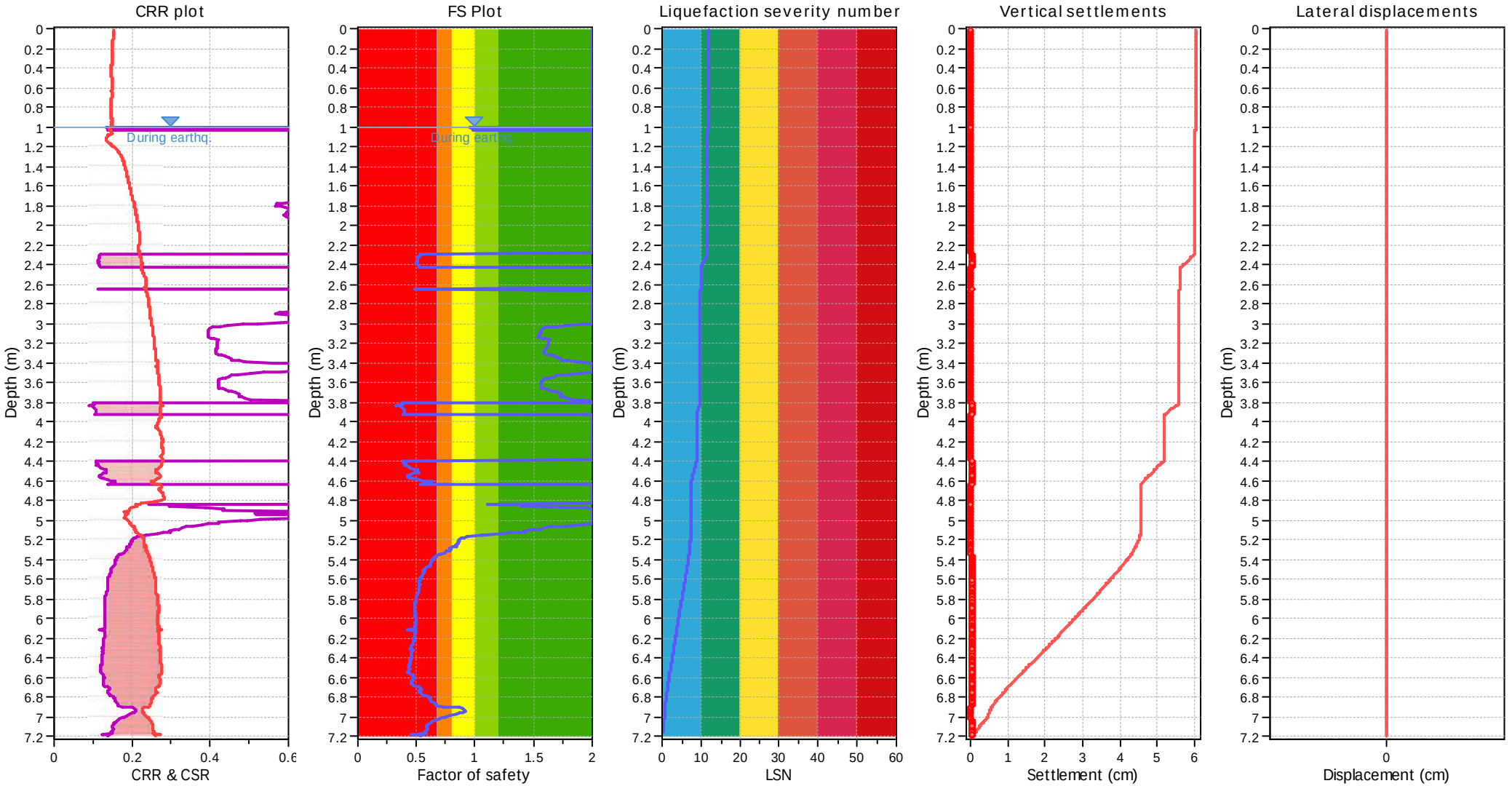






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	10.00 m

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
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

