6 March 2025

PROPOSED STRUCTURE PLAN & PRIVATE PLAN CHANGE,

KARAKA ROAD, DRURY WEST

PRELIMINARY GEOTECHNICAL ASSESSMENT REPORT

Fisher & Paykel Healthcare Properties Limited

AKL2022-0214AB Rev 5

AKL2022-0214AB		
Date	**Revision**	**Comments**
20 February 2023	A	Initial draft for internal review.
24 February 2023	0	Final issue to client.
2 October 2023	1	Issued to support Plan Change Application
23 May 2024	2	Minor changes at Client's request
3 February 2025	3	Additional aerial photos & update to Geohazard Assessment Summary for Clause 23 Request
19 February 2025	4	Minor changes at Client's request
6 March 2025	5	Minor changes at Client's request

	Name	Signature	Position
Prepared by	Melissa Campbell		Senior Engineering Geologist
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APPENDICES

1 INTRODUCTION

1.1 Project Brief

Fisher & Paykel Healthcare Properties Limited (FPH) is proposing a Structure Plan (Structure Plan) and Private Plan Change (Plan Change) for land zoned Future Urban and Rural – Mixed Rural, located at 300, 328, 350, 370, & 458 Karaka Road, Drury (the Site). The land is bound by State Highway 22 to the north, Oira Creek to the west and the railway network of the North Island Main Trunk (NIMT) Line to the south.

This Structure Plan is proposed in replacement of the Drury-Opāheke Structure Plan for this part of Drury West and the Plan Change will involve rezoning the land that is currently zoned Future Urban to Business – Light Industry. The Rural-Mixed Rural zoned land in the west of the Site is included in the Structure Plan but is not proposed to be rezoned as part of the Plan Change.

The purpose of the Structure Plan and Plan Change is to facilitate the future development of a research & development and manufacturing campus to support the growth and expansion of Fisher & Paykel Healthcare.

CMW Geosciences (CMW) was engaged by Fisher & Paykel Healthcare Properties Limited (FPH) to carry out preliminary geotechnical reporting for the land described above. CMW has previously undertaken investigation and reporting on a large central portion of the subject site; this has been reviewed and incorporated into this report.

This report is to provide geotechnical input into the Structure Plan and Plan Change application.

1.2 Scope of Work

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKL2022-0214AA, Rev 0 dated 17 November 2022. The scope of work is defined as follows:

- Desktop analysis of the Site, including review of available existing reports, historic aerial photographs and published geology.
- Site walkover and geomorphology mapping.
- Provision of plans showing anticipated geology, geomorphology, and geotechnical hazard/constraint zones.
- Preliminary liquefaction assessment based on Cone Penetrometer Test (CPT) data. (CPT data from our previous investigation and reporting was used for this assessment).
- A Geotechnical Assessment Report summarising the above, including any areas of historic filling identified and discussion on potential constraints to future urban development. This report was provided initially for input to the draft Structure Plan and has been updated for the final Structure Plan and Plan Change application.

2 SITE LOCATION AND LANDFORM

- The Site comprises an area of approximately 105 hectares (of which approximately 88 hectares is the Plan Change portion of the Site) and is located immediately south of State Highway 22 (Karaka Road) and north of the North Island Main Trunk Railway Line, as shown in ***Figure 1***.
- The current general landform is presented on the attached Site Investigation Plan (***Appendix A***) and in ***Figure 2***.
- The subject area comprises 9 parcels of land, legally described as Lot 7 DP 14876, Pt Lot 5 DP 14876, Pt Lot 6 DP 14876, Pt Lot 3 DP 14876, Lot 4 DP 14876, Pt Lot 6 DP 14876, Lot 1 DP 205837, Lot 2 DP 523765 and Lot 1 DP 523765. These properties are identified as 300, 328, 350, 370 & 458 Karaka Road, Drury.
- Current land use is predominantly pasture, with a scattering of trees and shelter belts. Two large glasshouses occupy Lot 2 DP 523765 (328 Karaka Road), lying parallel with the railway line in the south-central portion of the Site. Four long sheds, previously accommodating a chicken farm, are in the elevated centre of the Site. A packhouse and associated parking areas occupy Lot 1 DP 523765 (300 Karaka Road) in the north-eastern corner.
- Stand-alone rural-residential dwellings and assorted farm buildings are present across the subject area. Due to the historical farming land use, rubbish fills, offal pits and uncontrolled fills may exist.
- The landform typically comprises very gently to gently sloping farmland, falling from the east towards the west. There are several natural drainage depressions comprising defined, tree-lined gullies as well as relatively shallow basins, some of which have been modified with the formation of farm ponds. In the western portion, the land falls gently to the stream (Oira Creek) which flows northwards along the boundary.
- Under the Auckland Council Unitary Plan, the land is currently zoned Future Urban, with the exception of the south-western corner, zoned Rural – Mixed Rural.

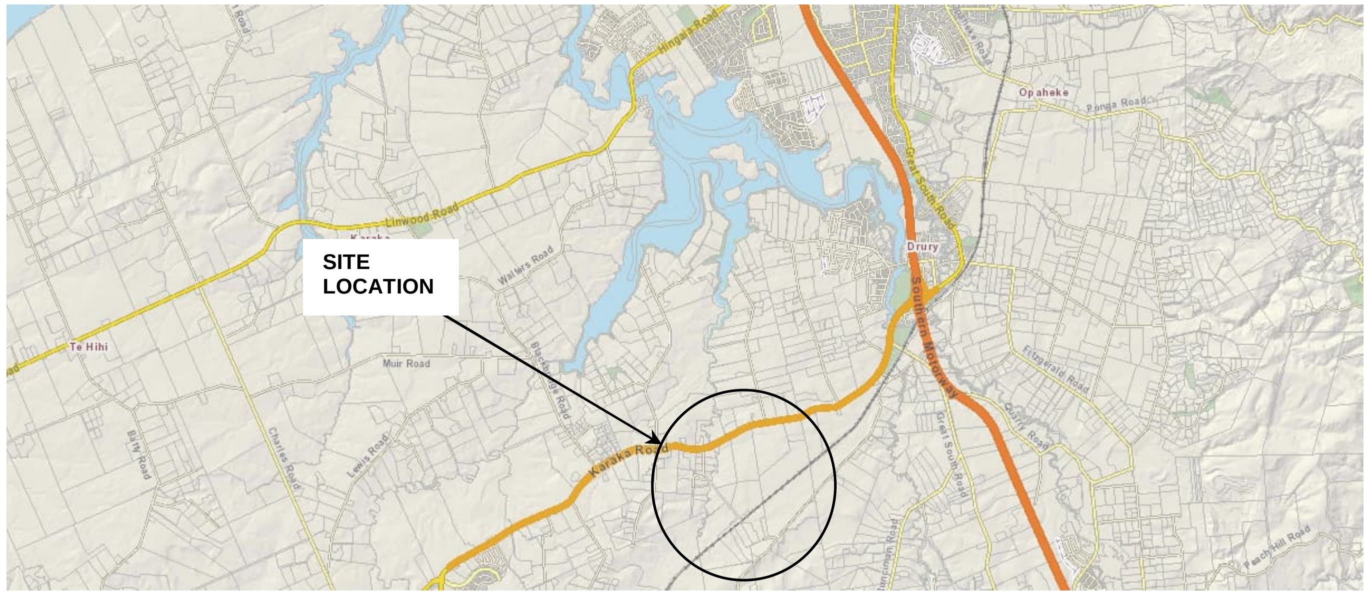


Figure 1: Site Location (Auckland Council GeoMaps)

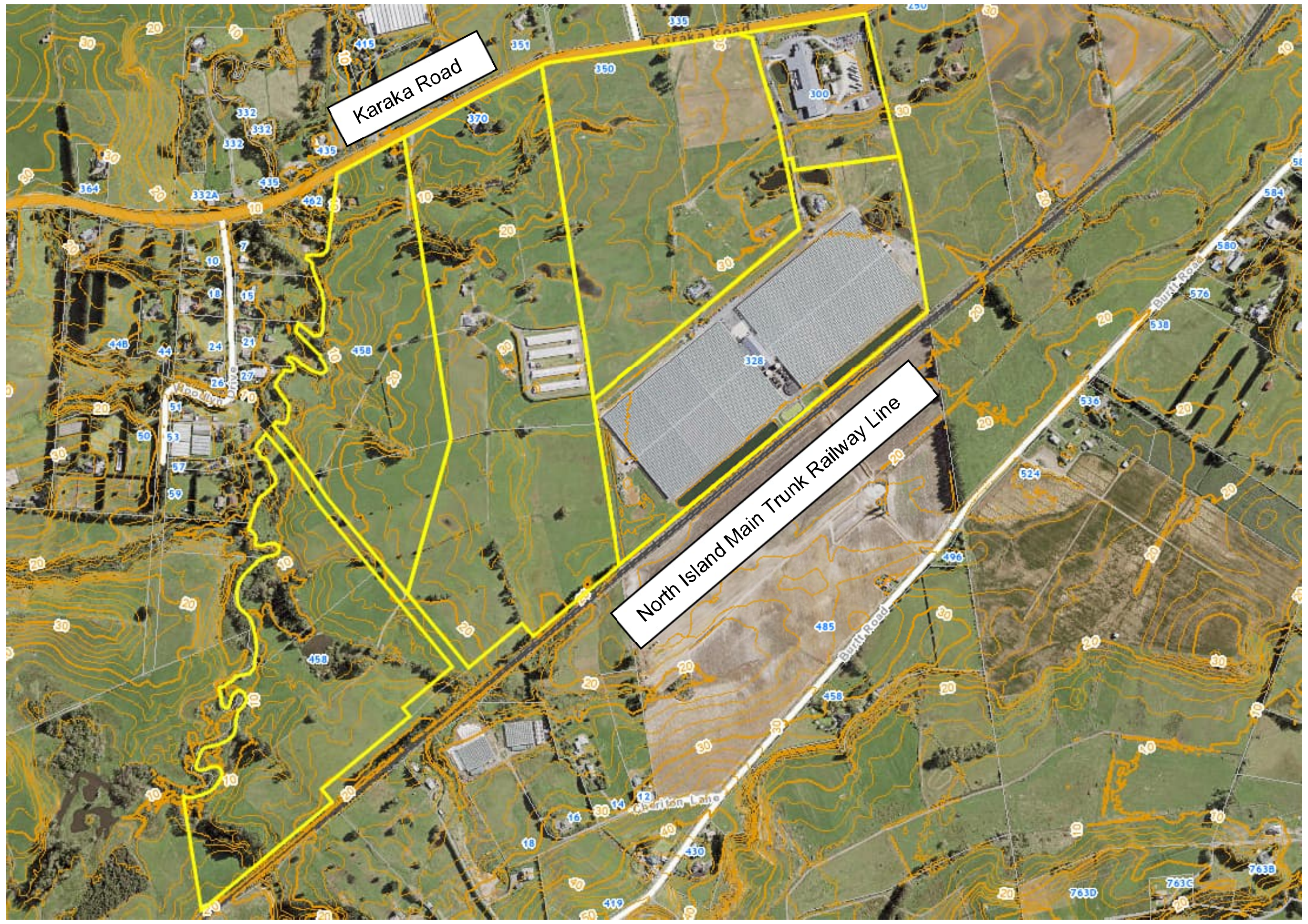


Figure 2: Landform (Auckland Council GeoMaps)

3 RELATED REPORTS REVIEWED

- CMW Geosciences Geotechnical Assessment Report, 350 & 370 Karaka Road, Drury, Ref AKS2022-0029AB Rev.0, 13 July 2022. (at ***Appendix B***).
- Geotek Services Ltd Geotechnical Investigation Report, 328 Karaka Road, Drury, Ref 948, 29 June 1999.

4 PROPOSED DEVELOPMENT

At this stage no concept plans are available, however it is our understanding that the Site is intended to be developed by the client for light industrial use. The Site will be zoned to enable business development.

Given that there are currently no earthworks proposals, we have made the following broad-brush assumptions (not be construed as limitations) so that we can provide commentary around the geotechnical suitability (or not) of the land in terms of land modification:

- Bulk earthworks comprising cuts and fills not exceeding 2m depth and;
- Future site development for commercial and medium-industrial buildings with Uniformly Distributed Floor Loadings of up to 30 kPa.

5 HISTORIC AERIAL PHOTOGRAPHS

Review of the earliest available aerial photographs shows the following:

- The Site was undeveloped in ***May 1942*** (Figure 3), with only minor dwellings and small farm buildings visible. The south-central portion of the Site where the large greenhouses now stand can be seen as low-lying and largely featureless. The central, more elevated areas are likely to be ancient erosional terrace features compared with the more recent gully erosion, evident as more sharply defined features, particularly in the west of the Site.
- By ***November 1961*** (Figure 4), trees and shelterbelts were more frequent across the Site, but little further development was observed.
- ***July 1981*** – several ponds (highlighted in red in Figure 5) have been formed from existing watercourses.
- ***March 1988*** – two of the four chicken farm sheds have been constructed (highlighted in red in Figure 6). Four sheds are visible by 1996 (Figure 7).
- ***2001*** – The large greenhouses and packing shed have been constructed, each with adjacent ponds. What appears to be topsoil stockpiles are immediately north of the glasshouses, together with two dwellings (or similar sized buildings). (Figure 8).
- ***2006*** – the pond to the north of the glasshouses has been extended to the east of the accessway, presumably by a culvert. (Figure 9).
- ***2017*** - further ponded water is visible in the centre of the site. (Figures 10 & 11). The northern of these two features appears to be artificially formed in what was previously a dry gully feature, whilst the southern has poorly defined edges with a fenceline crossing it, suggesting it is a temporary feature.

Figure 3: 1942 Aerial Photo (Retrolens)

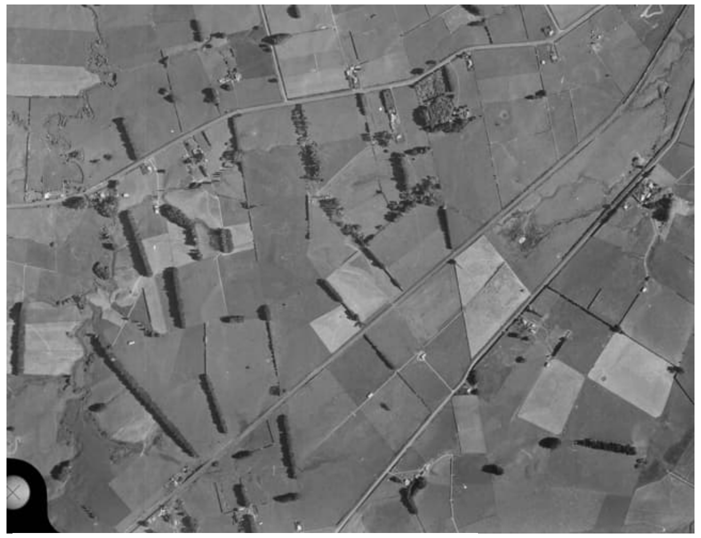


Figure 4: 1961 Aerial Photo (Retrolens)

Figure 5: 1981 Aerial Photo (Retrolens)

Figure 6: 1988 Aerial Photo (Retrolens)

Figure 7: 1996 Aerial Photo (AC GeoMaps)

Figure 8: 2001 Aerial Photo (AC GeoMaps)

Figure 9: 2006 Aerial Photo (AC GeoMaps)

Figure 10: 2017 Aerial Photo (AC GeoMaps)

Figure 11: 2017 Aerial Photo (AC GeoMaps)

6 GROUND MODEL

6.1 Geomorphology

- The geomorphology of the Site was mapped by examination of aerial photography and during a site walkover and is shown in the ***Geology & Geomorphology Plan*** in ***Appendix A*** and in ***Figure 12***.
- The geomorphology reflects the underlying geology and associated slope processes. The elevated areas are likely to be ancient erosional terrace features compared with the more recent gully erosion, evident as more sharply defined features.
- Benching / terrace features are discernible in places, corresponding to some extent with the heads of minor watercourses. This may indicate the contact between the overlying ash deposits and Puketoka Formation beneath.
- In the vicinity of creek at western boundary and the larger tributary in the north of the Site, slope instability features are present, such as minor scarps and debris mounds. Those observed during our walkover are presented on the ***Geomorphology Plan***, however it should be noted that not every feature present is recorded, particularly small-scale landslips in gully flanks.
- Land modification has occurred in several locations across the Site: in particular in areas underlying and adjacent to the large greenhouses, the chicken sheds, and the packhouse. Additionally, there are areas around the gullies where the man-made ponds have been formed which could contain disturbed ground.

6.2 Ground Investigation

- No further investigation has been carried out however the fieldwork previously conducted within the Site by CMW was reviewed and incorporated into this report. The entire Site is mapped as the same geological unit and our desktop study did not identify any significant features which warrant specific investigation at this stage of the project. Further specific investigation and design should be undertaken at the detailed design stage.
- This comprised the drilling of ten hand auger boreholes and four Cone Penetrometer (CPT) Tests. The investigation was carried out between 31 March and 14 April 2022.
- The investigation locations are shown on the Site Investigation Plan in ***Appendix A***. Borehole and CPT logs are contained in the previous report in ***Appendix B***.

6.3 Published Geology

- An overlay from published geological maps for the area, presented in ***Figure 11***, depicts the regional geology as comprising Late Pliocene to Middle Pleistocene pumiceous alluvial deposits of the Puketoka Formation (Pup). These deposits are described as undifferentiated deposits of clays, silts and sands, with lenses of peaty or organic clays. Soils within this geology can be variable in strength and sensitive to disturbance, especially where pumiceous silts and sands are encountered.
- To the south of the Site are mapped volcanic deposits from the South Auckland Volcanic Field, consisting of lithic tuff, comprising comminuted pre-volcanic materials with basaltic fragments, and unconsolidated ash and lapilli deposits. The landform described above suggests these deposits may also exist within the Site.
- Based on the known history of the Site as farmland, some superficial depths of fill could be anticipated as a result of soft landscaping to create building platforms, farm tracks and ponds. Pockets of recent alluvial material can also be expected around gully features and other overland flow paths.
- The nearest active fault is the Drury Fault which is approximately 5km east of the Site.
- Geohazards associated with each geology were identified through the preliminary assessment presented in Section 7.