LIQUEFACTION ANALYSIS REPORT

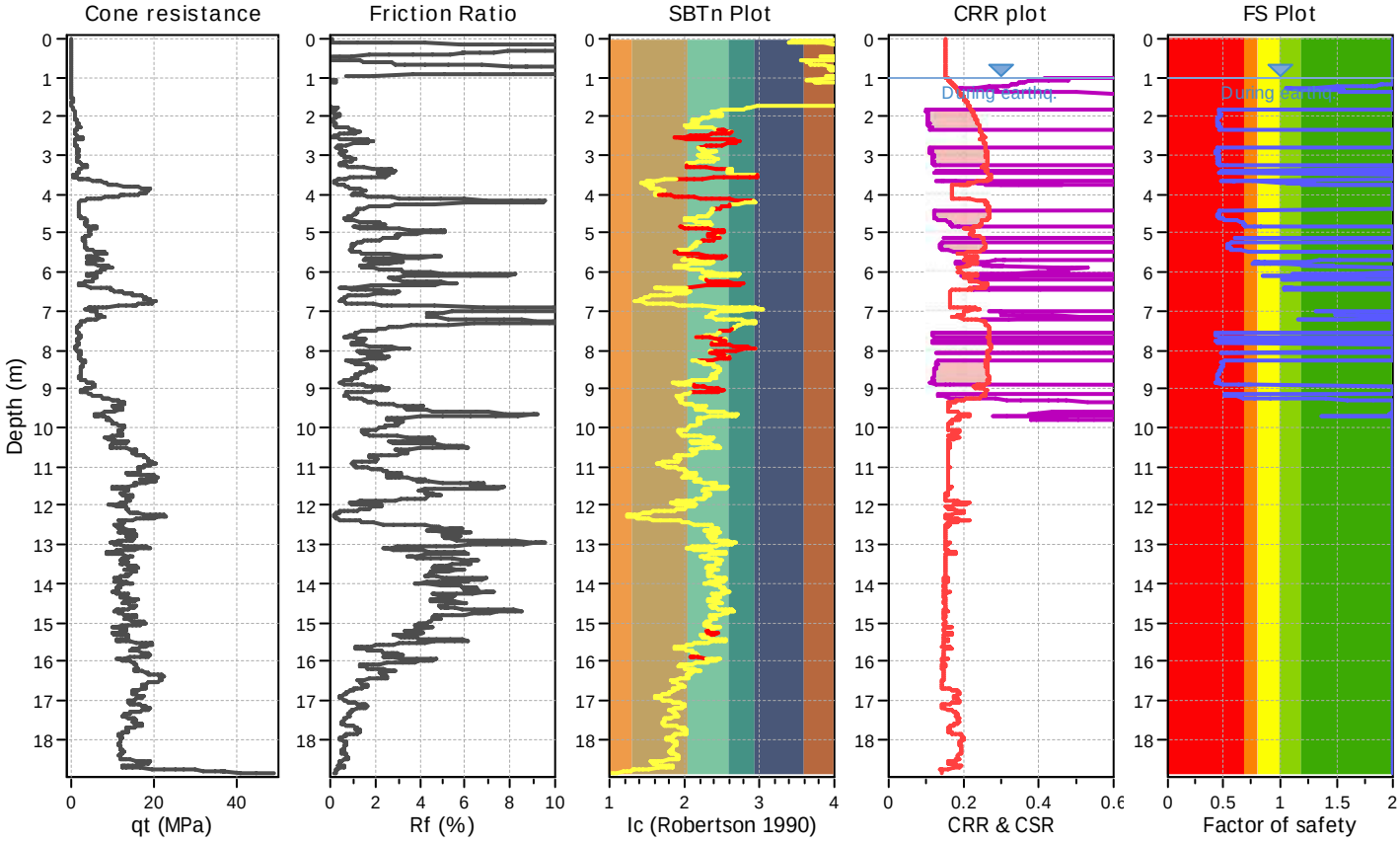
Project title :