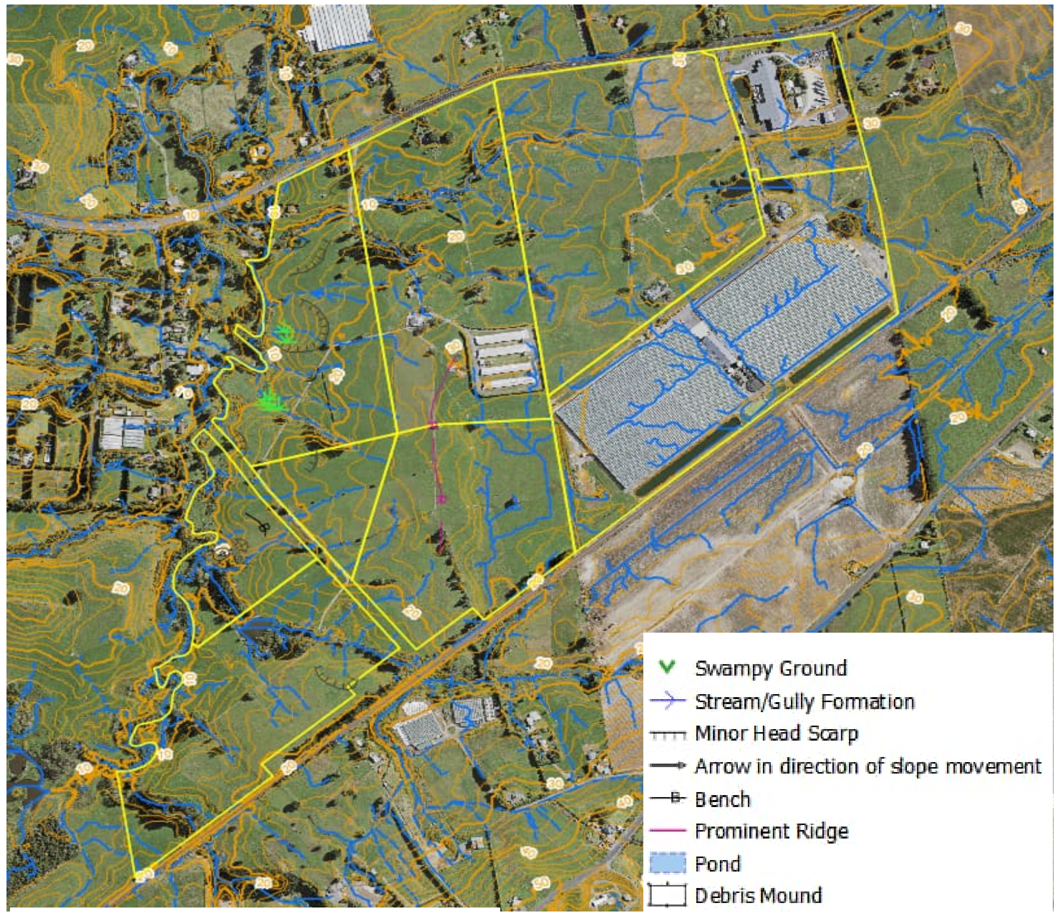


Figure 12: Geomorphology Plan

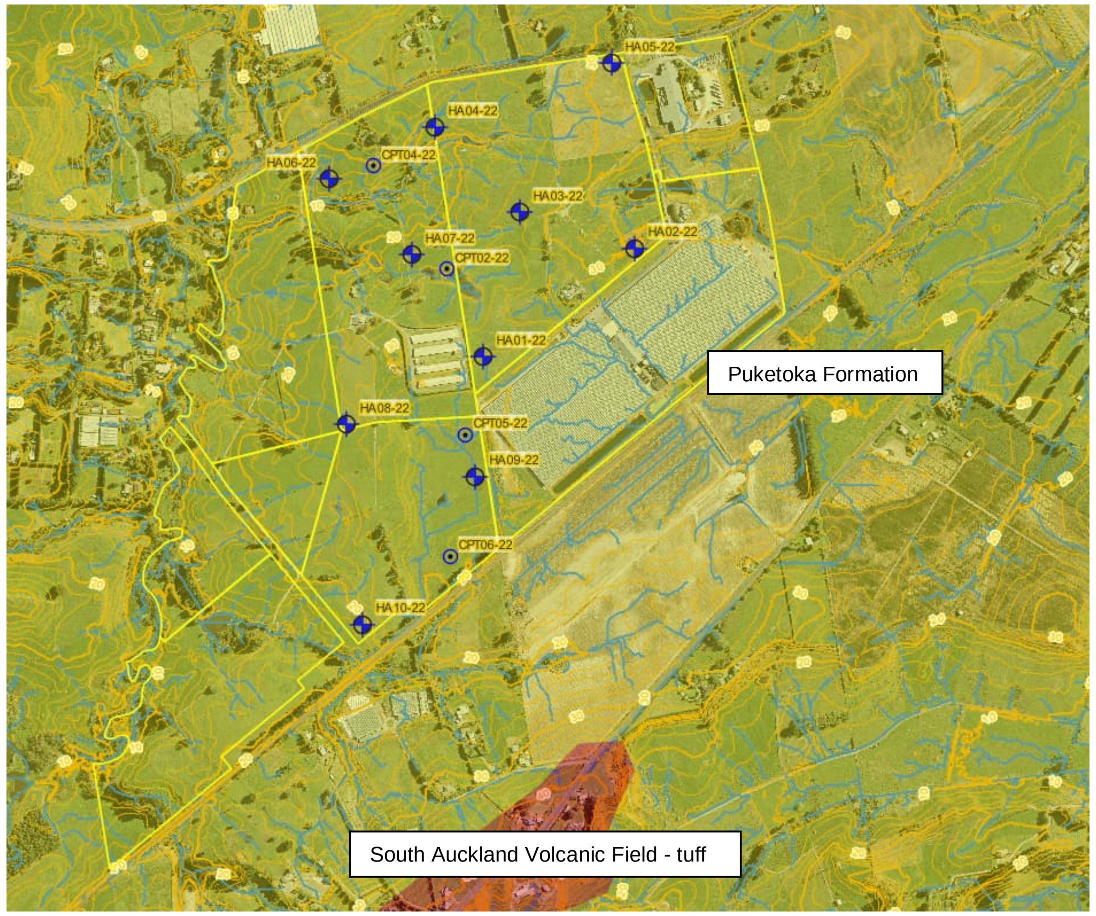


Figure 13: Geology Plan

Geological Unit	Location	Description	Behaviour
Topsoil	Encountered across the Site and in hand auger boreholes to depths of between 0.2 and 0.3 metres below ground level (mbgl). In HA02-22, topsoil was encountered to 0.9mbgl which we believe was in the location of the old topsoil stockpile identified in our historic aerial photograph review.	N/A	N/A
Fill	No evidence of fill was encountered in our hand auger boreholes. Fill was however noted in geotechnical reporting for the packhouse in the north-eastern corner of the Site. Based on our aerial photograph review, we expect several areas of fill deposits / disturbed ground: in and around the existing farm tracks, ponds and building platforms. Due to the historic farming use of the Site, there is potential for more widespread areas of uncertified / non-engineered fill.	N/A	Thorough site stripping and inspections will be required prior to the placement of any filling during earthworks construction, with any non-engineered filling identified and removed to the satisfaction of the supervising Geo-Professional. Depending on the quality and consistency of the material, it may be suitable for re-use as bulk filling.
Recent / Holocene Alluvial Material	Although not identified in our hand auger boreholes, we expect localised deposits of these materials in the gullies and ponds present across the Site. CPT02-22 was positioned in the middle of an old pond which was not holding water at the time of investigation. It is inferred that soft to firm soils extend up to 2.0m depth in this location.	Soft organics & alluvial sediments, typically wet to saturated. Mostly poorly compacted.	Susceptible to soil creep and shallow flows on gentle slopes, particularly when saturated. Will usually subside if unsupported or overloaded. ***Subsidence*** (load induced settlement) is the predominant geohazard in this geology. Where encountered, these unsuitable soils will need to be mucked out and subsoil drainage installed before any bulk filling is undertaken. If significant depths are encountered, ground improvement or piled foundations may be required to limit consolidation settlements to acceptable limits for future structures.
South Auckland Volcanic Field – tuff	Encountered in hand auger boreholes across the Site at depths ranging from 1.2mbgl to 3.0mbgl.	Competent surficial volcanic ash soil. Typically consisted of very stiff to hard, clayey silt and silty clay with peak undrained shear strengths measuring in excess of 134kPa.	Capable of soil creep and slumping on steeper slopes. ***Landslip*** can be expected in the vicinity of incised watercourses.
Puketoka Formation	Encountered in hand auger boreholes across the Site, underlying the volcanic soils, to at least the target depth of 5m. The four CPTs conducted refused on dense / hard materials at between 17 to 20m, indicating this unit extends to at least this depth. Where encountered, groundwater was within this unit – at approximately 5m depth in the central elevated portion of the Site, and between 1-3m in low-lying areas. In HA09-22 in the low-lying area in the south of the Site, peat was encountered to a depth of 1.0mbgl, overlying soft to firm organic clays to 3.2mbgl. It should be cautioned that elsewhere in this low-lying area the peat may be thicker/ extend deeper.	Typically comprises pumiceous sandstone, carbonaceous mudstone, and may contain peat. May interfinger with the tuff of the South Auckland Volcanic Field described above. Generally lower in strength and more variable in consistency compared with the overlying volcanics, these materials were still competent in general terms with no obvious evidence of weak and/or highly compressible materials. In hand auger boreholes, these materials were typically stiff to hard, inorganic silty clay and sandy silt with peak undrained shear strengths measuring in excess of 75kPa. Undrained shear strengths in the organic material in HA09-22 were recorded as low as 29kPa. The inferred material strengths in the CPT tests confirmed the Puketoka Formation soils are generally stiff to very stiff with no obvious layers of weak / compressible materials at depth.	Capable of soil creep and slumping on steeper slopes, particularly when saturated. ***Landslip*** can be expected in the vicinity of incised watercourses. ***Liquefaction*** is unlikely to be a hazard in this geology, despite its saturated state. Susceptibility analysis of a soil also considers its age and plasticity. Pliocene – Pleistocene aged materials have a very low to low risk of liquefaction and deposits in this area are frequently plastic. ***Subsidence (load induced settlement)*** can occur in these deposits where soft clays / peat deposits are encountered. Ground improvement or piled foundations may be required to limit consolidation settlements to acceptable limits for future structures.

7 GEOHAZARDS ASSESSMENT & MITIGATION

Two ***Geohazard Zones*** have been identified.

- **Zone 1** encompasses the more frequent instability features observed near the stream and watercourses in the western portion of the Site. We anticipate an esplanade reserve will be applied along the stream edge within this zone also. This zone will require specific investigation and assessment once development proposals area known.
- **Zone 2** encompasses the remainder of the Site where instability may still occur but is likely to be more easily remediated with drainage and filling of gullies.

The presence of potentially compressible alluvial soils is common across both zones.

The extents of these areas are shown in the appended ***Geohazard Zone Plan (Appendix A)***. The unmitigated Auckland Council Code of Practice for Land Development and Subdivision (ACCOP) risk ratings range from low to extreme, but residual risks following development will be very low to low and are considered acceptable. A guide to the assessment of risk ratings is provided beneath the summary table below.

Geohazard Assessment Summary

Item	Geotechnical Hazard	Description	Area Assessed	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
1	Earthquake	Liquefaction	Entire Site	Low-lying areas such as those in the vicinity of the large glasshouses Liquefaction occurs in loose saturated cohesionless soils that are subject to cyclic shear loading during an earthquake. This process leads to pore pressure build-up, soil grains moving into suspension and temporary loss of strength causing vertical and lateral ground deformation. In accordance with MBIE/NZGS guidance the liquefaction susceptibility of the soils at this Site was assessed with respect to geological age and compositional (soil fabric and density) criteria. This assessment indicated a very low to low risk of liquefaction, however the sandy silts within the Puketoka Formation may have some susceptibility. In addition, four CPTs were analysed using the software package CLiq as part of our previous reporting. Full details of this analysis are in Section 6.5 of that report, at ***Appendix B***. The results indicate low liquefaction risk for the site, considering importance level 2 structures.	1	5	5	Mitigation not required	1	5	5
		Lateral Spread	Entire Site	Due to the low liquefaction risk, lateral spread risk is anticipated to be low. In addition, subsurface conditions indicate that the reactive soils are below the depth of the non-liquefiable "crust"	1	5	5	Mitigation not required	1	5	5

Geohazard Assessment Summary

Item	Geotechnical Hazard	Description	Area Assessed	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
2	Slope Instability / Landslide	Global Instability	Stream adjacent areas and slopes (Geohazard Zone 1)	The slopes in and around the defined gully margins are considered to be at risk of soil creep and shallow slump failures.	4	5	20	Slope stability remedial works in this geology typically includes installation of subsoil drainage, including underfill drains in mucked-out gully alignments, and placement of engineered fills in these gullies. If these gully flanks are not supported by bulk filling, specific slope stability assessment will be necessary.	1	5	5
		Soil Creep	Elevated areas and slopes (Entire Site)	Refer to Global Instability section above	4	4	16	Mitigated by design of slope gradients, including use of retaining walls and by design of footings.	1	4	4
		Cut / Fill Batter Instability	Unknown (Future cut and fill areas)	Batters unknown as earthworks plans have not yet been provided.	3	4	12	Mitigated by stormwater control and surface stabilisation/ treatment in design.	1	4	4
		Stream Bank Instability and Erosion	Stream adjacent areas	Refer to Global Instability section above.	3	5	15	Consider shallowing stream slope gradients, installing rip rap or gabions at the base of the stream to mitigate scour. A setback or specific design zone may be set in place from the crest of the stream bank slope to nearby structures where specific engineering design will be required.	1	5	5
		Bearing Capacity Failure	Entire Site	Alluvial terrace areas, particularly those adjacent to the western stream and the low-lying area occupied by the large glasshouses.	3	4	12	A consideration for large buildings and rapid loading on alluvial soils. Ground improvement techniques (such as preload/surcharge with or without wick drains or displacement piles) and/ or pile foundations.	1	4	4
3	Problematic Soils	Expansive Soils	Entire Site	Expansive soils are classified in NZS 3604 as those soils having a liquid limit of more than 50% <u>and</u> linear shrinkage of more than 15%. Lab testing was not undertaken in the site investigation. Soil expansivity to be assessed in the construction phase.	4	4	16	Soil expansivity to be assessed in the earthworks/construction phase of the project. Foundations to be designed accordingly for the Expansive Class.	1	4	4
4	Settlement	Compressible Soils	Soft Soils/Load Induced Settlement	Alluvial terrace areas, particularly those adjacent to the western stream and the low-lying area occupied by	4	5	20	In areas where fills are placed over soft deposits, allowance needs to be made for post-construction settlement of the fills	1	5	5

Geohazard Assessment Summary											
Item	Geotechnical Hazard	Description	Area Assessed	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
				the large glasshouses potentially affected.				and the underlying ground that could cause damage to future structures. Consideration in the design needs to be given to the quantum of settlement that is likely to occur (i.e., ensuring it is insufficient to influence the cut/ fill volumes and balance during earthworks and/ or damage structures) and the time taken for the settlement to occur (i.e., ensuring it will be largely completed by the time a normal civil works programme would likely be commencing). A preliminary settlement assessment was conducted on four CPTs using CPeT-IT software, as part of our previous reporting. (Section 6.9 of appended report, at ***Appendix B***). Given that no earthworks proposals are available, filling in the order of 2m above existing levels and future widespread industrial building loads of 30 kPa were assessed. The worst-case primary settlement calculated was approximately 35mm. Typical post construction settlements over a design life of 50 years are predicted to be less than 15mm. Generally this shows that the ground conditions encountered are relatively incompressible. Remedial options for speeding settlements in areas of deep compressible soils include preloading and installation of wick drains but based on our experience, pre-loading without wick drains is able to provide good results. Locations and heights of surcharge must be subject to geotechnical review to avoid causing bearing capacity failure in the underlying soils.			
5	Erosion	Cut Batters	Unknown (Future cut areas)	Earthworks plan not provided.	3	4	12	Maximum cut batter of 1V:3H, or steeper with surface	1	4	4

Geohazard Assessment Summary											
Item	Geotechnical Hazard	Description	Area Assessed	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
								stabilisation/treatment included in design.			
		Fill Batters	Unknown (Future fill areas)	Earthworks plan not provided	3	4	12	Appropriate stormwater control and surface stabilisation/treatment in design required.	1	4	4

RISK ASSESSMENT GUIDE - ACCOPS						
Risk Matrix		CONSEQUENCE				
		Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
RISK CATEGORIES	**Health & Safety and Disruption** (Including staff, sub-contractors or the public. Injury or illness)	No significant community (e.g. sociological or cultural) issues. Localised short term reversible disruption to the community, resulting in no noticeable damage.	Local community (e.g. sociological or cultural) concerns that can be dealt with. OR Localised minor reversible damage and disruption to the community, with no potential public safety issues or long-term effect.	Injury or illness likely. OR Significant community (e.g. sociological or cultural) concerns causing delays and modifications to plans. OR Localised medium term (1 to 3 weeks) reversible damage and disruption to the community, with some potential safety issues.	Injury or permanent disability likely. OR Widespread significant community (e.g. sociological or cultural) causing significant delays and modifications to plans. OR Localised or widespread long term (greater than 3 weeks) reversible or irreversible damage; disruption to community.	Fatality likely. OR Major community (e.g. sociological or cultural) concerns causing major re-think or complete failure of plans. Localised or widespread damage and disruption to the community (any duration), with potential for loss of life.
	Environment (Including air quality and noise, water contamination or sedimentation, soil contamination, impact on others, protected areas or species.)	Small localised and reversible environmental impact: • Slight, short term damage to use of land and/or water • Slight short-term damage to land and/or water ecosystems • No noticeable species reduction • Occasional inconsistency with the intent of legislation, Auckland Plan	Contained and reversible (minimal) environmental impact. OR Localised minor reversible damage to (use of) land and/or water OR Localised minor reversible damage to land and/or water ecosystems OR Temporary reduction in one species OR Minor erosion and/or damage to property. OR Minor inconsistency with the intent of legislation, Auckland Plan.	Measurable damage to the environment; significant corrective action. OR Localised, medium term reversible damage to land and/or water ecosystems OR Moderate reduction in one or more species OR Moderate erosion and/or damage to property. Recovery time 1 month. OR Repeated inconsistency with the intent of legislation, Auckland Plan.	Irreversible localised damage (major) to the environment OR Widespread, long term reversible damage to land and/or water ecosystems OR Significant reduction in one or more species OR Severe erosion and/or damage to property. Recovery time up to 6 months OR Repeated and significant inconsistency with the intent of legislation, Auckland Plan.	Extensive irreversible damage (widespread) to the environment. OR Widespread, irreversible damage to land and/or water ecosystems. OR Permanent loss of one or more species. OR Destruction of property / widespread flooding. Recovery time exceeding 6 months. OR No recognition of the intent of legislation, Auckland Plan.
	Assets and Economy	Economic loss <$0.5M OR Damage / loss of a minor asset worth <$5k OR Assets not useable / available for short defined period	Economic loss 0.5M-$1M OR asset damage <$10K OR assets not useable / available for short undefined period	Economic loss $1M-$10M OR asset damage <$50k OR assets not useable / available for the medium term	Economic loss $10M-$100M OR asset damage <$500k OR Assets not useable / available for the long term	Economic loss >$100M OR asset damage >$1M OR Total loss of asset that cannot be replaced
LIKELIHOOD	5 **Almost Certain** (greater than 90% chance of occurring during period of exposure)	Medium 5	High 10	Very High 15	Extreme 20	Extreme 25
	4 **Event Likely to Occur** (50% to 90% chance of occurring during period of exposure)	Low 4	Medium 8	High 12	Very High 16	Extreme 20
	3 **Event May Occur** (25% to 50% chance of occurring during period of exposure)	Low 3	Medium 6	Medium 9	High 12	Very High 15
	2 **Event Unlikely to Occur** (10% to 25% chance of occurring during period of exposure)	Very Low 2	Low 4	Medium 6	Medium 8	High 10
	1 **Event Rarely Occurs** (less than 10% chance of occurring during period of exposure)	Very Low 1	Very Low 2	Low 3	Low 4	Medium 5

Figure 14: Geohazard Zone Plan

8 SITE CONSTRAINTS

A number of watercourses exist within the subject area. Classification of the watercourses is outside CMW's scope and is being undertaken by others.

Should any of these watercourses need to be retained, geotechnical remediation measures such as (for example) undercuts, shear keys and / or retaining walls may be required to stabilise adjacent land, depending on the location of the watercourse and the proposed landform. It can be assumed that any filling will have underfill drainage placed beneath it to allow the flow of water to continue through the watercourse and to prevent the build-up of groundwater pressures from developing beneath the fill.

Geotechnical remediation measures will be developed fully at the detailed design stage which will occur at the time of Resource Consent application.

9 CONCLUSION

On the basis of our hazard assessment, we consider that the land is suitable for creating stable building platforms and infrastructure, having normally acceptable levels of post-development residual risk from natural hazards. Any proposed earthworks are to be undertaken in accordance with all relevant standards and documents. The engineering controls required to control existing, latent risks are commonplace works in this terrain that are consistent with those being adopted on nearby land. Further site investigation and design will need to be undertaken to quantify the geotechnical controls prior to the commencement of any works.

10 CLOSURE

This report has been prepared for use by Fisher & Paykel Healthcare Properties Limited in relation to the Karaka Road, Drury West project in accordance with the scope, proposed uses and limitations described in the report. Should you have further questions relating to the use of your report please do not hesitate to contact us.

Where a party other than Fisher & Paykel Healthcare Properties Limited seeks to rely upon or otherwise use this report, the consent of CMW should be sought prior to any such use. CMW can then advise whether the report and its contents are suitable for the intended use by the other party.

Additional important information regarding the use of your CMW report is provided in the '*Using your CMW Report*' document attached to this report.

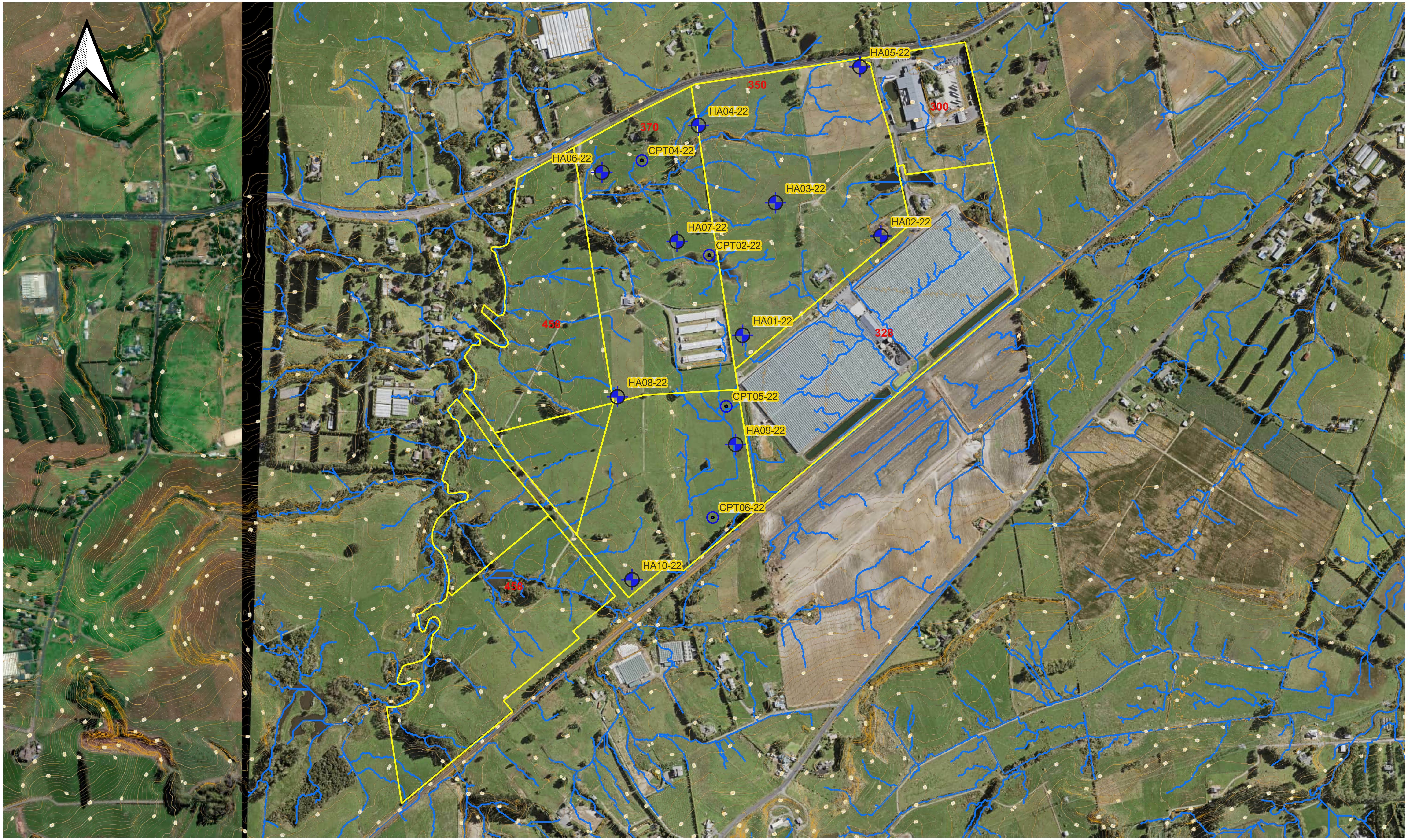
REFERENCES

Edbrooke, S. W. (compiler) 2001: Geology of the Auckland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 3. 1 sheet +74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences.

Schofield, J. C. 1989: Sheets Q10 & R10 – Helensville and Whangaparaoa. Geological map of New Zealand 1:50 000. Map (2 sheets) and notes. Wellington, New Zealand. Department of Scientific and Industrial

Appendix A: CMW DRAWINGS

Site Investigation Plan
Geology & Geomorphology Plan
Geohazard Zone Plan



LEGEND:

- CPT
- Hand Auger
- Land Parcel Boundary
- Overland Flow Paths

NOTES: 1. Existing Contour from Auckland Council GeoMaps

0 50 100 150 200 250 m

CMW Geosciences

CLIENT: FISHER & PAYKEL HEALTHCARE LTD		DRAWN: MJC	PROJECT: AKL2022-0214
PROJECT: KARAKA ROAD DRURY WEST		CHECKED: CR	DRAWING: 01
		REVISION: 0	SCALE: 1:7500
TITLE: SITE INVESTIGATION PLAN		DATE: 24/02/2023	SHEET: A3 L

LEGEND:

Geomorphology Points
- SWAMPY GROUND

Geomorphology Lines
- ARROW IN DIRECTION OF SLOPE MOVEMENT
- MINOR HEAD SCARP
- BENCH
- PROMINENT RIDGE

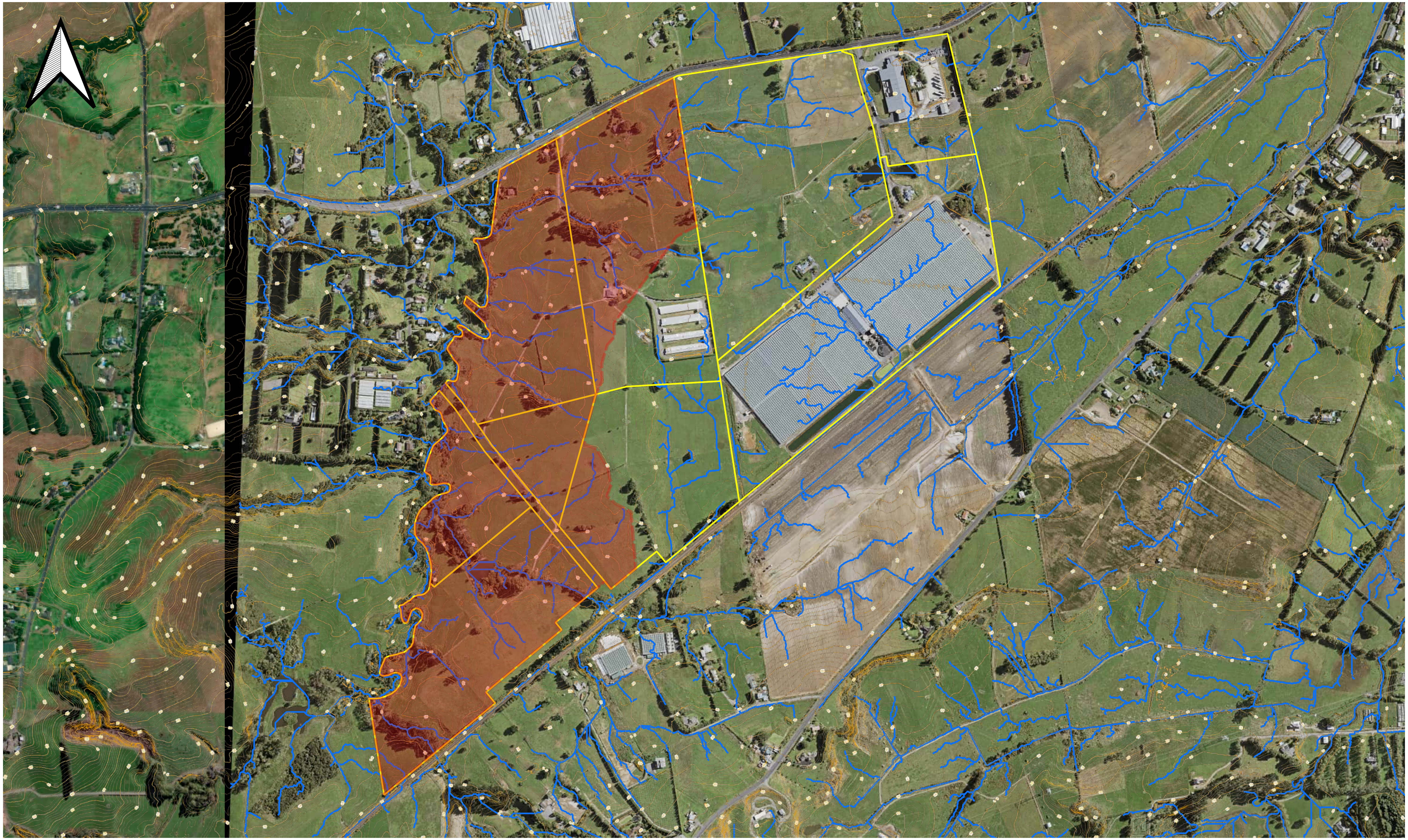
Geomorphology Polygons
- DEBRIS MOUND
- Auckland Council Land Parcel Boundary

GNS Geology Units 1:250,000 (QMap)
- Kerikeri Volcanic Group
- Tauranga Group
- Overland Flow Paths

0 25 50 75 100 125 m

NOTES: 1. Existing Contour from Auckland Council GeoMaps.

CMW Geosciences	CLIENT: **FISHER & PAYKEL HEALTHCARE LIMITED**	DRAWN: MJC	PROJECT: AKL2022-0214
	PROJECT: **KARAKA ROAD, DRURY WEST**	CHECKED: CR	DRAWING: 02
		REVISION: 0	SCALE: 1:7500
	TITLE: **GEOLOGY AND GEOMORPHOLOGY PLAN**	DATE: 24/02/2023	SHEET: A3 L



LEGEND:

Geohazard Zone 1 (remainder of site is Zone 2)

Auckland Council Land Parcel Boundary

Overland Flow Paths

NOTES: 1. Existing Contour from Auckland Council GeoMaps

0 50 100 150 200 250 m

CMW Geosciences

CLIENT: FISHER & PAYKEL HEALTHCARE LIMITED	DRAWN: MJC	PROJECT: AKL2022-0214
PROJECT: KARAKA ROAD, DRURY WEST	CHECKED: CR	DRAWING: 03
	REVISION: 0	SCALE: 1:7500
TITLE: GEOHAZARD ZONE PLAN	DATE: 24/02/2023	SHEET: A3 L

Appendix B: CMW REPORT AKS2022-0029AB

13 July 2022 Document Ref: AKS2022-0029AB Rev. 0

Dines Group Limited
22 Bowden Road,
Mount Wellington,
Auckland 1060

Attention: Colin Botica

RE: GEOTECHNICAL ASSESSMENT REPORT
350 & 370 KARAKA ROAD, DRURY

1 INTRODUCTION

1.1 Project Brief

CMW Geosciences (CMW) was engaged by Dines Group Limited to carry out a geotechnical assessment of 350 & 370 Karaka Road in Drury which we understand are both currently zoned under the Auckland Unitary Plan as a "Future Urban Zone". At this stage, no concept plans are available, but it is our understanding that the sites may be developed for commercial / industrial subdivision with the possibility of mixed use.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKS2021-0073AB Rev 0, dated 04 August 2021.

This report is intended to support a feasibility study and we outline our findings from our preliminary investigations as described herein. This report may be used to supplement future geotechnical assessment of land modification and future commercial / industrial development but will likely require further investigations and geotechnical analyses.

1.2 Scope of Work

As detailed in our services proposal letter referenced above, the agreed of scope of work is defined as follows:

- Desktop study of available information relevant to the proposed development.
- Arrange and execute a geotechnical investigation comprising:
    - 10 no. hand augered (HA) boreholes to a maximum depth of 5m; and
    - One day of CPT investigation to depths of 20m.
- Preparation of a Geotechnical Assessment Report outlining our findings, anticipated geotechnical hazards and preliminary comments with regards to suitability of the sites for future commercial/industrial or residential subdivision.

2 SITE DESCRIPTION

2.1 Site Location

The sites are legally described as Lot 1 DP 205837, Lot 4 DP 14876, Pt lot 6 DP 14876 and identified as #350) and #370 Karaka Road respectively. Combined, the sites encompass an area of approximately 47.2Ha.

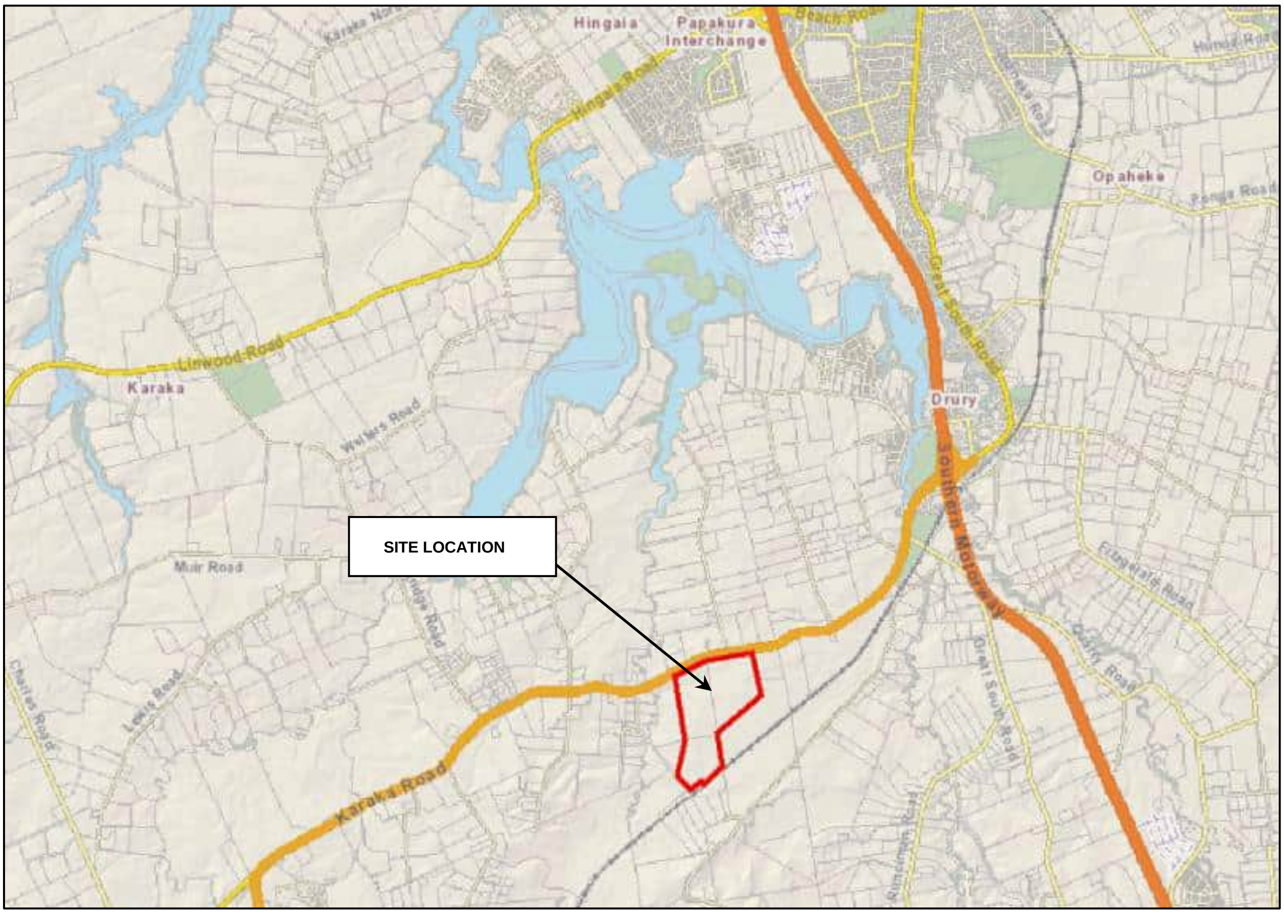


Figure 1: Site Location (Auckland Council GIS)

2.2 Landform

As seen in ***Figure 2*** below, the landform typically comprises very gently to gently sloping farmland, falling from the east towards the west. There are several natural drainage depressions comprising defined, tree-lined gullies as well as relatively shallow basins, some of which have been modified with the formation of farm ponds. We describe the landform as well as site features in more detail in the following sections.

Figure 2: Aerial Photo (2017) of the site with 2.0m contours (Auckland Council GIS).

2.2.1 350 Karaka Road

The landform falls from highpoints along the eastern boundary line around ~RL33.0 down to the current boundary between #350/#370 where the ground levels range around RL25.0 to RL20.0. There are three distinctive pond areas:

- Large pond depression in the south-eastern corner which extends across the neighbouring boundary to the east albeit intersected by a neighbouring driveway which we presume uses a culvert pipe under the driveway (see Figure 3 below);
- Also note what appear to be sand dredging works;

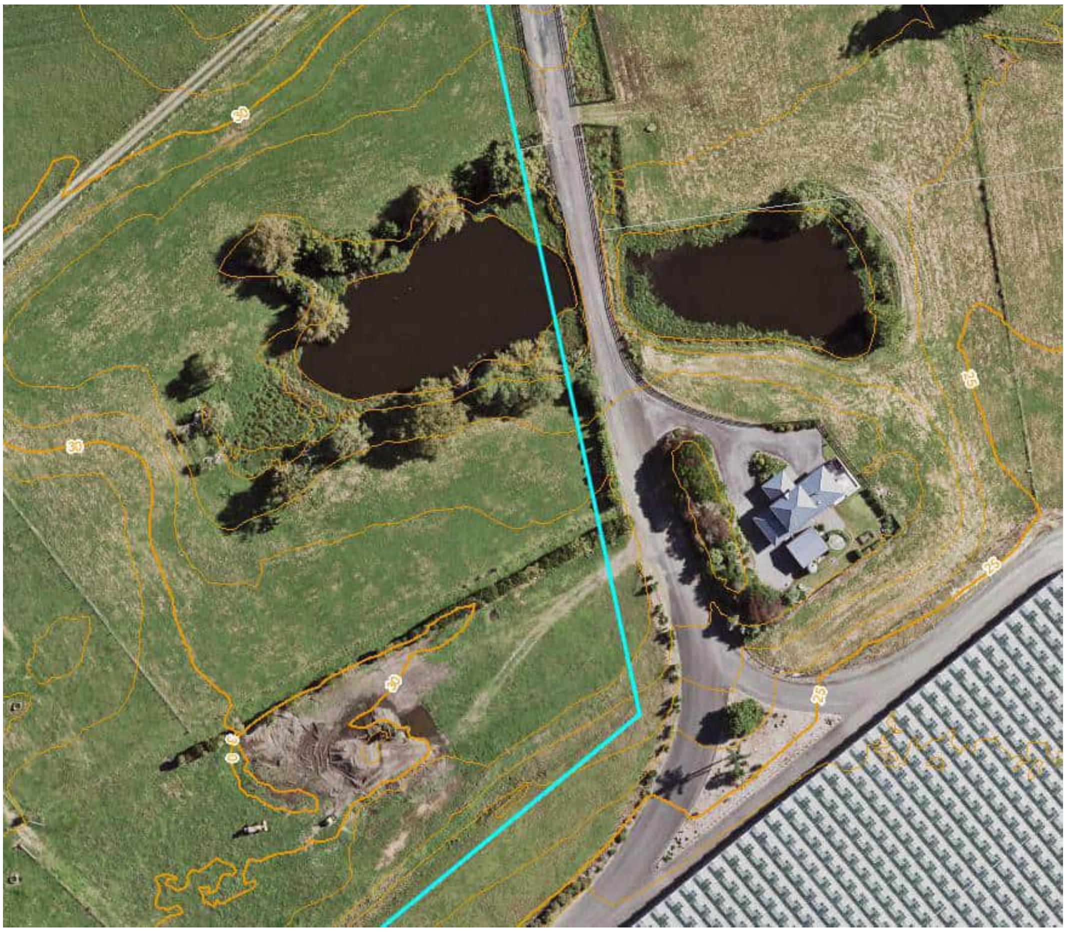


Figure 3: Pond in south-east corner of #350. Note the topsoil stockpile works. (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

- Relatively shallow incised gully in the north-west corner which has been dammed in two locations forming two ponds (see Figure 4 below);

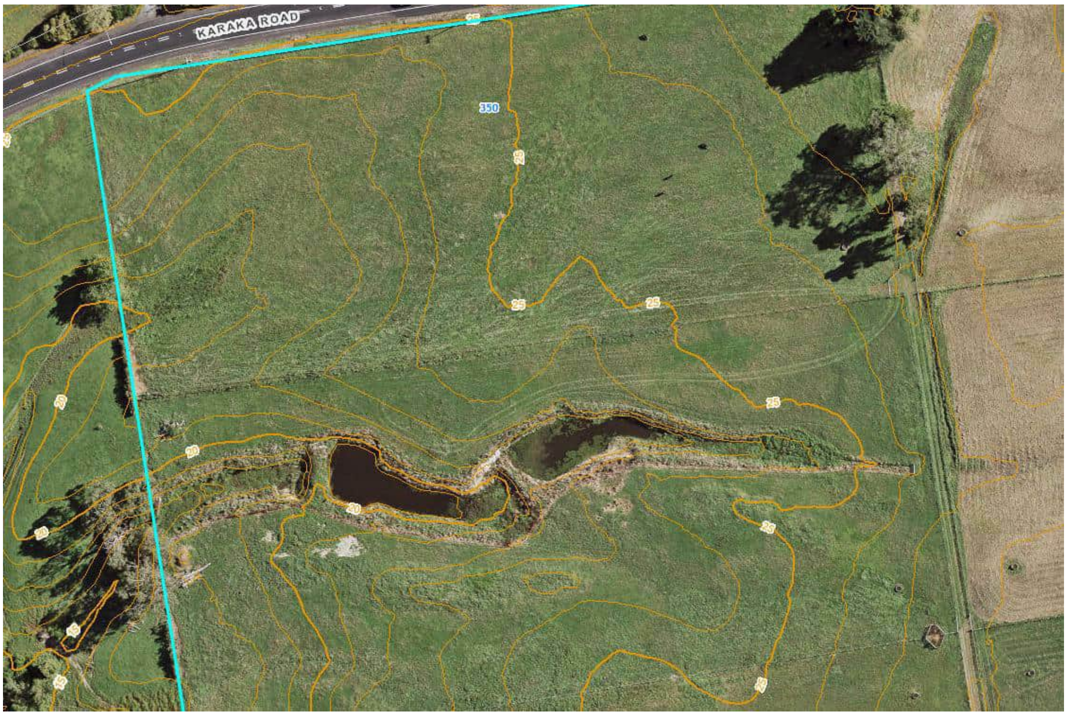


Figure 4: Gully ponds in north-west corner of #350. Note the two dam banks (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

- Relatively shallow but broad depression in the south-west corner which has a large pond which extends across into #370 (see Figure 5 below).