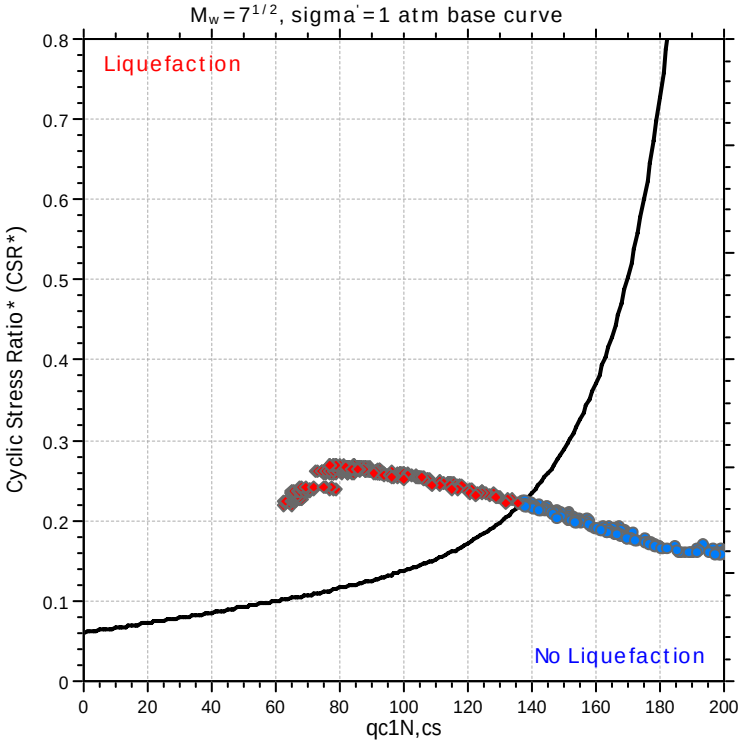
Location :

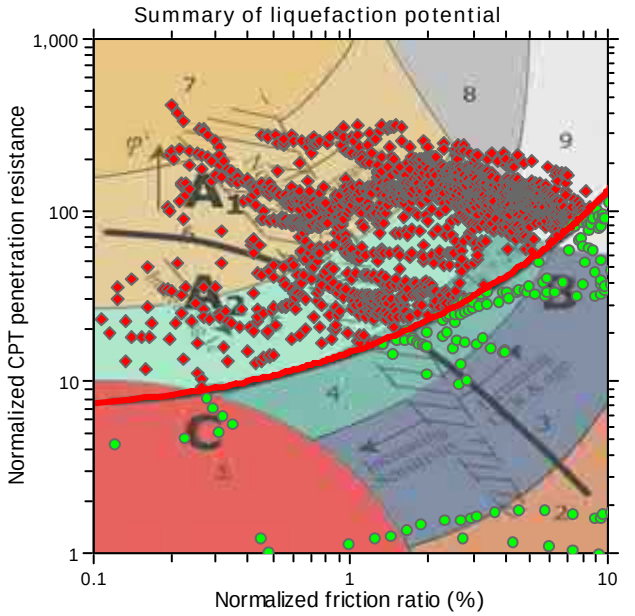
CPT file : CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 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:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