Figure 5: Gully ponds in north-west corner of #350. Note the house accessed from the neighbouring property to the south (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

2.2.2 370 Karaka Road

The landform comprises three distinctly contrasting topographies with the northern-third dominated by two gullies; the central-third comprising a highpoint; and the southern-third a broad near-level depression to the east and rolling slopes to the west:

- The north-third contains a main gully which is tree-lined and comprising moderate to steep-sided banks along with a small pond formed by a dam crossing (see Figure 6 below);
- A second tree-lined gully with two larger ponded dams;
- Ground levels range between ~RL20.0 to ~RL10.0;

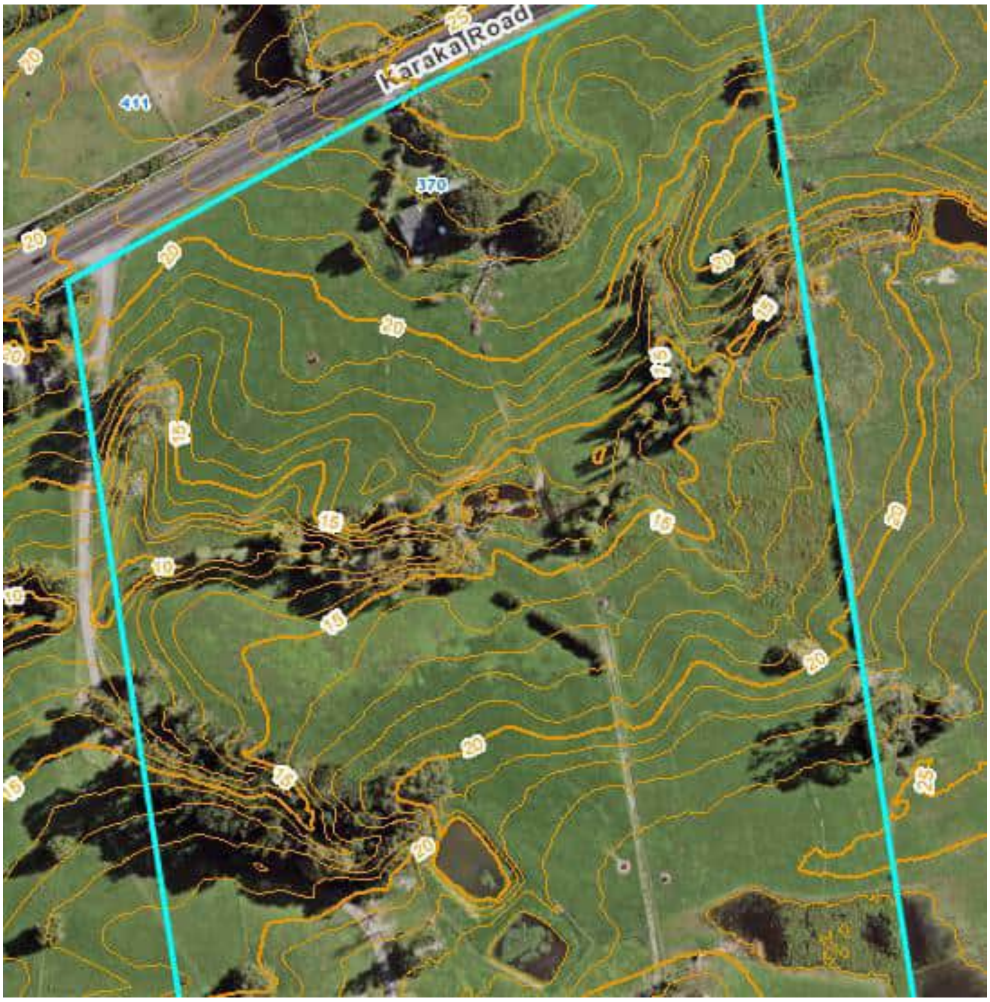


Figure 6: Tree-lined gullies with ponds in north-third of #370. Note the house to the north accessed from Karaka Road with a second house to the south accessed from three different accessways and neighbouring properties (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

- Elevated central-third of #370 where four large farm sheds and adjacent dwelling are situated (see Figure 7 below);
- Ground levels range between ~RL25.0 to ~RL30.0;

Figure 7: Elevated central-third with four large farm sheds and adjacent dwelling (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

- Southern-third of #370 comprises a broad, near-level depression to the east (~RL21.0) and rolling slopes either side of ridgeline to the west ranging ~RL28.0 to ~RL18.0 (see Figure 8 below);

Figure 8: Southern-third of #370 with broad near-level depression to the east and rolling slopes either side of a ridgeline to the west (2017 Aerial Photo with 1.0m contours from Auckland Council GIS).

3 PROPOSED DEVELOPMENT

We understand that both 350 & 370 Karaka Road are currently zoned under the Auckland Unitary Plan as a "Future Urban Zone". At this stage, no concept plans are available, but it is our understanding that the sites may be developed for commercial / industrial subdivision with the possibility of mixed use.

Given that there are currently no earthworks proposals, we have made the following broad-brush assumptions (not be construed as limitations) so that we provide commentary around the geotechnical suitability (or not) of the land in terms of land modification:

- Bulk earthworks comprising cuts and fills not exceeding 2.0m depth: and
- Future site development for commercial and medium-industrial buildings with Uniformly Distributed Floor Loadings of up to 30 kPa.

4 INVESTIGATION SCOPE

4.1 Desktop Study

Prior to the site investigation, a desktop review was undertaken of available geotechnical information, including Auckland Council GIS database "Geomaps" and Retrolens historic aerial photography, as well as publicly available information from the NZ Geotechnical Database. A Dial Before You Dig online service search was also undertaken.

4.1.1 Historical Aerial Photograph Review

Review of historic aerial photographs indicate that the site was undeveloped in May 1942 (Figure 9 below, earliest available aerial), with only minor dwellings visible in the northern portion of #370. Note the "humps and hollows" across the landform which we believe are ancient erosional terrace features compared with the more recent gully erosion features which are evident as much sharper and localised features.

Figure 9: 1942 historical aerial photo (Retrolens).

By 1996, (see Figure 10 below), we can see four large, rectangular farm buildings as well as a farmhouse constructed centrally within #370 along with several ponds. Note the large man-made pond now evident along the eastern boundary of #350.

Figure 10: 1996 historical aerial photo (Retrolens).

By 2001 (see Figure 11 below), the significantly large glasshouses on the neighbouring property to the south-east were constructed with evidence of a large stockpile of topsoil extending across onto #350. The farmhouses on #350 are also evident.

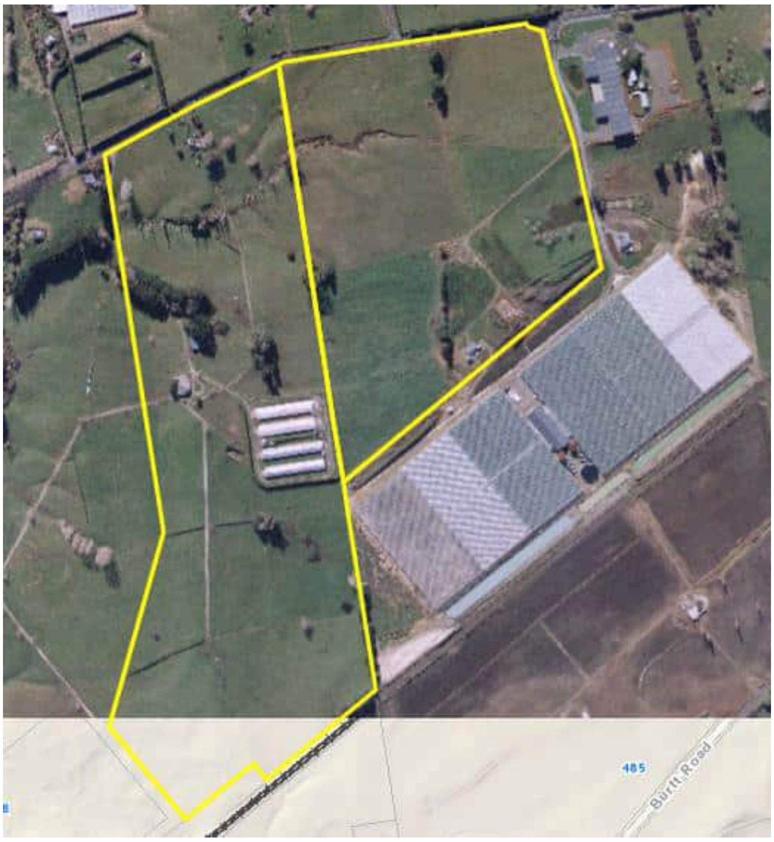


Figure 11: 2001 historical aerial photo (Retrolens).

By 2006 (see Figure 12 below), there are stockpiles evident to the south of the northern-gully in #350 whilst there are earthworks evident along the southern boundary of #350. No works are evident in #370.

Figure 12: 2006 historical aerial photo (Retrolens).

The 2017 aerial photos (see section 2.2 Landform above) show the construction of the remaining ponds occurred sometime after 2006 but prior to 2017.

In summary, based on the intermittent historical aerial photographs we have reviewed, there appears to have been several episodes of land modification, which although localised to specific areas of the sites, suggests that the southern boundary area of #350 was used to stockpile material when the neighbouring glass houses were built. There are also areas around the gully depressions, in particular where the man-made ponds are formed, which could comprise disturbed ground.

4.2 Field Investigation

Following a Dial Before You Dig online search, and onsite buried service detection, the field investigation was carried out between 31th March 2022 and 14th April 2022. All fieldwork was carried out under the direction of CMW Geosciences in general accordance with the NZGS specifications[1] and logged in accordance with NZGS guidance[2].

The scope of fieldwork completed was as follows:

- Undertook a walkover survey of the site to assess the general landform, site conditions and adjacent structures / infrastructure;
- An on-site services search was carried out by a specialist contractor to identify the presence of any underground obstructions or hazards prior to the field investigation program commencing;
- 10 no. hand auger boreholes, denoted HA01-22 to HA10-22, were drilled using a 50mm diameter auger to a target depth of 5.0m below existing ground levels to visually observe the near surface soil profile and to facilitate vane shear strength testing. Engineering logs of the hand auger boreholes, together with peak and remoulded vane shear strengths are presented in ***Appendix B***.
- 4 (no.) Cone Penetrometer Tests (CPT) were undertaken across #370 as we did not have approved access for the CPT rig across #350 locations denoted CPT02-22, CPT04-22 to CPT06-22, were pushed to depths of up to 20m to define the ground model through the proposed excavation depth and through the underlying zone of influence of fills as well as future building foundations. Results of the CPT's, presented as traces of tip resistance (q_c), friction resistance (f_s) and friction ratio are presented in ***Appendix C.***

The approximate locations of the respective investigation sites referred to above are shown on the Site Investigation Plan included in ***Appendix A***. Test locations were measured using hand-held GPS and elevations were inferred from the AC GIS database.

5 GROUND MODEL

5.1 Published Geology

An extract from published geological maps[3] for the area, presented in **Figure 13**, depicts the regional geology as comprising Late Pliocene to Middle Pleistocene pumiceous alluvial deposits of the Puketoka Formation (Pup). These deposits are described as undifferentiated deposits of clays, silts and sands, with lenses of peaty or organic clays. Soils within this geology can be variable in strength and sensitive to disturbance, especially where pumiceous silts and sands are encountered.

The published geological maps for the area also indicate to the south of the site is mapped volcanic deposits from the South Auckland Volcanic Field, consisting of lithic tuff, comprising comminated pre-volcanic materials with basaltic fragments, and unconsolidated ash and lapilli deposits.

Based on the known history of the site as farmland, some superficial depths of fill could be anticipated as a result of soft landscaping to create building platforms, farm tracks and ponds.

Pockets of recent alluvial material can also be expected around gully features and other overland flow paths.

The nearest active fault is the Drury Fault which is approximately 5km east of the site.

[1] NZ Geotechnical Society (2017) NZ Ground Investigation Specification, Volume 1 – Master Specification
[2] NZ Geotechnical Society (2005), Field Description of Soil and Rock, Guideline for the field classification and description of soil and rock for engineering purposes.

[3] Edbrooke, S.W. (compiler) 2001: Geology of the Auckland area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 3. 74 p. + 1 folded map

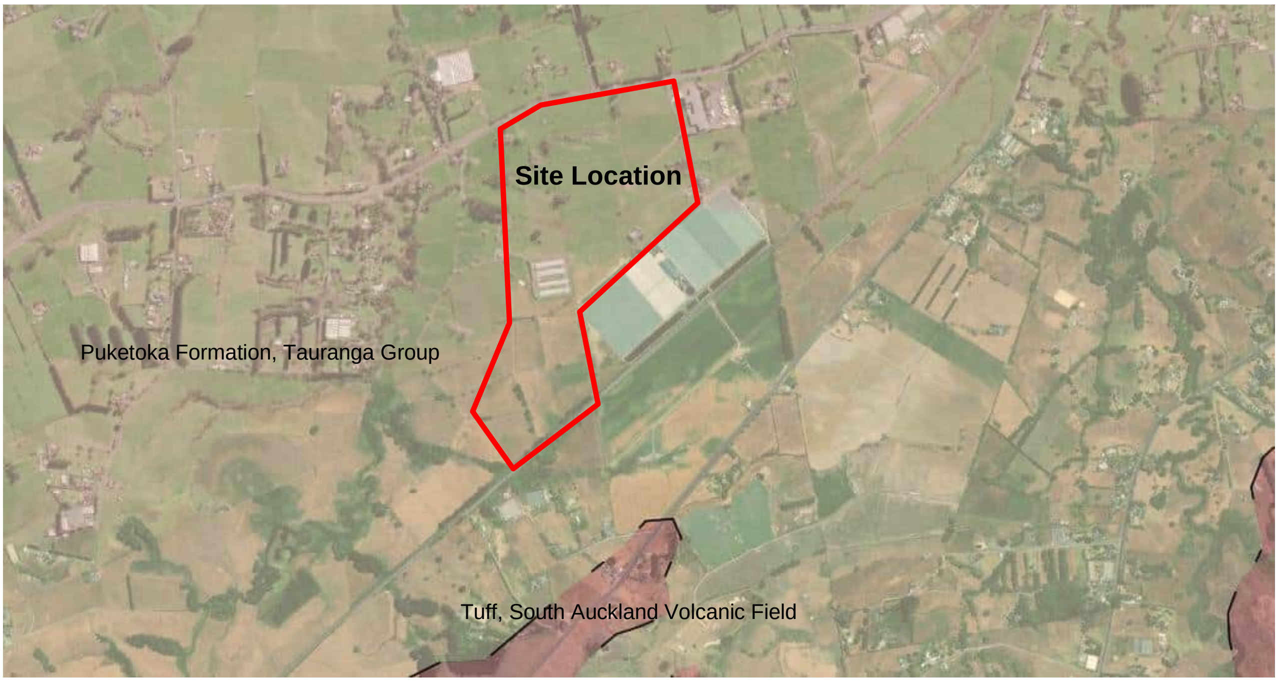


Figure 13: Regional Geology (GNS Science Geology Web App)

5.2 Stratigraphic Units

The ground conditions encountered and inferred from the investigation were considered to consistent with the published geology for the area and can be generalised according to the following subsurface sequences.

5.2.1 Topsoil

Topsoil was typically encountered across both #350 & #370 to depths of between 0.2 metres below ground level (mbgl) up to 0.3mbgl. At HA02, topsoil was encountered to 0.9mbgl of topsoil which we believe was around the location of the old topsoil stockpile identified in our historic aerial photograph review.

5.2.2 Fill

There was no obvious evidence of man-made fill encountered in our hand augered boreholes.

However, on the basis of our aerial photograph review, we expect there to be several areas of fill deposits / disturbed ground; in particular in and around the existing farm tracks, ponds and building platforms.

Furthermore, due to the historic farm-use of the site, there is potential for more widespread areas of uncertified / non-engineered fill used for historic land modification purposes across the site.

For this reason, we stress the need for thorough site stripping inspections prior to the placement of any filling during earthworks construction, with any non-engineered filling identified and removed to the satisfaction of the supervising Geo-Professional.

Depending on the quality and consistency of the material, it may be suitable for re-use as bulk filling.

5.2.3 Recent / Holocene Alluvial Material

Although we did not directly identify recent alluvial deposits in our hand augered boreholes, we expect such localised deposits of soft organics & alluvial sediments within the gullies and ponds present across both sites. Where encountered, these unsuitable soils will need to be mucked out and subsoil drainage installed before any bulk filling is undertaken.

CPT02 was positioned in the middle of what we believe was an old pond which was not holding water at the time of investigation. Never-the-less, it is inferred that soft to firm soils extend up to 2.0m depth in this location. Below this depth the materials were consistently stiff to very stiff becoming hard below 17 metres depth.

5.2.4 South Auckland Volcanic Field Materials

#350

Competent surficial volcanic ash soil to depths ranging between 1.2mbgl to 3.0mbgl. This material typically consisted of very stiff to hard, clayey silt and silty clay with peak undrained shear strengths measuring >134kPa.

#370

Across the majority of the site, competent surficial volcanic ash soil to depths ranging between 1.2mbgl to 2.2mbgl in HA06 to HA08 & HA10. This material typically consisted of stiff to hard, clayey silt and silty clay with peak undrained shear strengths measuring >81kPa.

5.2.5 Puketoka Formation

We encountered Puketoka Formation alluvial soils underlying the volcanic soils to our target depths of 5.0m. Although these materials were generally lower in strength and more variable in terms of consistency when compared with the overlying volcanics, these materials were still competent in general terms with no obvious evidence of weak and/or compressible materials.

This material typically consisted of generally stiff to hard, inorganic silty clay and sandy silt with peak undrained shear strengths measuring >75kPa.

The inferred material strengths in the CPT tests confirmed the Puketoka formation soils are generally stiff to very stiff with no obvious layers of weak / compressible materials at depth with refusal on hard / dense materials around 17.5mbgl to 20mbgl.

5.2.5.1 Peat / Organic Mud and Soft/Firm Soils

In HA09, which was drilled in the low-lying area in the south-east corner of #370, we encountered peat from the ground surface to a depth of 1.0mbgl in turn overlying soft to firm “mud” comprising organic clays to a depth of 3.2m with undrained shear strengths measured as low as 29kPa. Below 3.2mbgl depth, the material strength increased to >78kPa with no obvious evidence of organic soils.

It should be cautioned that elsewhere in this low-lying area the peat may be thicker/ extend deeper. Based on CPT5, inferred soft to firm material was encountered between 1.0mbgl to 2.5mbgl.

5.3 Groundwater

A summary of the hand auger boreholes and groundwater occurrences is provided in ***Table 1*** below.

Table 1: Summary of hand auger boreholes

Hand auger number	RL m	Target Depth (m below ground)	Termination Depth (m below ground)	Reason for Termination	Groundwater depth	
					m below ground	RL m
HA01-22	32.0	5	5	Target Depth	Not Encountered	N/A
HA02-22	29.0	5	5	Target Depth	Not Encountered	N/A
HA03-22	27.5	5	5	Target Depth	Not Encountered	N/A
HA04-22	21.9	5	5	Target Depth	Not Encountered	N/A
HA05-22	25.8	5	5	Target Depth	Not Encountered	N/A
HA06-22	24.0	5	5	Target Depth	4.8	19.2
HA07-22	17.5	5	5	Target Depth	4.8	12.7
HA08-22	25.0	5	5	Target Depth	4.8	19.2
HA09-22	22.0	5	5	Target Depth	1.0	21.0
HA10-22	19.0	5	5	Target Depth	3.0	16.0

During the investigation, which was completed in autumn conditions (April 2022), no groundwater was encountered in the five hand augers drilled to 5mbgl across #350.

In the five hand augers drilled across, groundwater was encountered at depths of around 4.8mbgl in HA06 to HA08, in the northern half of #370. In the lower-lying area to the south-east of #370 we encountered shallow groundwater at a depth of 1.0mbgl existing ground levels and in HA10 at the very southern end of #370, ground water was encountered at 3.0mbgl depth.

6 PRINCIPAL GEOHAZARDS AND PRELIMINARY RECOMMENDATIONS

6.1 General

On the basis of our preliminary geotechnical assessment as described in herein, we can confirm that we have considered both foundation and land stability risks and we generally consider that the site should not be exposed to unsatisfactory Geotechnical risk, subject to:

- the comments and recommendations made below; as well as
- the design and construction of appropriate bulk earthworks in conjunction with Geotechnical Review which will likely require additional investigation and analyses.

Furthermore, section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence). A Natural Hazards Risk Assessment will therefore need to be undertaken at the time of formal geotechnical reporting prior to Resource Consent submission.

The following sections of this report provide an assessment of the geohazards relevant to this site.

6.2 Seismic Site Subsoil Category

We consider that the site subsoils are likely to be Class C (Shallow soils) in accordance with the definition in NZS1170.5, on the basis that:

- The materials are not Class A, Class B or Class E; and
- The depth of soft soils does not exceed 20 metres;
- The depth of firm soils does not exceed 25 metres; and
- The depth of stiff soils does not exceed 40 metres.

6.3 Seismicity

A seismic assessment has been carried out in general accordance with NZGS guidance[4] to calculate the peak horizontal ground acceleration or PGA (a_{max}) as follows:

$$a_{max} = C_{0,1000} \frac{R}{1.3} x \; f \; x \; g$$

Where: $C_{0,1000}$ = unweighted PGA coefficient (0.15 for Auckland, Class C)

R = return period factor given in NZS1170.5, Table 3.5

f = site response factor subject to subsoil class (1.33 for Class C)

g = acceleration due to gravity

The ULS PGA was calculated based on a 50-year design life in accordance with the New Zealand Building Code[5] and importance level (IL) 2 structures (i.e. we have assumed that future buildings will have a gross floor area less than 10,000m^2 and less than 300 people can congregate within future buildings).

The PGA for an ultimate limit state (ULS) earthquake scenario is as follows:

[4] NZ Geotechnical Society publication "Earthquake geotechnical engineering practice, Module 1: Overview of the standards", Nov 2021)
[5] Ministry of Business, Innovation and Employment (1992) NZ Building Code Handbook, Third Edition, Amendment 13 (effective from 14 February 2014)

Table 2: Design Peak Ground Acceleration (PGA) for Various Limit States				
Limit State	**AEP**	**R**	**PGA(g)**	**$Magnitude_{eff}$**
ULS (IL2)	1/500	1.0	0.19	6.5
Note: SLS = serviceability limit state; ULS = ultimate limit state; AEP = annual exceedance probability				

6.4 Fault Rupture

The nearest recognised active fault is the Wairoa North and South Faults which are approximately 15km east of the site. These faults have undocumented slip rates and occurrences and given the reasonably significant separation distance from the site, the risk of fault rupture is considered to be low.

6.5 Liquefaction and Lateral Spreading

6.5.1 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[6] the liquefaction susceptibility of the soils at this site has been considered with respect to geological age, soil fabric and soil consistency / density.

6.5.2 Geological Age

Case history data compiled in empirical charts for liquefaction evaluation, shows that the vast majority of liquefaction events are triggered in geologically young and relatively unconsolidated deposits such as Holocene age alluvium or man-made fills[7,8]. On the basis of our investigations as described herein, we have not encountered any widespread evidence of Holocene deposits nor any significant deposits of man-made fills. Where either of these recent deposits are encountered, they will be undercut and removed thereby removing the risk either by static fill and/or building loading or liquefaction induced settlement.

It is generally considered that Pleistocene aged alluvium (>12,000 years before present) has a very low to low risk of liquefaction[9]

Stratigraphic units encountered beneath the site during our investigations comprise:

- Puketoka Formation alluvial deposits, which are dated no earlier than 70,000 years and up to 3.6 million years before present; and
- South Auckland Volcanic deposits, which are dated no earlier than 510,000 years and up to 1.59 million years before present.

Notwithstanding this, age alone is often debated as being of insufficient evidence to discount liquefaction potential due to its qualitative nature. Consideration can therefore be given to applying an ageing factor (K_{DR})

[6] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (Nov 2021)
[7] Seed, H.B. and Idriss, I.M. (1971) *A simplified procedure for evaluating soil liquefaction potential*, Earthquake Engineering Research Centre, Report No. EERC 70-9, University of California
[8] Youd, T.L. and Perkins, D.M. (1978) Mapping liquefaction-induced ground failure potential, *Journal of the Geotechnical Engineering Division,* ASCE, Vol. 104, No. GT4, Proc Paper 13659, p. 433-446
[9] Saftner, D.A.; Green, R.A.; Hryciw, R.D. (2015). Use of explosives to investigate liquefaction resistance of aged sand deposits, *Engineering Geology*, Vol 199, p.140-147.

to site specific liquefaction analyses in accordance with methods presented in Saftner et al[10] and represented in ***Figure 14*** below:

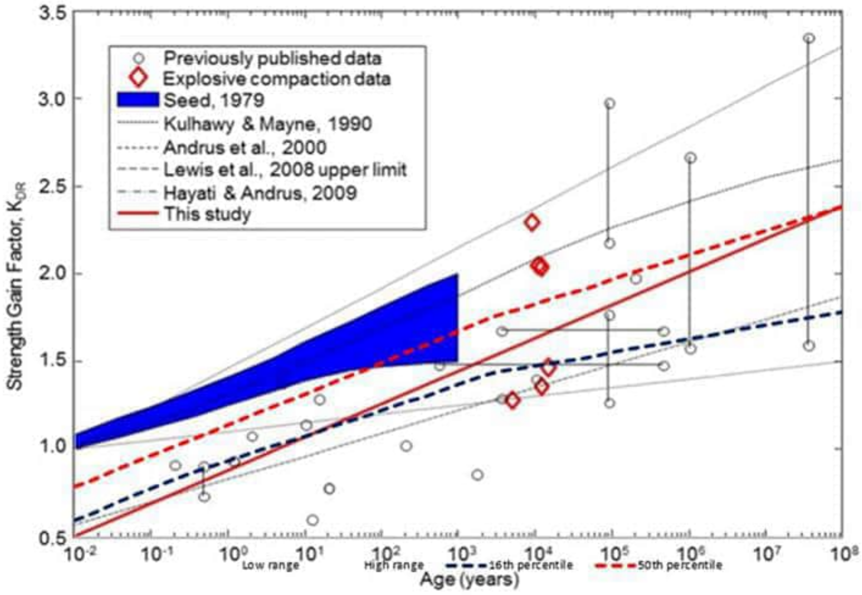


Figure 14: Ageing factors as presented in Saftner et al with 16th and 50th percentiles

From the range of the age factors presented in Figure 14 a conservatively low estimate was adopted to determine a minimum KDR=1.3 for both the South Auckland Volcanic materials and Puketoka Formation deposits.

6.5.3 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable. NZGS guidance[5] sets out the plasticity index (PI) criteria for liquefaction susceptibility as follows:

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

The fines content of the sands beneath the site also has a significant impact on their liquefaction susceptibility.

Specific plasticity index laboratory test results were not undertaken for this site for the following reasons:

- The upper soil horizon of South Auckland Volcanics and Puketoka Formation soils comprises stiff to hard cohesive clays and silts with high plasticity from visual/tactile tests and therefore considered to have low susceptibility to liquefaction.
- The sandy SILTs within the underlying Puketoka Formation, in combination with presence of elevated groundwater levels, suggest that there may be some susceptibility to liquefaction.

6.5.4 Specific Analyses

Analyses were undertaken using the raw data from the CPT tests which were first filtered through the software package CPe-IT[11] and then analysed using the accompanying software package CLiq[12]. The liquefaction

[10] Saftner, D.A.; Green, R.A.; Hryciw, R.D. (2015). Use of explosives to investigate liquefaction resistance of aged sand deposits, *Engineering Geology*, Vol 199, p.140-147.

[11] CPe-IT ver 3.0.2.1 by Geologismiki
[12] CLiq ver 3.3.2.9 by Geologismiki

analyses compared the cyclic stress ratio (CSR), being a function of the earthquake magnitude for the design return period event, to the cyclic resistance ratio (CRR), being a function of the CPT cone resistance (qc) and friction ratio (Rf).

A ground water level of 4.0 mbgl was applied in our analyses for CPT02 and CPT04 to the north and 2.0mbgl for CPT05 and CPT06 to the south.

Results for the ULS liquefaction analyses are summarised as follows:

- Low risk of potential liquefaction (LPI);
- Little to no expression of liquefaction (LSN) for CPT02, CPT04 & CPT05;
- Minor expression of liquefaction (LSN) for CPT06;
- Overall low probability of liquefaction;
- Predicted total vertical settlements of no greater than 50mm across CPT02, CPT04 & CPT05 locations;
- Predicted total vertical settlements of up to 140mm at CPT06 location;
- Predicted lateral stretch/displacement typically no greater than 80mm at CPT02 & CPT04 locations; and
- Predicted lateral stretch/displacement between 200mm to 600mm at CPT05 & CPT06 locations.

On closer inspection of the displacement graphs for these specific locations, we can see that the greatest settlement and lateral displacement magnitudes are occurring at beyond the following depths:

- CPT02 below 13.0mbgl;
- CPT04 below 6.0mbgl;
- CPT05 below 4.5mbgl; and
- CPT06 below 6.5mbgl.

These “reactive” soils are below the depth of non-liquefiable overburden or “crust”.

Subject to earthworks modification of the site which doesn’t significantly decrease the thickness of “crust” as well as the application of engineered fill to create a thicker “crust” as well as filling in the “free-faces” of the gullies, it is unlikely that liquefaction induced settlement nor lateral stretch should be a significant risk to the future development.

6.6 Cyclic Softening

The fine-grained alluvium, while not liquefiable due to its high plasticity, may be susceptible to some strength loss, referred to as cyclic softening, during a ULS seismic event.

Cyclic softening analyses of those soils was carried out in accordance with Boulanger[13] and Idriss[14]. This correlates earthquake magnitude to the estimated number of equivalent stress cycles (Figure 15) and then correlates number of cycles to a cyclic shear strength ratio (Figure 16).

[13] Boulanger, R.W. and Idriss. I. M. (2007) Evaluation of Cyclic Softening in Silts and Clays, Journal of Geotechnical and Environmental Engineering, Vol 133, Issue 6.
[14] Idriss, I. M. and Boulanger, R. W. (2008) Soil Liquefaction During Earthquakes. Monograph 12, Earthquake Engineering Research Institute.

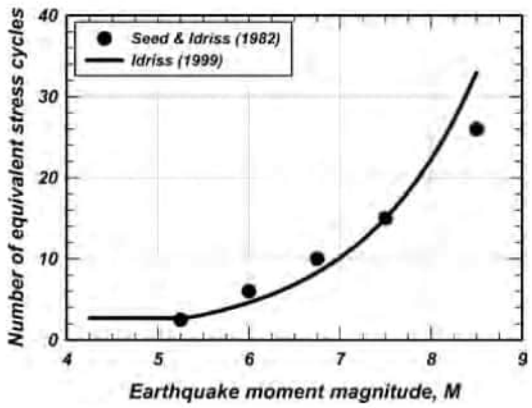


Figure 15: Relationship between earthquake magnitude and mean number of uniform stress cycles

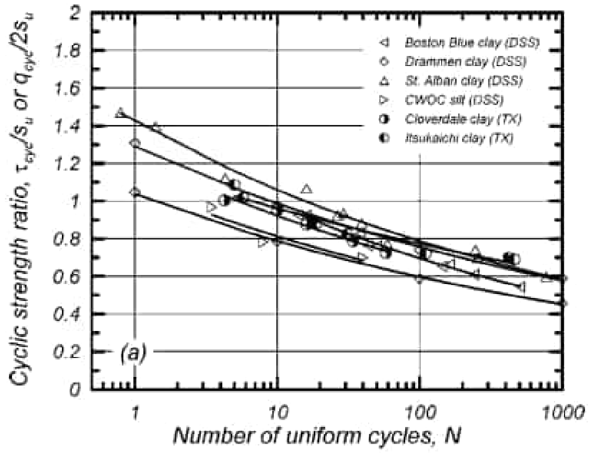


Figure 16: Relationship between cyclic strength ratio and number of uniform stress cycles

Based on the above assessment, 6 stress cycles are estimated during the ULS M6.2 earthquake resulting in a worst-case cyclic shear strength of 85% of the peak shear strength. Reduced shear strengths should be considered for any future slope stability analyses deemed necessary once earthworks proposals have been made available for review which should include the proposed stormwater pond formation.

6.7 Slope Stability

Generally speaking, we consider the majority of the existing slope gradients in and around the subject site are gently sloping and at low risk of instability. The slopes in and around the defined gully margins are however considered to be at risk of soil creep and shallow slump failures. However, subject to these gullies being filled, this risk should be mitigated. If these gully flanks are not supported by bulk filling then slope stability assessment will be necessary.

Although we have not had the benefit of reviewing development proposals, we consider that for bulk earthworks involving cut and / or fill depths greater than 2.0m and / or batter slopes steeper than 1V:3H, stability analyses will likely be required.

6.8 Erosion

Whilst we have not had the benefit of reviewing earthworks proposals, we make the following generalised comments with regards to erosion and mitigation measures:

- The existing landform is gently sloping with defined overland flow paths which do not reveal any obvious evidence of surface erosion.

- Future development and land modification should reduce the risk of overland flows which may cause erosion.
- Localised batter slopes should typically be formed at no steeper than 1V:3H, including the internal and external pond batter slopes, and the surface of the batters must appropriately be stabilised with topsoil, planting of vegetation and stormwater controls via surface water interception and diversion.
- Where any proposed stormwater controls (in the form of swale drains) are proposed, we expect that the swale is lined with geotextile as well as rock riprap to mitigate soil erosion from the surface flow.

6.9 Load Induced Settlement

An assessment of static settlements was completed using the CPT interpretation software CPeT-IT[15].

Given that there are currently no earthworks proposed, we have assumed earthworks filling in the order of 2.0m above existing levels, coupled with future widespread industrial building loads anticipated as being in the order of 30 kPa, there is a greater than normal risk of consolidation occurring in the underlying natural alluvial deposits.

Qualitatively speaking, we consider that the greatest risk of consolidation settlement is predominantly confined to the localised Holocene age deposits. To reduce this risk, we recommend that all weak Holocene age deposits are “mucked-out” in the gullies exposing the Volcanic Ash and Puketoka Formation soils prior to filling.

We summarise preliminary predicted settlements as follows:

- CPT02: 35mm (Primary) and 15mm (Secondary);
- CPT04: 25mm (Primary) and 10mm (Secondary);
- CPT05: 30mm (Primary) and 10mm (Secondary); and
- CPT06: 20mm (Primary) and 5mm (Secondary).

On the basis of these preliminary settlement predictions, consolidation is predicted to be rapid with predominantly elastic settlements occurring which are predicted to be largely “built-out” during the earthworks and civil construction with predicted magnitudes of between 20mm to 35mm should be expected. Long-term post-construction or creep settlements over a design life of 50 years are predicted to be less than 15mm.

Depending on the depth of future proposed cut and fill earthworks, further site investigations as well as settlement analyses may need to be undertaken as part of any future detailed investigation and design. This should allow for the development of appropriate ground remediation options if necessary.

Weak and/or compressible subsoils may be subject to consolidation settlements due to potential loadings from industrial buildings and floor slabs. If any soft materials are discovered during earthworks, it is recommended to undercut them and replace with compacted engineered fill. In addition, general ground improvement methods, including pile foundation, reinforced fill rafts and basal reinforcement may be necessary to mitigate any potential settlement hazards identified.

6.10 Expansive Soils

Seasonal shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and/ or foundations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels. This hazard is addressed by a combination of careful foundation design and site preparation.

Although no laboratory expansive soil testing was conducted as part of this report, based on our experience and visual/ tactile assessment of the materials on-site, we recommend assuming a preliminary expansive class of H1 to H2. This should be assessed by laboratory testing once development proposals have been confirmed.

[15] CPeT-IT ver 3.0.2.1 by Geologismiki

6.11 Sensitive Soils

We caution that both the surface volcanic ash soils and the underlying Puketoka Formation soils can be prone to strength loss/sensitivity to disturbance once bulk excavated. Filling can be difficult and requires additional conditioning when compared with more plastic clays. Allowance should be made for conditioning, re-working and possibly lime/cement stabilisation. We recommend laboratory testing is undertaken including soil limits and compaction curve testing once development proposals have been confirmed.

6.12 Earthworks

All earthworks should be undertaken in accordance with the following standards:

- NZS4431:1989 "Code of Practice for Earth Fill for Residential Development" and
- Section 2 "Earthworks & Geotechnical Requirements" of NZS4404:2010 "Land Development and Subdivision Infrastructure" and
- Section 2 "Earthworks and Geotechnical Requirements" of the Auckland Council Code of Practice for Land Development & Subdivision (Version 1.6 dated 24 September 2013).

We stress that all works should be undertaken in a careful and safe manner so that Health & Safety is not compromised, and that suitable Erosion & Sediment control measures are put in place. Any stockpiles placed should be constructed in an appropriate manner so that land stability and/or adjacent structures are not compromised.

It is anticipated South Auckland Volcanic, and Puketoka Formation soils will be won on-site from cut areas and re-used as fill across the more depressed site areas.

Given the stiffness, density and fabric of the soil units generally encountered in our investigation, it is expected that excavation of these materials will be readily achieved with conventional earthworks plant.

Whilst the proposed cut and fill depths are not yet confirmed, we consider that for the most part, the materials encountered within our investigation boreholes up to 2.0mbgl, should not present too many challenges during construction.

We caution that, depending on the time of year, the deeper soils may contain high moisture contents, along with more silty and possibly sandy soils, which can be sensitive to disturbance, and can make them particularly challenging to earthwork. These materials can be used within engineered fills although they may require block cutting and top loading techniques.

Where these materials are encountered, the amount of drying, blending and compaction effort required should not be underestimated.

Furthermore, contractors involved in any earthworks should be made aware of their presence. Sensitive soils can be difficult to work as they are prone to significant strength loss when disturbed and accordingly, careful site management is required.

Although widespread historic filling was not encountered in our hand auger boreholes across the site, due to historic land use there is potential that areas of uncontrolled fill will be encountered during earthworks construction. In particular around the man-made ponds, farm tracks and existing building platforms as well as the southern boundary of #350.

Underfill drains will need to be installed beneath new fills within low lying tributaries and gully inverts. Once a proposed cut fill earthworks plan is finalised, we can provide recommended locations for underfill drains.

Allowance must be made to remove and undercut soft materials before installation of underfill drainage,

6.13 Stormwater Soakage

Given that the sites soils are predominantly clayey in nature, coefficients of permeability are considered to be low. Accordingly, rain gardens / attenuation ponds are not expected to provide any significant ground soakage function.

If raingardens are required, then the design and placement of such structures must be reviewed by the geotechnical engineer to ensure that the details are appropriate for each location.

7 FUTURE FOUNDATIONS & DEVELOPMENT

Once the subdivisional works have been completed, a Geotechnical Completion Report (GCR) should be prepared confirming the earthworks have been completed satisfactorily with any geotechnical limitations expressed in terms of future site development. In addition, the GCR should provide geotechnical design recommendations for the development of future commercial / industrial buildings.

On this site our provisional expectation is that provided earthworks are completed in accordance with the standards and recommendations described herein, the following will apply:

7.1 Preliminary Foundation Recommendation

We consider that at this preliminary stage, for the areas of the site where filling is undertaken above existing ground level or where excavations of no more than 2.0mbgl are undertaken, a Geotechnical Ultimate Bearing Capacity (GUBC) of 300 kPa should be appropriate for shallow foundations design.

However, there is a risk that bulk excavations may expose sensitive soils, either at the surface or within the influence of shallow foundations and the GUBC may need to be lowered accordingly unless remedial works are undertaken to reinstate a competent foundation subgrade.

7.2 Expansive Soils

On the basis of our visual tactile assessment, results of laboratory testing and reference to BRANZ Report SR120A, we have provisionally assessed the AS2870 Site Class for the development to range between Class H1(Highly) to Class H2 (Highly subclass 2).

Mitigation of the expansive soil hazard is undertaken by a combination of appropriate foundation design selection at Building Consent stage and appropriate moisture control within subgrade soils during construction. Usual solutions to mitigate these risks include (but are not limited to):

- specifically designed or proprietary stiffened foundation systems.
- deepening and/or piling of foundations.
- undercutting and replacing reactive soil subgrade with non-reactive hardfill; and/or
- controls on planting of certain tree species close to buildings.

Foundation contractors must also be aware of this issue and the need to maintain appropriate moisture contents in the footings and building platform subgrade between the time of excavation and pouring concrete. Remedial actions that may be appropriate include platform protection with a hard fill layer, pouring of a blinding layer of concrete in footing bases and soaking of the building platform with sprinklers for an extended period.

The resulting effects of possible shrinkage and swelling in relation to brittle building construction should be considered at the time of preparation of the relevant Geotechnical Completion Report which will require further representative sampling of soils and subsequent testing of the magnitude of possible shrinkage and swelling generally in accordance with AS2870:2011 which will require specific soil characterisation by laboratory testing.