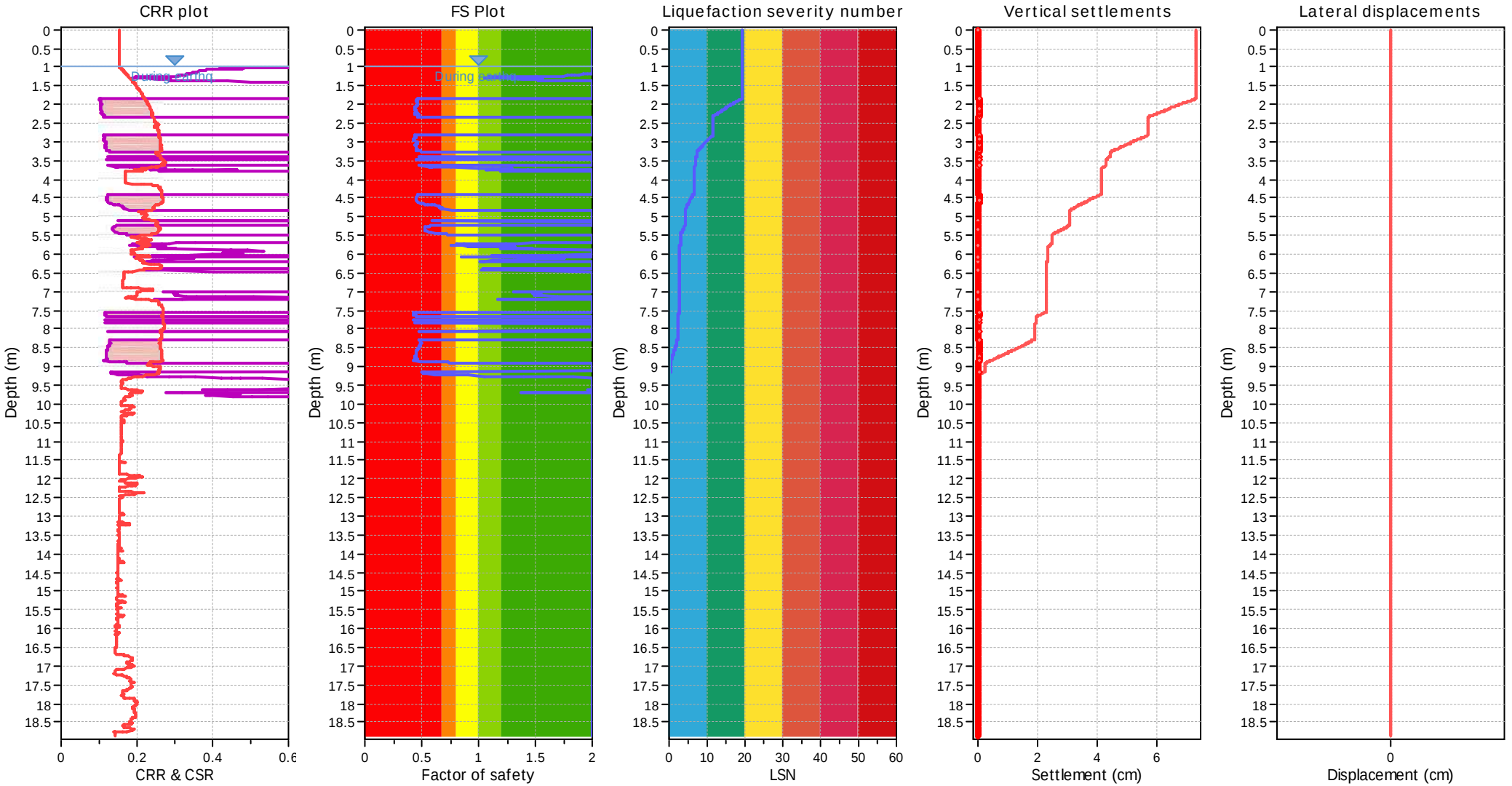






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	10.00 m

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
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

LIQUEFACTION ANALYSIS REPORT

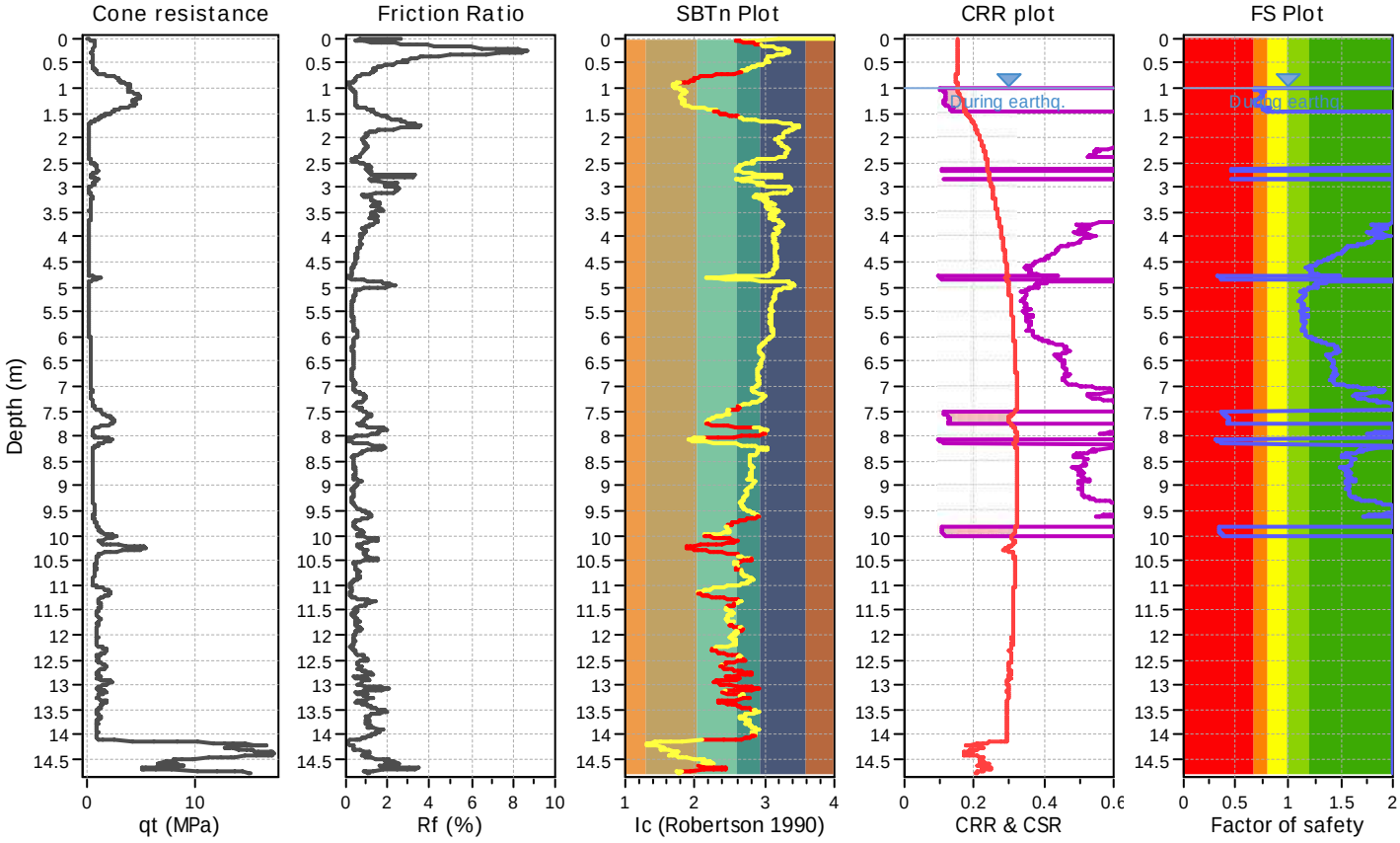
Project title :