8 FURTHER WORK

This Geotechnical Assessment Report has been prepared without the benefit of reviewing earthworks development proposals. For this reason, this report should only be used for the purposes of a feasibility study as intended. CMW Geosciences must be given the opportunity to review earthworks development proposals and undertake further work as described later herein prior to any Consent application.

Following a review of the proposed earthworks and civil plans, we recommend the following scope of work be undertaken:

- More detailed site investigation to better define the extents and compressibility risks, in particular the low-lying area in southern third of #370.
- Additional Cone Penetration Tests (CPT) to target areas of filling where consolidation of soils at depth under the additional loading may cause significant settlements at ground surface. Our current level of site investigation is lean given the primary purpose of feasibility level reporting only.
- Slope stability analyses may be required with a particular focus on proposed stormwater ponds, any proposed gradients steeper than 1V:3H, and critical areas that require retention due to proposed earthworks.
- Further detailed geotechnical reporting and analysis specific to the proposed development plans.

9 CLOSURE

Additional important information regarding the use of your CMW report is provided in the 'Using your CMW Report' document attached to this report.

This report has been prepared for use by Dines Group Limited in relation to a Geotechnical Assessment Report 350 & 370 Karaka Road, Drury as well as in accordance with the scope, proposed uses and limitations described in the report. Should you have further questions relating to the use of your report please do not hesitate to contact us.

Where a party other than Dines Group Limited to rely upon or otherwise use this report, the consent of CMW should be sought prior to any such use. CMW can then advise whether the report and its contents are suitable for the intended use by the other party.

For and on behalf of CMW Geosciences

Prepared by:	Reviewed and authorised by:
Richard Tichborne	Eugene Crestanello
Senior Engineering Geologist	**Associate Engineering Geologist**
richardt@cmwgeo.com	eugenec@cmwgeo.com

Distribution: 1 electronic copy to Dines Group Limited
Original held at CMW Geosciences.

Appendices:

Appendix A: Site Investigation Plan

Appendix B: Hand Auger Logs

Appendix C: CPT Investigation Data

USING YOUR CMW GEOTECHNICAL REPORT

Geotechnical reporting relies on interpretation of facts and collected information using experience, professional judgement, and opinion. As such it generally has a level of uncertainty attached to it, which is often far less exact than other engineering design disciplines. The notes below provide general advice on what can be reasonably expected from your report and the inherent limitations of a geotechnical report.

Preparation of your report

Your geotechnical report has been written for your use on your project. The contents of your report may not meet the needs of others who may have different objectives or requirements. The report has been prepared using generally accepted Geotechnical Engineering and Engineering Geology practices and procedures. The opinions and conclusions reached in your report are made in accordance with these accepted principles. Specific items of geotechnical or geological importance are highlighted in the report.

In producing your report, we have relied on the information which is referenced or summarised in the report. If further information becomes available or the nature of your project changes, then the findings in this report may no longer be appropriate. In such cases the report must be reviewed, and any necessary changes must be made by us.

Your geotechnical report is based on your project's requirements

Your geotechnical report has been developed based on your specific project requirements and only applies to the site in this report. Project requirements could include the type of works being undertaken; project locality, size and configuration; the location of any structures on or around the site; the presence of underground utilities; proposed design methodology; the duration or design life of the works; and construction method and/or sequencing.

The information or advice in your geotechnical report should not be applied to any other project given the intrinsic differences between different projects and site locations. Similarly geotechnical information, data and conclusions from other sites and projects may not be relevant or appropriate for your project.

Interpretation of geotechnical data

Site investigations identify subsurface conditions at discrete locations. Additional geotechnical information (e.g. literature and external data source review, laboratory testing etc) are interpreted by Geologists or Engineers to provide an opinion about a site specific ground models, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist due to the variability of geological environments. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. Interpretation of factual data can be influenced by design and/or construction methods. Where these methods change review of the interpretation in the report may be required.

Subsurface conditions can change

Subsurface conditions are created by natural processes and then can be altered anthropically or over time. For example, groundwater levels can vary with time or activities adjacent to your site, fill may be placed on a site, or the consistency of near surface conditions might be susceptible to seasonal changes. The report is based on conditions which existed at the time of investigation. It is important to confirm whether conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

Interpretation and use by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical report. To help avoid misinterpretations, it is important to retain the assistance of CMW to work with other project design professionals who are affected by the contents of your report. CMW staff can explain the report implications to design professionals and then review design plans and specifications to see that they have correctly incorporated the findings of this report.

Your report's recommendations require confirmation during construction

Your report is based on site conditions as revealed through selective point sampling. Engineering judgement is then applied to assess how indicative of actual conditions throughout an area the point sampling might be. Any assumptions made cannot be substantiated until construction is complete. For this reason, you should retain geotechnical services throughout the construction stage, to identify variances from previous assumption, conduct additional tests if required and recommend solutions to problems encountered on site.

A Geotechnical Engineer, who is fully familiar with the site and the background information, can assess whether the report's recommendations remain valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misinterpreted.

Environmental Matters Are Not Covered

Unless specifically discussed in your report environmental matters are not covered by a CMW Geotechnical Report. Environmental matters might include the level of contaminants present of the site covered by this report, potential uses or treatment of contaminated materials or the disposal of contaminated materials. These matters can be complex and are often governed by specific legislation.

The personnel, equipment, and techniques used to perform an environmental study can differ significantly from those used in this report. For that reason, our report does not provide environmental recommendations. Unanticipated subsurface environmental problems can have large consequences for your site. If you have not obtained your own environmental information about the project site, ask your CMW contact about how to find environmental risk-management guidance.

Appendix A: Site Investigation Plan

LEGEND:

- HA01-22 HAND AUGER (HA) LOCATION
- CPT01-22 CONE PENETROMETER TEST (CPT) LOCATION
- SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS MAP

0 50 100 150 200 250 m

1:5000

CMW Geosciences

CLIENT:	DINES GROUP LIMITED	DRAWN:	JS	PROJECT:	AKS2022-0029
PROJECT:	350 & 370 KARAKA ROAD, DRURY	CHECKED:	RT	DRAWING:	01
		REVISION:	A	SCALE:	XXX
TITLE:	SITE INVESTIGATION PLAN	DATE:	25/05/2022	SHEET:	A3 L

\\CMWGEOSCIENCES.SHAREPOINT.COM@SSL\DAVWWWROOT\SITES\TICHSTEAM\SHARED DOCUMENTS\SOUTH AUCKLAND PROJECT DOCUMENTS\2022\AKS2022-0029 350 & 370 KARAKA ROAD, KARAKA\DRAWINGS\AKS2022-0029 SITE INVESTIGATION PLAN.DWG

Appendix B: Hand Auger Logs

HAND AUGER BOREHOLE LOG - HA01-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 31/03/2022
Borehole Location: Refer to Site Plan   Logged by: KvR   Checked by: SF   Scale: 1:25   Sheet 1 of 1

CMW Geosciences

Position: 1771051.2mE; 5889390.7mN Projection: NZTM
Elevation: 32.00m   Datum: AUCKHT1946   Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			32.0		OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)			
			31.8		CL: Silty CLAY: Brown. Low plasticity. Insensitive. (South Auckland Volcanics)	D		
	0.4	Peak = >192.9kPa						
	0.8	Peak = >192.9kPa						
			31.0	1	ML: Clayey SILT with trace fine sand: Light brownish orange. Low plasticity. Insensitive. (South Auckland Volcanics)	D to M		
	1.2	Peak = >192.9kPa						
	1.6	Peak = >192.9kPa						
	2.0	Peak = >192.9kPa		2				
	2.4	Peak = >192.9kPa						
			29.5		CL: Clayey SILT: Light brownish orange mottled minor orange. Low plasticity. Insensitive. (South Auckland Volcanics)	M	VSt	
	2.8	Peak = >192.9kPa						
			29.0	3	CH: Silty CLAY: Grey mottled light red. High plasticity. (Puketoka Formation)			
	3.2	Peak = 151kPa Residual = 126kPa						
					... *at 3.50m, Becoming white mottled light red and orange.*	M to W		
	3.6	Peak = 190kPa Residual = 157kPa						
	4.0	Peak = 118kPa Residual = 110kPa		4				
	4.4	Peak = >192.9kPa						
	4.8	Peak = 190kPa Residual = 120kPa				W		
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2082   DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA02-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to Site Plan | Logged by: KvR | Checked by: SF | Scale: 1:25 | Sheet 1 of 1

Position: 1771344.4mE; 5889601.0mN Projection: NZTM
Elevation: 29.00m | Datum: AUCKHT1946 | Survey Source: Hand Held GPS

Groundwater	Depth	Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			29.0		OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)	D		
			28.1		ML: Clayey SILT: Orange brown. Low plasticity. Insensitive to moderately sensitive. (South Auckland Volcanics)			
	1.0	Peak = >192.9kPa		1			VSt	
	1.2	Peak = 139kPa Residual = 44kPa						
	1.6	Peak = >192.9kPa			... *at 1.60m, Becoming mottled trace red, orange and white.*			
	2.0	Peak = >192.9kPa		2				
	2.4	Peak = 134kPa Residual = 94kPa	26.6		CH: Silty CLAY: White mottled minor pink and light orange. High plasticity, Insensitive to moderately sensitive. (Puketoka Formation)	M		
	2.8	Peak = 99kPa Residual = 58kPa						
				3			St	
	3.2	Peak = 84kPa Residual = 47kPa						
					... *at 3.40m, Becoming white mottled minor light pink with trace fine to medium sand.*	M to W		
	3.6	Peak = 154kPa Residual = 41kPa						
					... *at 3.80m, Becoming white with minor fine to medium sand.*			
	4.0	Peak = 139kPa Residual = 55kPa	25.0	4	SM: Fine to medium sandy SILT with minor clay: White. Low plasticity. Insensitive to moderately sensitive. (Puketoka Formation)		VSt	
	4.4	Peak = >192.9kPa						
					... *at 4.50m, Becoming with no clay.*	W to S		
	4.8	Peak = UTP					H	
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2082 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA03-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 31/03/2022
Borehole Location: Refer to Site Plan   Logged by: RDK   Checked by: SF   Scale: 1:25   Sheet 1 of 1

Position: 1771121.1mE; 5889671.4mN   Projection: NZTM
Elevation: 27.50m   Datum: AUCKHT1946   Survey Source: Hand Held GPS

Groundwater	Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density
			27.5		OL: TOPSOIL: Dark brown. Low plasticity. Trace rootlets. (Topsoil)		
			27.4		CL: CLAY: Brown. Low plasticity. (South Auckland Volcanics)	D	H
	0.4	Peak = UTP					
					... from 0.50m to 1.20m, Becoming orange brown mottled black with some silt	D to M	
	0.8	Peak = UTP					
				1			
	1.2	Peak = >197.6kPa	26.3		CH: Silty CLAY: Reddish orange brown mottled trace light grey and black. (South Auckland Volcanics)	M	VSt
	1.6	Peak = 184kPa Residual = 108kPa			... from 1.60m to 2.60m, Becoming grey mottled orange brown trace black.		
	2.0	Peak = >197.6kPa		2			
	2.4	Peak = >197.6kPa					
			24.9		CH: Silty CLAY: Light blue grey with trace orange and red. (Puketoka Formation)		
	2.8	Peak = 146kPa Residual = 100kPa					
				3			
	3.2	Peak = 170kPa Residual = 97kPa					
	3.6	Peak = 105kPa Residual = 59kPa			... from 3.70m to 4.20m, Becoming light brown with trace light grey and red mottled black.		
	4.0	Peak = 102kPa Residual = 56kPa		4			
					... from 4.20m to 4.50m, Becoming orange brown mottled some black.		
	4.4	Peak = 157kPa Residual = 91kPa			... from 4.50m to 5.00m, Becoming light brown trace orange and grey mottled black.		
	4.8	Peak = UTP					H
				5	Borehole terminated at 5.0 m		

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Termination Reason: Target Depth Reached
Shear Vane No: 3206   DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA04-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 31/03/2022
Borehole Location: Refer to Site Plan — Logged by: RDK — Checked by: SF — Scale: 1:25 — Sheet 1 of 1

Position: 1770957.8mE; 5889835.3mN Projection: NZTM
Elevation: 21.90m — Datum: AUCKHT1946 — Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit); Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			21.9		OL: TOPSOIL: Brown. Low plasticity. (Topsoil)	D		
			21.8		CL: Silty CLAY: Brown. Low plasticity. (South Auckland Volcanics)	D		
	0.4	Peak = 162kPa Residual = 26kPa			... *at 0.40m, Becoming mottled light grey with trace fine sand.*	D to M	VSt	
	0.8	Peak = 184kPa Residual = 48kPa				M	VSt	
				1				
	1.2	Peak = >197.6kPa	20.7		CH: Silty CLAY: Light grey mottled some brown and dark grey. High plasticity. Insensitive to moderately sensitive. (Puketoka Formation)	M	VSt	
	1.6	Peak = 170kPa Residual = 53kPa				M	VSt	
	2.0	Peak = 149kPa Residual = 61kPa		2		M	VSt	
					... *at 2.20m, Becoming orange brown mottled some grey.*	M	VSt	
	2.4	Peak = 157kPa Residual = 56kPa				M	VSt	
	2.8	Peak = 170kPa Residual = 50kPa				M	VSt	
				3				
	3.2	Peak = UTP	18.7		MH: Silty CLAY with some fine to coarse sand: Blue grey. High plasticity. Insensitive. (Puketoka Formation)	M	H	
	3.6	Peak = 119kPa Residual = 48kPa				M	VSt	
					... *at 3.70m, Becoming light blue grey with trace fine sand.*	M	VSt	
	4.0	Peak = 102kPa Residual = 56kPa		4		M	VSt	
	4.4	Peak = 75kPa Residual = 40kPa				M	St	
	4.8	Peak = 75kPa Residual = 42kPa				M	St	
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 3206 — DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA05-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 31/03/2022
Borehole Location: Refer to Site Plan   Logged by: RDK   Checked by: SF   Scale: 1:25   Sheet 1 of 1

Position: 1771300.0mE; 5889959.3mN Projection: NZTM
Elevation: 25.80m   Datum: AUCKHT1946   Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			25.8			OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)	D		
			25.7			ML: Clayey SILT: Brown. Low plasticity. Insensitive. (South Auckland Volcanics)			
	0.4	Peak = >197.4kPa							
	0.8	Peak = >197.4kPa						VSt	
				1					
	1.2	Peak = UTP						H	
	1.6	Peak = >197.4kPa							
			24.1			CH: Silty CLAY: Orange brown mottled trace grey and black. High plasticity. Insensitive. (Puketoka Formation)	D to M		
	2.0	Peak = 140kPa Residual = 72kPa		2					
	2.4	Peak = 157kPa Residual = 86kPa						VSt	
						... at 2.70m, Becoming brown mottled some grey trace orange, black, red.			
	2.8	Peak = 146kPa Residual = 91kPa							
				3					
	3.2	Peak = 181kPa Residual = 64kPa	22.6			ML: Sandy SILT: Light blue grey mottled orange, dark brown and black. (Puketoka Formation)	M		
	3.6	Peak = UTP							
	4.0	Peak = UTP		4				H	
						... at 4.30m, Becoming light blue grey mottled dark grey.			
	4.4	Peak = UTP							
	4.8	Peak = >197.4kPa						VSt	
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 3206   DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA06-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to Site Plan | Logged by: KvR | Checked by: SF | Scale: 1:25 | Sheet 1 of 1

CMW Geosciences

Position: 1770753.3mE; 5889735.8mN Projection: NZTM
Elevation: 24.00m Datum: AUCKHT1946 Survey Source: Hand Held GPS

Samples & Insitu Tests

Depth	Type & Results
0.4	Peak = >192.9kPa
0.8	Peak = >192.9kPa
1.2	Peak = 99kPa Residual = 58kPa
1.6	Peak = 139kPa Residual = 55kPa
2.0	Peak = 145kPa Residual = 44kPa
2.4	Peak = 172kPa Residual = 50kPa
2.8	Peak = >192.9kPa
3.2	Peak = 168kPa Residual = 44kPa
3.6	Peak = 126kPa Residual = 44kPa
4.0	Peak = >192.9kPa
4.4	Peak = 134kPa Residual = 44kPa
4.8	Peak = 131kPa Residual = 64kPa

Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density
24.0	0.0	OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)	D	
23.9	0.1	CH: SIlty CLAY: Orange brown. High plasticity. Insensitive to moderately sensitive. (South Auckland Volcanics)	D	VSt
	1.0	... at 1.00m, Becoming mottled minor red.	D to M	VSt / St
	1.5	... at 1.50m, Becoming mottled light grey.	M	St / VSt
	1.8	... at 1.80m, Becoming orange mottled red.	M	VSt
	2.0	... from 2.00m to 2.20m, Becoming white mottled orange and pink.	M	VSt
21.8	2.2	ML: SILT with some fine to medium sand and trace clay: Light orange brown. Low plasticity. Insensitive to moderately sensitive. (Puketoka Formation)	M; M to W	VSt
	4.2	... at 4.20m, Becoming light grey.	W; W to S; S	VSt
	5.0	Borehole terminated at 5.0 m		

Groundwater: Ingress; 01-04-2022

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Termination Reason: Target Depth Reached
Shear Vane No: 2082 DCP No:
Remarks: Groundwater encountered at 4.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA07-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to Site Plan | Logged by: KvR | Checked by: SF | Scale: 1:25 | Sheet 1 of 1

Position: 1770912.4mE; 5889589.4mN Projection: NZTM
Elevation: 17.50m | Datum: AUCKHT1946 | Survey Source: Hand Held GPS

Groundwater	Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			17.5	0	OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)			
			17.3	0.2	MH: Clayey SILT: Light orange brown. High plasticity. Insensitive to moderately sensitive. (South Auckland Volcanics)			
	0.4	Peak = 190kPa Residual = 47kPa				D		
	0.8	Peak = >192.9kPa			... at 0.80m, Becoming mottled trace red.			
				1				
	1.2	Peak = >192.9kPa				M		
					... at 1.40m, Becoming mottled trace white.			
	1.6	Peak = >192.9kPa						
					... at 1.80m, Becoming with trace fine sand.			
	2.0	Peak = >192.9kPa		2				
			15.3	2.2	ML: SILT with some fine sand and trace clay: Light orange brown. Low plasticity. Insensitive to moderately sensitive. (Puketoka Formation)			
	2.4	Peak = >192.9kPa				M to W	VSt	
	2.8	Peak = >192.9kPa			... from 2.80m to 2.90m, Becoming mottled some light grey.			
				3				
	3.2	Peak = >192.9kPa						
					... at 3.50m, Becoming dark orange.			
	3.6	Peak = >192.9kPa						
	4.0	Peak = >192.9kPa		4		W		
Ingress	4.4	Peak = >192.9kPa						
					... at 4.50m, Becoming light grey mottled orange with trace fine sand.			
01-04-2022	4.8	Peak = 186kPa Residual = 41kPa				W to S		
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2082 | DCP No:
Remarks: Groundwater encountered at 4.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA08-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to Site Plan | Logged by: KvR | Checked by: SF | Scale: 1:25 | Sheet 1 of 1

Position: 1770786.0mE; 5889260.4mN Projection: NZTM
Elevation: 25.00m Datum: AUCKHT1946 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			25.0		OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)			
			24.8		CH: Clayey SILT: Orange brown. High plasticity. Insensitive. (South Auckland Volcanics)	D		
	0.4	Peak = >192.9kPa						
	0.8	Peak = >192.9kPa			... at 0.80m, *Becoming light grey mottled light orange with minor fine sand.*	D to M		
				1				
	1.2	Peak = >192.9kPa						
	1.6	Peak = >192.9kPa						
			23.2		ML: Fine sandy SILT: Light pink mottled minor light orange and grey. Low plasticity. Insensitive to moderately sensitive. (Puketoka Formation)	M	VSt	
	2.0	Peak = >192.9kPa		2				
	2.4	Peak = >192.9kPa						
	2.8	Peak = 139kPa Residual = 30kPa						
				3	... at 3.00m, *Becoming with trace clay.*			
	3.2	Peak = 112kPa Residual = 58kPa			... at 3.20m, *Becoming light brown grey mottled minor light orange and pink.*			
	3.6	Peak = 99kPa Residual = 67kPa					St	
	4.0	Peak = 92kPa Residual = 50kPa		4		M to W		
	4.4	Peak = 99kPa Residual = 50kPa						
Ingress	4.8	Peak = 126kPa Residual = 52kPa				W	VSt	
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2082 DCP No:
Remarks: Groundwater not encountered.