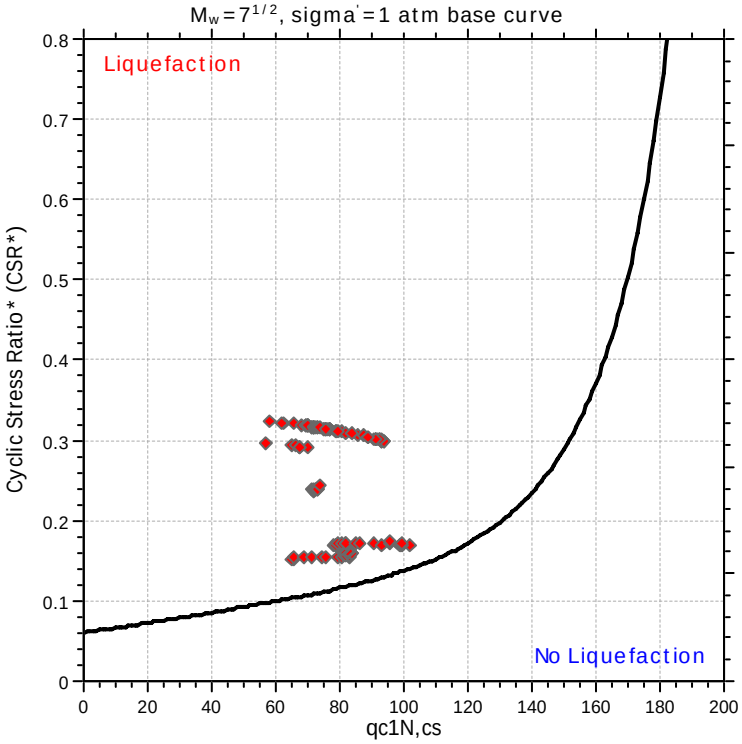
Location :

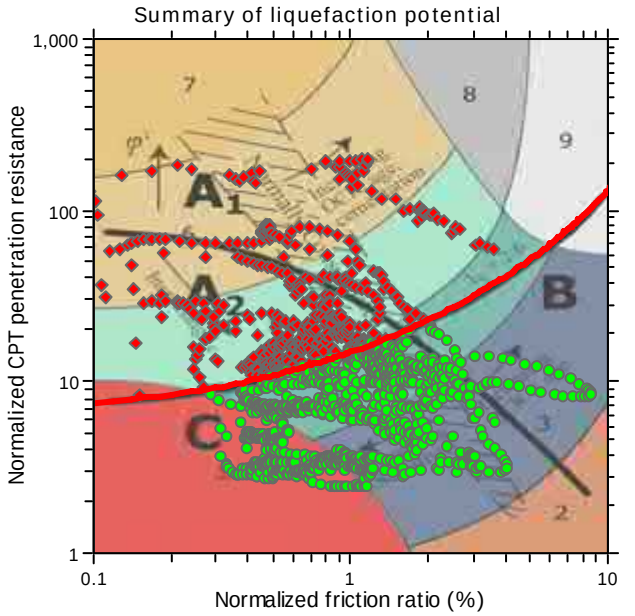
CPT file : CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 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:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

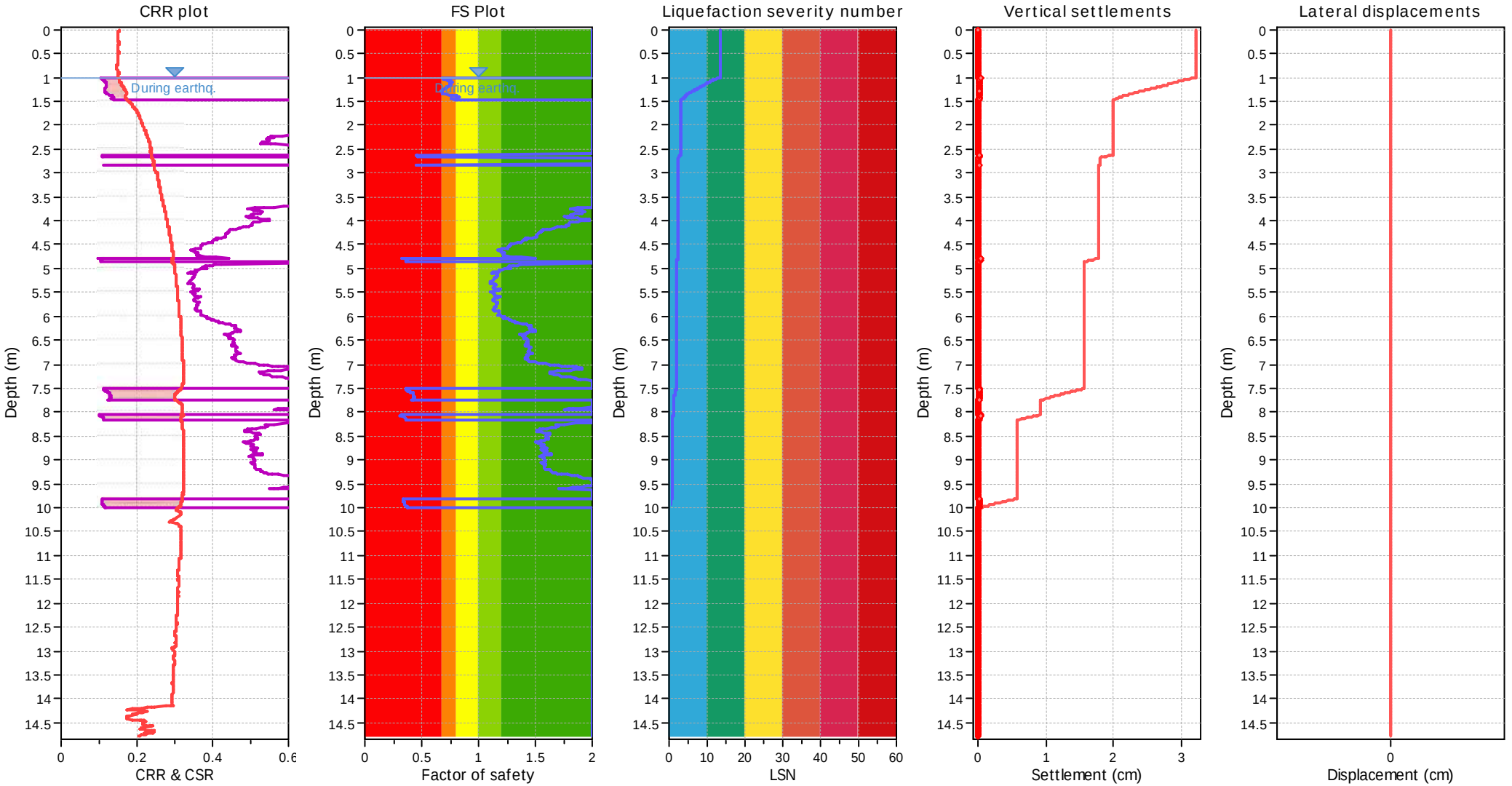






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and 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:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	10.00 m