HAND AUGER BOREHOLE LOG - HA09-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to site plan | Logged by: CK | Checked by: SF | Scale: 1:25 | Sheet 1 of 1

Position: 1771036.4mE; 5889159.0mN Projection: NZTM
Elevation: 22.00m Datum: AUCKHT1946 Survey Source: Hand Held GPS

Groundwater	Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density
			22.0		OL: TOPSOIL: dark brown. Low plasticity.		
			21.8		Pt: Fibrous silty PEAT: blackish brown. Low plasticity. Moderately sensitive. Minor rootlets and brown wood fragments. (Puketoka Formation)	M to W	St
	0.4	Peak = 91kPa Residual = 34kPa					
01-04-2022	0.8	Peak = 59kPa Residual = 18kPa					
			21.0	1	CL: Silty CLAY with trace sand: brown. Low plasticity. Sand: fine. Insensitive to moderately sensitive. (Puketoka Formation)	W to S	
	1.2	Peak = 29kPa Residual = 12kPa					
	1.6	Peak = 34kPa Residual = 21kPa				S	F
	2.0	Peak = 59kPa Residual = 18kPa		2			St
	2.4	Peak = 42kPa Residual = 26kPa					
	2.8	Peak = 37kPa Residual = 26kPa	19.2		CH: CLAY: brown mottled light brown and grey. High plasticity. (Puketoka Formation)	W to S	F
				3			
	3.2	Peak = 78kPa Residual = 42kPa					
	3.6	Peak = 83kPa Residual = 59kPa					St
	4.0	Peak = 132kPa Residual = 89kPa		4			
	4.4	Peak = 127kPa Residual = 48kPa					VSt
	4.8	Peak = 132kPa Residual = 64kPa					
				5	Borehole terminated at 5.0 m		

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Termination Reason: Target Depth Reached
Shear Vane No: DCP No:
Remarks: Groundwater encountered at 1.0m. Poor recovery from 1.3m to 2.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA10-22

Client: Dines Group Limited
Project: 350 & 370 Karaka Road
Site Location: Drury
Project No.: AKS2022-0029
Date: 01/04/2022
Borehole Location: Refer to Site Plan   Logged by: KvR   Checked by: SF   Scale: 1:25   Sheet 1 of 1

Position: 1770817.0mE; 5888872.6mN Projection: NZTM
Elevation: 19.00m Datum: AUCKHT1946 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit); Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			19.0		OL: TOPSOIL: Dark brown. Low plasticity. Minor rootlets. (Topsoil)	D		
			18.8		MH: Clayey SILT: Orange brown. High plasticity. Moderately sensitive. (South Auckland Volcanics)	D to M		
	0.4	Peak = 99kPa Residual = 44kPa						
	0.8	Peak = 81kPa Residual = 30kPa				M		
				1			St	
	1.2	Peak = 78kPa Residual = 44kPa	17.8		MH: Fine sandy SILT with minor clay: Light grey. high plasticity. Moderately sensitive. (Puketoka Formation)			
Ingres	1.6	Peak = 86kPa Residual = 27kPa			*... at 1.60m, Becoming light grey mottled minor orange.*			
	2.0	Peak = 120kPa Residual = 36kPa		2	*... at 2.00m, Becoming orange.*	W		
	2.4	Peak = 139kPa Residual = 58kPa						
01-04-2022	2.8	Peak = 131kPa Residual = 41kPa					VSt	
				3	*... from 3.00m to 3.40m, Becoming with some dark orange fine sand sized limonite inclusions.*			
	3.2	Peak = >192.9kPa						
	3.6	Peak = 86kPa Residual = 55kPa	15.3		CH: Silty CLAY: Dark grey. High plasticity. Insensitive. (Puketoka Formation)		St	
	4.0	Peak = 102kPa Residual = 70kPa		4		W to S	VSt	
	4.4	Peak = 99kPa Residual = 64kPa						
	4.8	Peak = 99kPa Residual = 58kPa					St	
				5	Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2082   DCP No:
Remarks: Groundwater encountered at 3.0m. Poor recovery 3.5-4.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

CMW Geosciences – SOIL (Field Logging Guide)

SEQUENCE OF TERMS:
Fine: Soil Symbol – Soil Type – Colour – Structure – (Consistency) – (Moisture) – Bedding – Plasticity – Sensitivity – Additional Comments – Origin/Geological Unit
Coarse: Soil Symbol – Soil Type – Colour – Structure – Grading – Particle shape – (Relative Density) – (Moisture) – Bedding – Additional Comments – Origin/Geological Unit

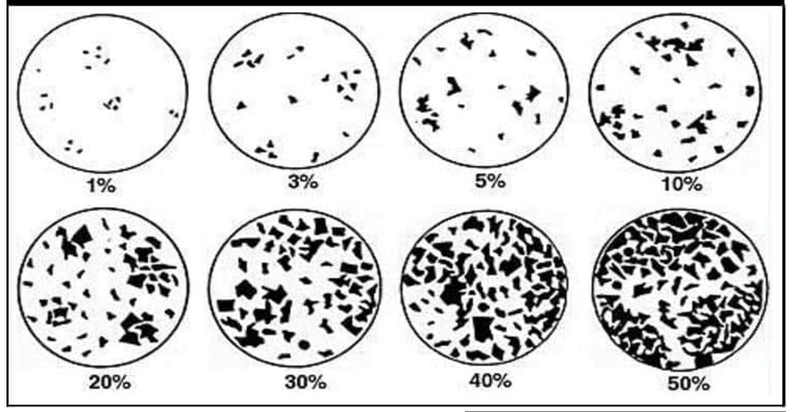
BEHAVIOURAL SOIL CLASSIFICATION SYSTEM

Major Divisions (behaviour based logging)			Soil Symbol	Soil Name
Coarse grained soils more than 65%>0.06mm	Gravel >50% of coarse fraction >2mm	Clean gravel <5% smaller 0.075mm	GW	Well graded gravel, fine to coarse gravel
			GP	Poorly graded gravel
		Gravel with >12% fines	GM	Silty gravel
			GC	Clayey gravel
	Sand ≥50% of coarse fraction <2mm	Clean sand	SW	Well-graded sand, fine to coarse sand
			SP	Poorly graded sand
		Sand with >12% fines	SM	Silty sand
			SC	Clayey sand
Fine grained soils 35% or more <0.06mm	Exhibits dilatant behaviour	inorganic	ML	Silt
			MH	Silt of high plasticity
		organic	OL	Organic silt
	No dilatant behaviour	inorganic	CL	Clay of low plasticity
			CH	Clay of high plasticity
		organic	OH	Organic clay
Highly Organic Soils			Pt	Peat

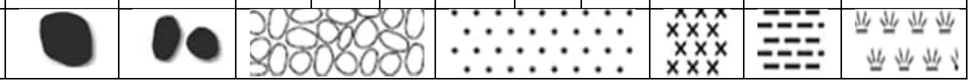
PROPORTIONAL TERMS DEFINITION

Fraction	Term	% of Soil Mass	Example
Major	(…) [UPPER CASE]	≥50 [major constituents]	GRAVEL
Subordinate	(…) [lower case]	20 – 50	Sandy
Minor	with some…	12 – 20	with some sand
	with minor…	5 – 12	with minor sand
	with trace of (or slightly)	< 5	with trace of sand (slightly sandy)

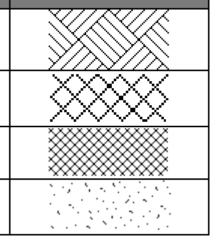
VISUAL PROPORTION PERCENTAGE



GRAIN SIZE CRITERIA

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		
Graphic Symbol											

ADDITIONAL GRAPHIC LOG SYMBOLS

Term	Symbol
Topsoil	
Fill	
Bitumen	
Concrete	

ORGANIC SOILS / DESCRIPTORS

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However, topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidize rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. **Firm:** Fibres already compressed together **Spongy:** Very compressible and open structure **Plastic:** Can be moulded in hand and smears in fingers **Fibrous:** Plant remains recognisable and retain some strength **Amorphous:** No recognisable plant remains
Rootlets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill)
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

SHADE AND COLOUR

1	2	3
light dark mottled streaked	pinkish reddish yellowish brownish greenish bluish greyish	pink red orange yellow brown green blue white grey black

SOIL STRUCTURE

Term	Description
Homogeneous	The total lack of visible bedding and the same colour and appearance throughout
Bedded	The presence of layers
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Polished	Fracture planes are polished or glossy
Slickensided	Fracture planes are striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensoidal	Discontinuous pockets of a soil within a different soil mass

GRADING (GRAVELS & SANDS)

Term	Description	
Well Graded	Good representation of all particle size ranges from largest to smallest	
Poorly Graded	Limited representation of grain sizes – further divided into:	
	Uniformly graded	Most particles about the same size
	Gap graded	Absence of one or more intermediate sizes

ROUNDING/PARTICLE SHAPE

Rounded	Subrounded	Subangular	Angular
			

CONSISTENCY TERMS FOR FINE SOILS

Descriptive term	Undrained Shear Strength (kPa)	Diagnostic Features	Abbreviation
Very Soft	<12	Easily exudes between fingers when squeezed	VS
Soft	12-25	Easily indented by fingers	S
Firm	25-50	Indented by strong finger pressure and can be indented by thumb pressure	F
Stiff	50-100	Cannot be indented by thumb pressure	St
Very Stiff	100-200	Can be indented by thumb nail	VSt
Hard	200-500	Difficult to indent by thumb nail	H

DENSITY INDEX (RELATIVE DENSITY) TERMS FOR COARSE SOILS

Descriptive term	Density Index (RD)	SPT "N" value (blows/300mm)	Dynamic Cone (blows/100mm)	Abbreviation
Very Dense	> 85	> 50	> 17	VD
Dense	65 - 85	30 - 50	7 - 17	D
Medium dense	35 - 65	10 - 30	3 - 7	MD
Loose	15 - 35	4 - 10	1 - 3	L
Very loose	< 15	< 4	0 - 2	VL

Note:

- Where strength data cannot be confirmed Loosely Packed (LP) and Tightly Packed (TP) may be used.
- No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Penetrometer (Scala) Test values.
- SPT "N" values are uncorrected.

MOISTURE CONDITION

Condition	Description	Coarse Soils	Fine Soils	Abbreviation
Dry	Looks and feels dry	Runs freely through hands	Hard, powdery or friable	D
Moist	Feels cool, darkened in colour	Tends to cohere	Weakened by moisture, but no free water on hands when remoulding	M
Wet			Weakened by moisture, free water forms on hands when handling	W
Saturated	Feels cool, darkened in colour and free water is present on the sample			S

BEDDING THICKNESS (Sedimentary)

Term	Bed Thickness
Thinly laminated	< 2mm
Laminated	2mm - 6mm
Very thin	6mm - 20mm
Thin	20mm - 60mm
Moderately thin	60mm - 200mm
Moderately thick	0.2m - 0.6m
Thick	0.6m - 2m
Very thick	> 2m

BEDDING INCLINATION

Term	Inclination (from horizontal)
Sub-horizontal	0º - 5º
Gently inclined	6º - 15º
Moderately inclined	16º - 30º
Steeply inclined	31º - 60º
Very steeply inclined	61º - 80º
Sub vertical	81º - 90º

SENSITIVITY OF SOIL

Descriptive Term	Shear Strength Ratio = $\frac{undisturbed}{remoulded}$
Insensitive, normal	< 2
Moderately sensitive	2 – 4
Sensitive	4 – 8
Extra sensitive	8 – 16
Quick	> 16

PLASTICITY (CLAYS & SILTS)

Term	Description
High plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendency to volume change
Low plasticity	When moulded can be crumbled in the fingers; may show quick or dilatant behaviour

CMW Geosciences – ROCK (Field Logging Guide)

SEQUENCE OF TERMS:

(Weathering) – Colour – Fabric or Bedding – Rock Name – (Strength) – Discontinuities – Additional notes – Origin/Geological Unit

SCALE OF ROCK MASS WEATHERING

Term	Grade	Description
Unweathered (fresh rock)	UW	Rockmass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.
Slightly Weathered	SW	The rock mass is not significantly weaker than when fresh. Rock may be discoloured along defects, some of which may have been opened slightly.
Moderately Weathered	MW	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to soil. Rock material may be discoloured and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration.
Highly Weathered	HW	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass is changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
Completely Weathered	CW	Original rock strength is lost, and the rock mass changed to a soil either by decomposition (with some rock fabric preserved) or by physical disintegration.
Residual Soil	RS	Rock is completely changed to a soil with the original fabric destroyed (pedological soil).

SHADE AND COLOUR

1	2	3
light dark mottled streaked	pinkish reddish yellowish brownish greenish bluish greyish	pink (pk) red (rd) orange (or) yellow (ye) brown (br) green (gr) blue (bl) white (wh) grey (gy) black (bk)

FABRIC TERMS

Fine (< 25mm)	Folded
Coarse (25 – 100mm)	Foliated
Massive (no fabric)	Gneissose
Banded	Interbedded
Bedded	Laminated
Cleaved	Lineated
Crossbedded	Schistose
Flowbanded	

BEDDING THICKNESS (Sedimentary)

Term	Bed Thickness
Thinly laminated	< 2mm
Laminated	2mm - 6mm
Very thin	6mm - 20mm
Thin	20mm - 60mm
Moderately thin	60mm - 200mm
Moderately thick	0.2m - 0.6m
Thick	0.6m - 2m
Very thick	> 2m

BEDDING INCLINATION

Term	Inclination (from horizontal)
Sub-horizontal	0º - 5º
Gently inclined	6º - 15º
Moderately inclined	16º - 30º
Steeply inclined	31º - 60º
Very steeply inclined	61º - 80º
Sub-vertical	81º - 90º

ROCK GRAPHIC LOG SYMBOLS

Type	Symbol
Siltstone	
Sandstone	
Mudstone	
Limestone	
Coal	
Breccia	
Conglomerate	
Igneous	
Metamorphic	
Pyroclastic (Volcanic Ash)	
Gypsum	

ROCK STRENGTH TERMS

Term	Abbreviation	Field Identification of Specimen	Unconfined uniaxial compressive strength q_u (MPa)	Point load strength $I_{s(50)}$ (MPa)
Extremely strong	ES	Can only be chipped with geological hammer	> 250	> 10
Very strong	VS	Requires many blows of geological hammer to break it	100 - 250	5 - 10
Strong	S	Requires more than one blow of geological hammer to fracture it	50 - 100	2 - 5
Moderately strong	MS	Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer	20 - 50	1 - 2
Weak	W	Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer	5 - 20	< 1
Very weak	VW	Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife	1 - 5	
Extremely weak (use soil description)	EW	Indented by thumb nail or other lesser strength terms used for soils	< 1	

Note: No correlation is implied between q_u and $I_{s(50)}$

SAMPLES

Sample	Abbreviation
Undisturbed sample 50mm	U50
Undisturbed sample 63mm	U63
SPT – sample recovered	N*
SPT – solid core	N_c
Bulk disturbed sample	B
Core sample	C

GROUNDWATER

Symbol	Definition
▼	Water strike or standing groundwater at date given
▽	Water strike (superseded by piezometer dip)

ADDITIONAL TERMS

Term	Definition
UTP	Unable to penetrate
RQD	Percentage of recovered core in lengths in excess of 100mm
Recovery	Percentage of recovered core

WELL INSTALLATION DETAILS

Term	Symbol
Plain standpipe	
Slotted standpipe	
Inclinometer	

WELL BACKFILL DETAILS

Term	Symbol
Bentonite Seal	
Sand Backfill	
Gravel Backfill	
Grout/Bentonite	
Concrete	

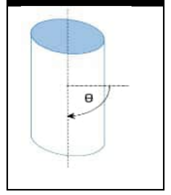
DRILLING METHOD

	Term/Diameter	Abbreviation
Drilling Method	Hand Auger	HA
	Open Barrel	OB
	Triple Tube	TT
	Core Loss	X
	Wash Bore	WB
	Percussion	PER
	Sonic	SNC
	Standard Penetration Test	SPT
Core Size	83.0mm	PQ3
	61.1mm	HQ3

SEQUENCE OF DEFECT TERMS

Sequence	Depth/depth range, number of defects, type, orientation, shape, roughness, aperture, infill description, seepage, block size and block shape
Example (abbreviation)	9.5m: 1, JN, 0º, PL, R, CL, LM
Example (description)	At 9.5 metres is one joint at 0º. Planar, rough, closed, with limonite infill

ORIENTATION



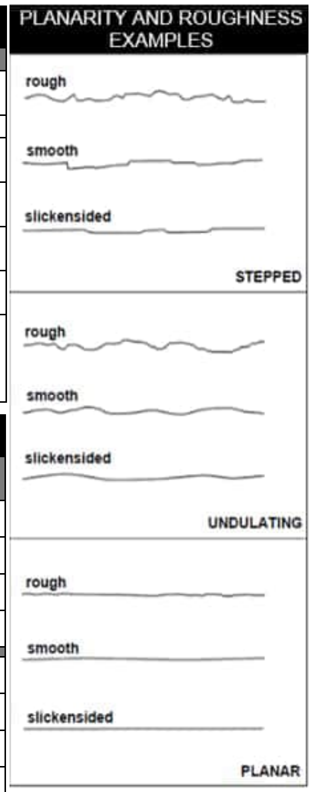
DEFECT TYPE TERMS

Term	Definition	Abbreviation
Drilling induced fracture	Fracture caused by drilling. Commonly smooth (core spun) or irregular (broke in tension)	DI
Contact	Surface between two different lithogies	CN
Bedding (may be open or closed)	Surface that separates each successive layer of stratified rock from its preceeding layer either parallel or sub-parallel to layering	B
Foliation	Repetitive layering in rocks caused by shearing and formed parallel to the direction of shear or perpendicular to the direction of higher pressure	F
Cleavage	Break along a planar anisotropic surface in rock determined by structure and strength of the crystal lattice Smooth surfaces often having reflective surfaces	CV
Joint	Single fracture across which rock has little or no tensile strength, but which is not parallel or sub-parallel to layering or planar anisotropy in the rock substance. May be open or closed.	JN
Sheared Zone	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joint, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	SZ
Sheared Surface	A near planar, curved or undulating surface, which is usually smooth, polished or slickensided	SS
Crushed Seam	Seam with roughly parallel, almost planar boundaries, composed of disorientated, usually angular fragments of the host rock. The seam has soil properties	CS
Decomposed Zone/Seam	Seam or zone of soil substance, often with gradational boundaries. Formed by weathering of the rock substance in place	WS
Infilled Seam/Zone	Seam or zone of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface	IS

PLANARITY AND ROUGHNESS

	Term	Description	Abbreviation
Planarity	Planar	The defect does not vary in orientation.	PL
	Undulating	The defect has a wavy surface.	UN
	Stepped	The defect has one or more well defined steps.	ST
	Note: The assessment of defect shape is partly influenced by the scale of the observation.		
Roughness	Slickensided	Grooved or striated surface usually polished.	SS
	Smooth	Smooth to touch. Few or no surface irregularities.	S
	Rough	Many small surface irregularities (amplitude generally more than 1mm). Feels like fine to coarse sandpaper.	R

PLANARITY AND ROUGHNESS EXAMPLES



APERTURE OF DISCONTINUITY SURFACES

Term	Aperture (mm)	Description	Abbreviation
Tight	Nil	Closed	CL
Very narrow	> 0 - 2		
Narrow	2 - 6		
Moderately narrow	6 - 20	Gapped	GA
Moderately wide	20 - 60	Open	OP
Wide	60 - 200		
Very wide	> 200		

INFILL TYPE

Term	Abbreviation
Clean	CN
Coated (Material)	CO
Infill (Material)	IF
Stained (Material/Colour)	ST

INFILL MATERIAL

Term	Abbreviation
Clay	CL
Silt	Z
Sand	S
Gravel	G
Calcite	CA
Carbonaceous	CB
Limonite	LM
Manganese	MG
Mica	MI
Pyrite	PY
Quartz	QZ
Sulphides	SU

SEEPAGE

Term	Abbreviation
Wet	W
Seepage	SP
Flow	F

SPACING OF DEFECTS/DISCONTINUITIES

Term	Spacing
Very widely spaced	> 2m
Widely spaced	600mm - 2m
Moderately widely spaced	200mm - 600mm
Closely spaced	60mm - 200mm
Very closely spaced	20mm - 60mm
Extremely closely spaced	< 20mm

DESCRIPTION OF BLOCK SIZE IN THE ROCK MASS

Term	Average Dimension	Abbreviation
Very Small	< 60mm	VS
Small	60 - 200mm	S
Medium	200 - 600mm	M
Large	600mm - 2m	L
Very Large	> 2m	VL