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

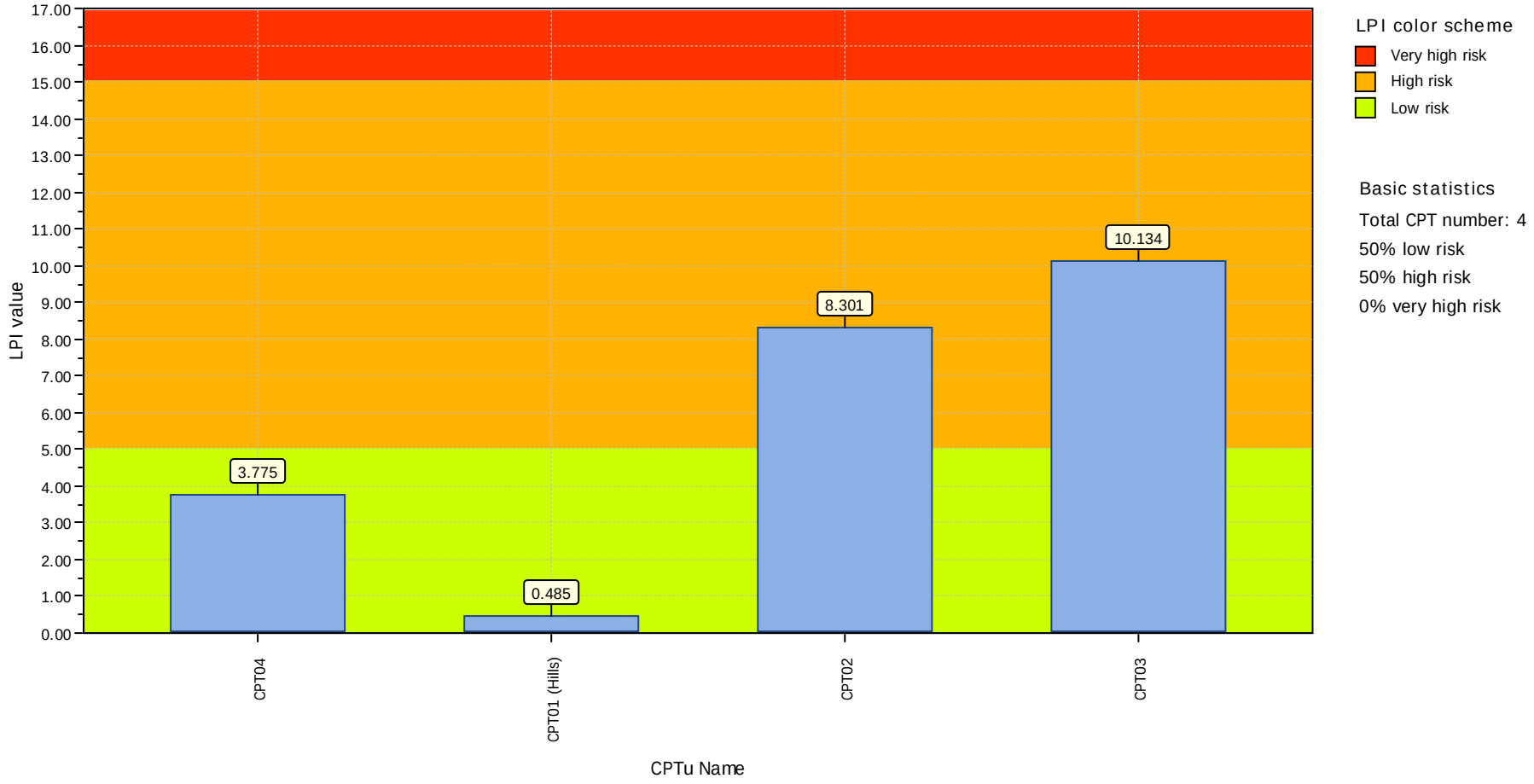
- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

Project title :

Location :

Overall Liquefaction Potential Index report

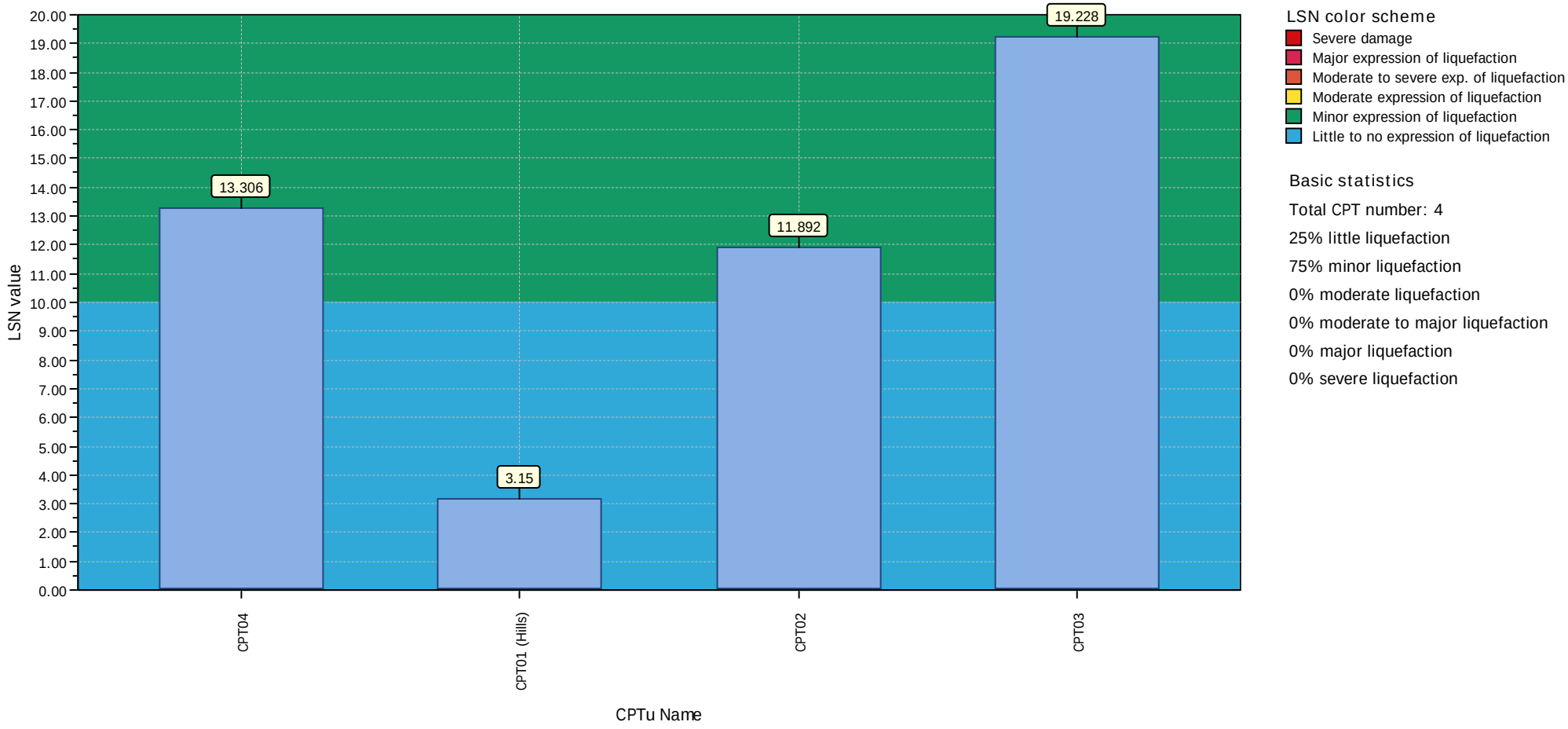


HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

Project title :

Location :

Overall Liquefaction Severity Number report



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

Basic statistics

Total CPT number: 4

25% little liquefaction

75% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

0% severe liquefaction

HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeo.co.nz

Project title :

Location :

Overall vertical settlements report