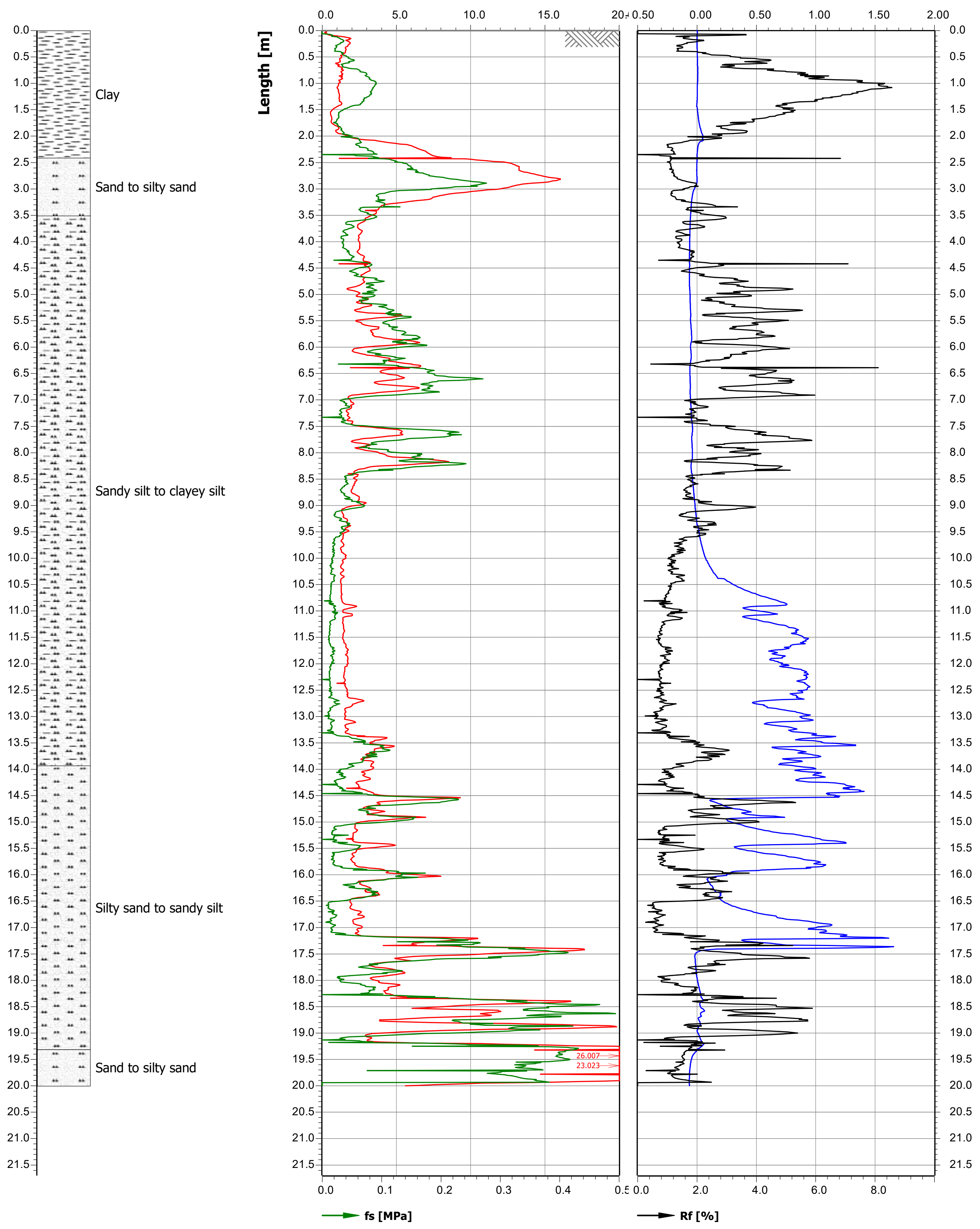
ROCK MASS BLOCK SHAPE

Block shape	Discontinuity Arrangement	Abbreviation
Polyhedral	Irregular discontinuities without arrangement into distinct sets, and of small persistence	Po
Tabular	One dominant set of parallel discontinuities (eg bedding planes), with other non-continuous discontinuities; block length and width >> thickness	Ta
Prismatic	Two dominant sets of discontinuities orthogonal and parallel, with a third irregular set; block length and width >> thickness	Pr
Equidimensional	Three dominant orthogonal sets of discontinuities, with some irregular discontinuities	Eq
Rhomboidal	Three or more dominant, mutually oblique sets of discontinuities; oblique shaped equidimensional blocks	Rh
Columnar	Several (usually more than three) sets of continuous, parallel discontinuities crossed by irregular discontinuities; length >> other dimensions	Co

Appendix C: CPT Investigation Data

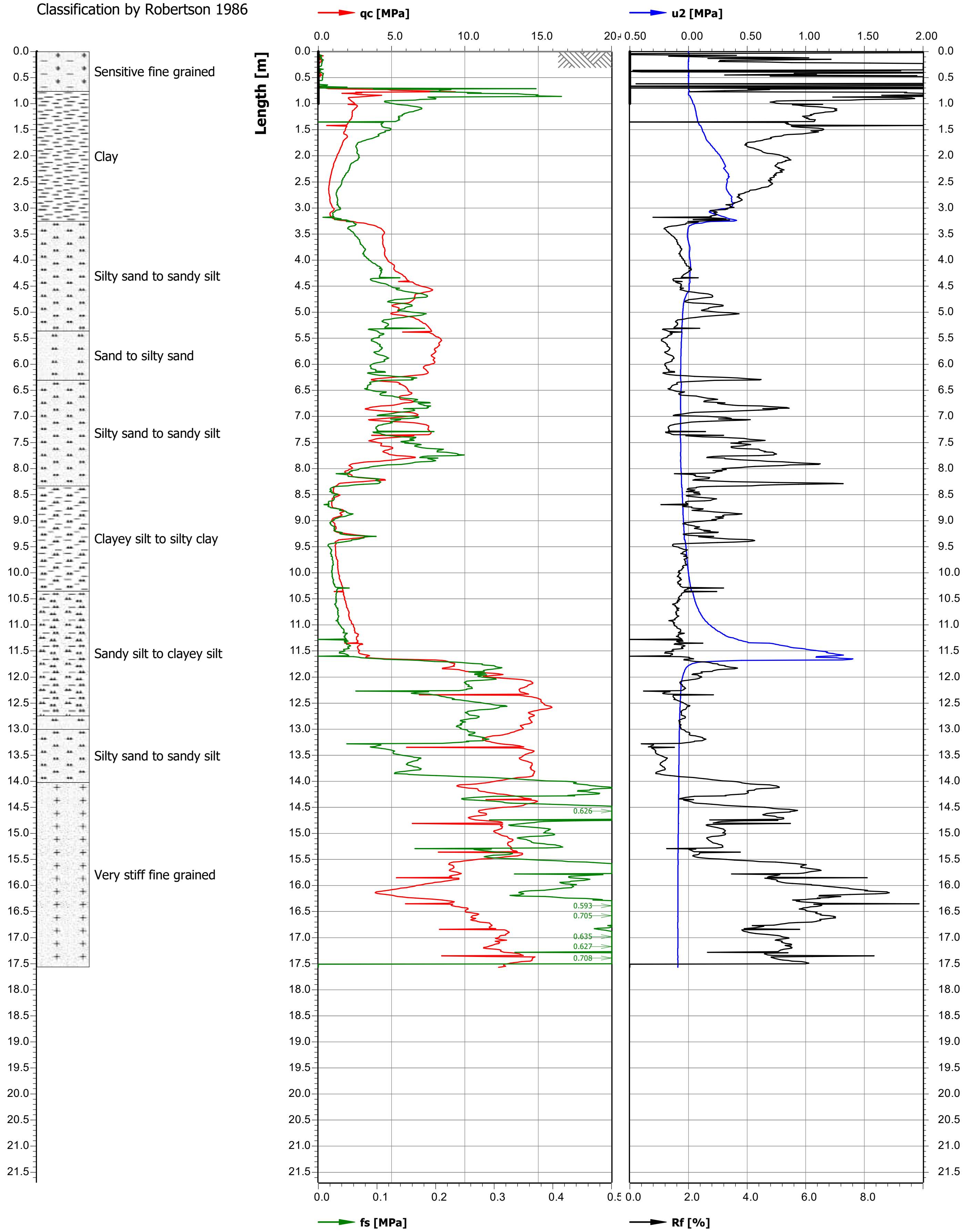
PRO-DRILL SPECIALIST DRILLING ENGINEERS	Project name CMW-AKS2022-0029	Date investigation 14/04/2022	
	Test name CPT02-22	Cone name S10CFIIP.2097	
Test location name	Client CMW	Net surface area quotient of ... 0.800/0.000	Nominal surface area of cone... 10.0/150.0
X coordinate [m]/Y coordinat... 0.00/0.00	Project contractors	Fig. no.:	
Z value [m] 0.00	Project engineer	Scale 1:100	Page 1/1
Remarks1			

Classification by Robertson 1986



PRO-DRILL SPECIALIST DRILLING ENGINEERS	Project name CMW-AKS2022-0029	Date investigation 14/04/2022	
	Test name CPT04-22	Cone name S10CFIIP.2097	
Test location name	Client CMW	Net surface area quotient of ... 0.800/0.000	Nominal surface area of cone... 10.0/150.0
X coordinate [m]/Y coordinat... 0.00/0.00	Project contractors	Fig. no.:	
Z value [m] 0.00	Project engineer	Scale 1:100	Page 1/1
Remarks1			

Classification by Robertson 1986



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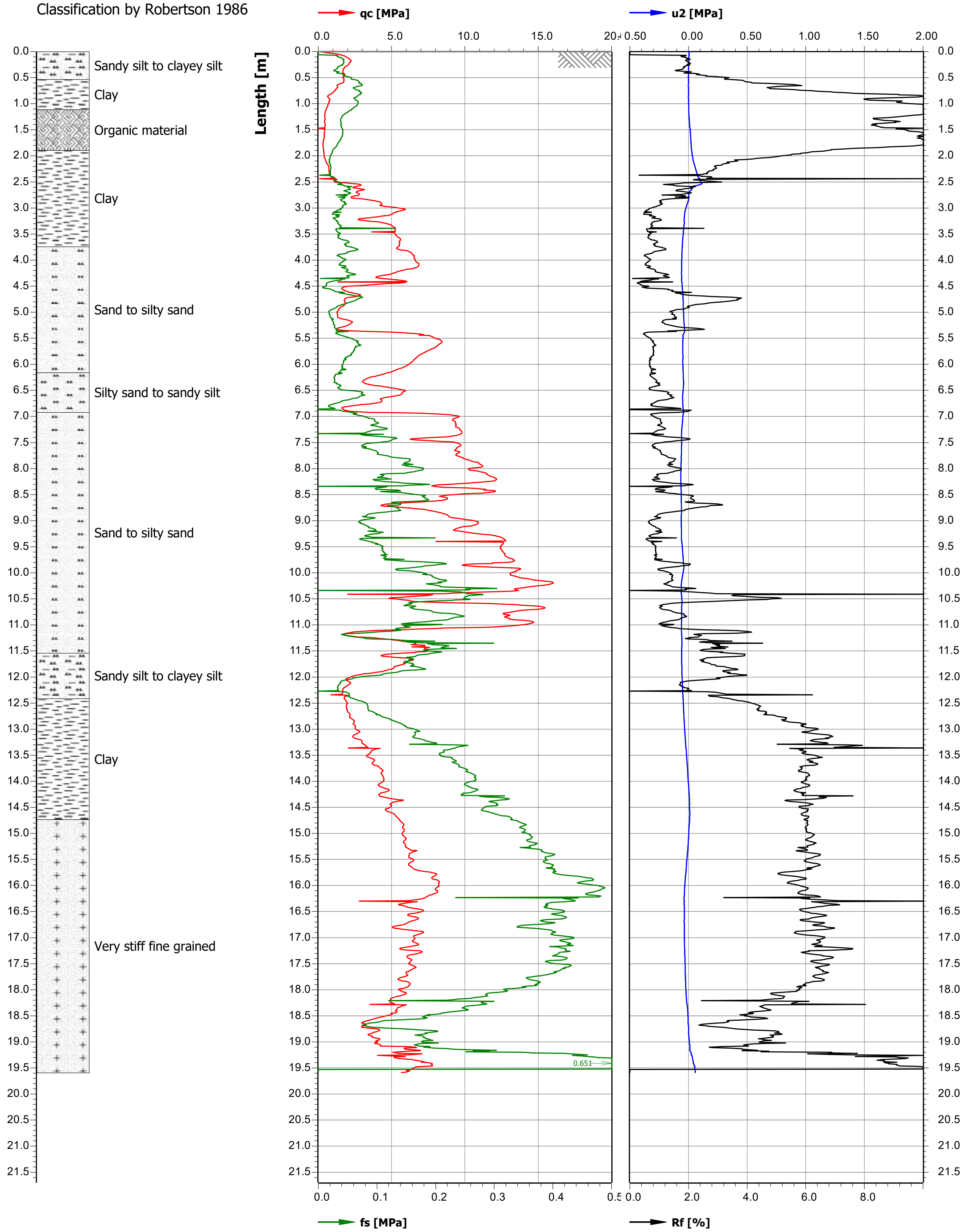
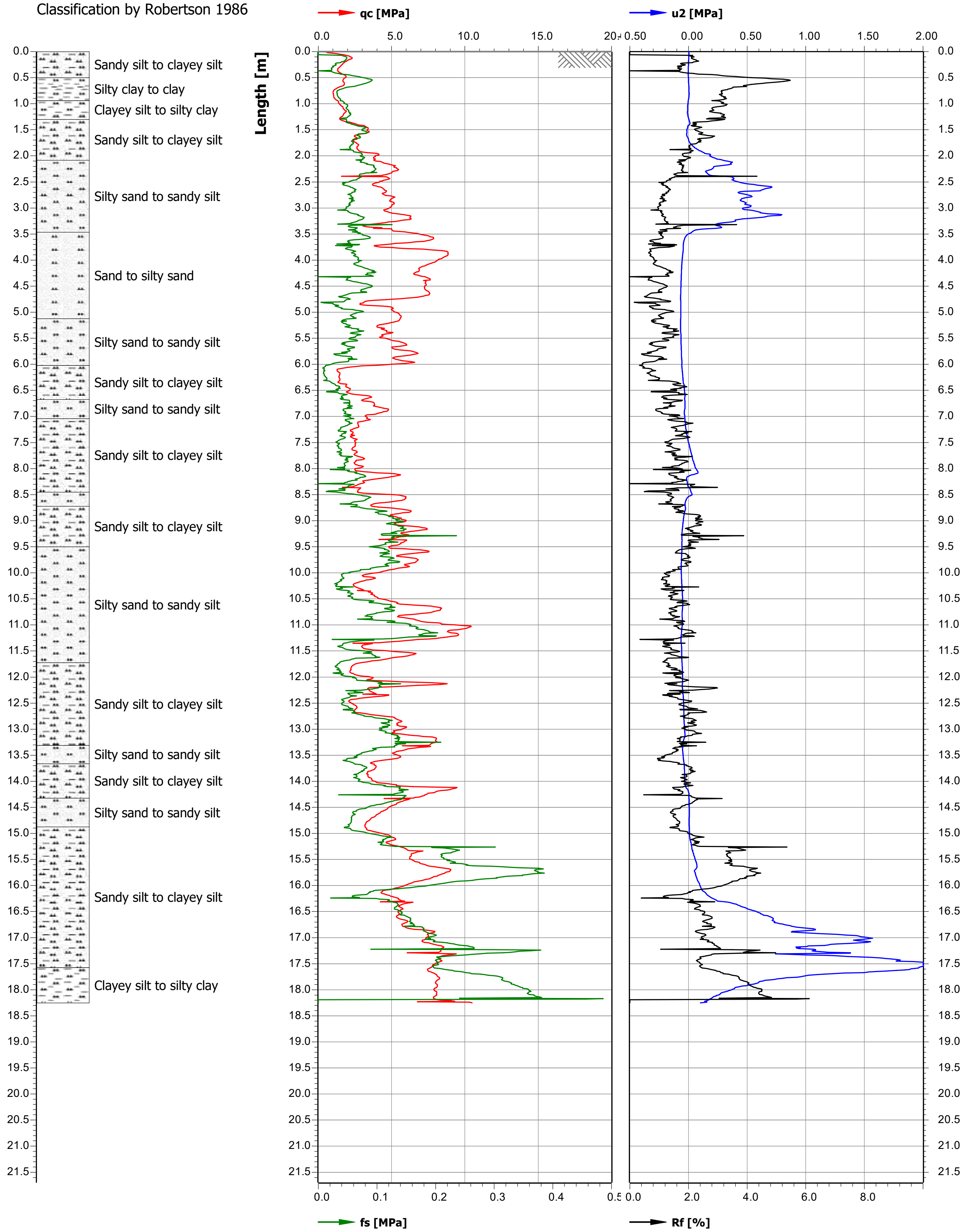
	Test name CPT05-22	Cone name S10CFIIP.2097	
Test location name	Client CMW	Net surface area quotient of ... 0.800/0.000	Nominal surface area of cone... 10.0/150.0
X coordinate [m]/Y coordinat... 0.00/0.00	Project contractors	Fig. no.:	
Z value [m] 0.00	Project engineer	Scale 1:100	Page 1/1
Remarks1			



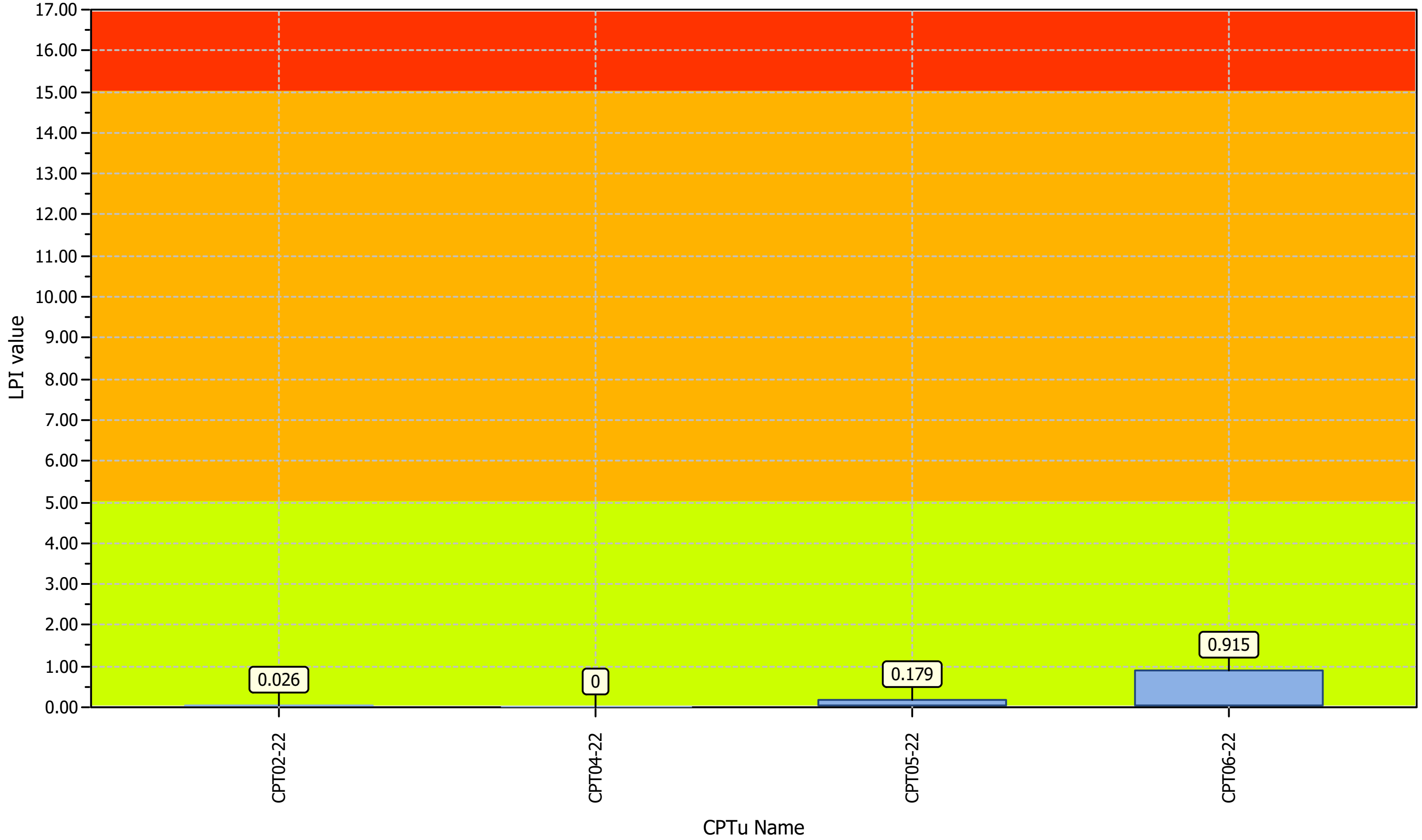
PRO-DRILL SPECIALIST DRILLING ENGINEERS	Project name CMW-AKS2022-0029	Date investigation 14/04/2022	
	Test name CPT06-22	Cone name S10CFIIP.2097	
Test location name	Client CMW	Net surface area quotient of ... 0.800/0.000	Nominal surface area of cone... 10.0/150.0
X coordinate [m]/Y coordinat... 0.00/0.00	Project contractors	Fig. no.:	
Z value [m] 0.00	Project engineer	Scale 1:100	Page 1/1
Remarks1			



Project title :

Location :

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

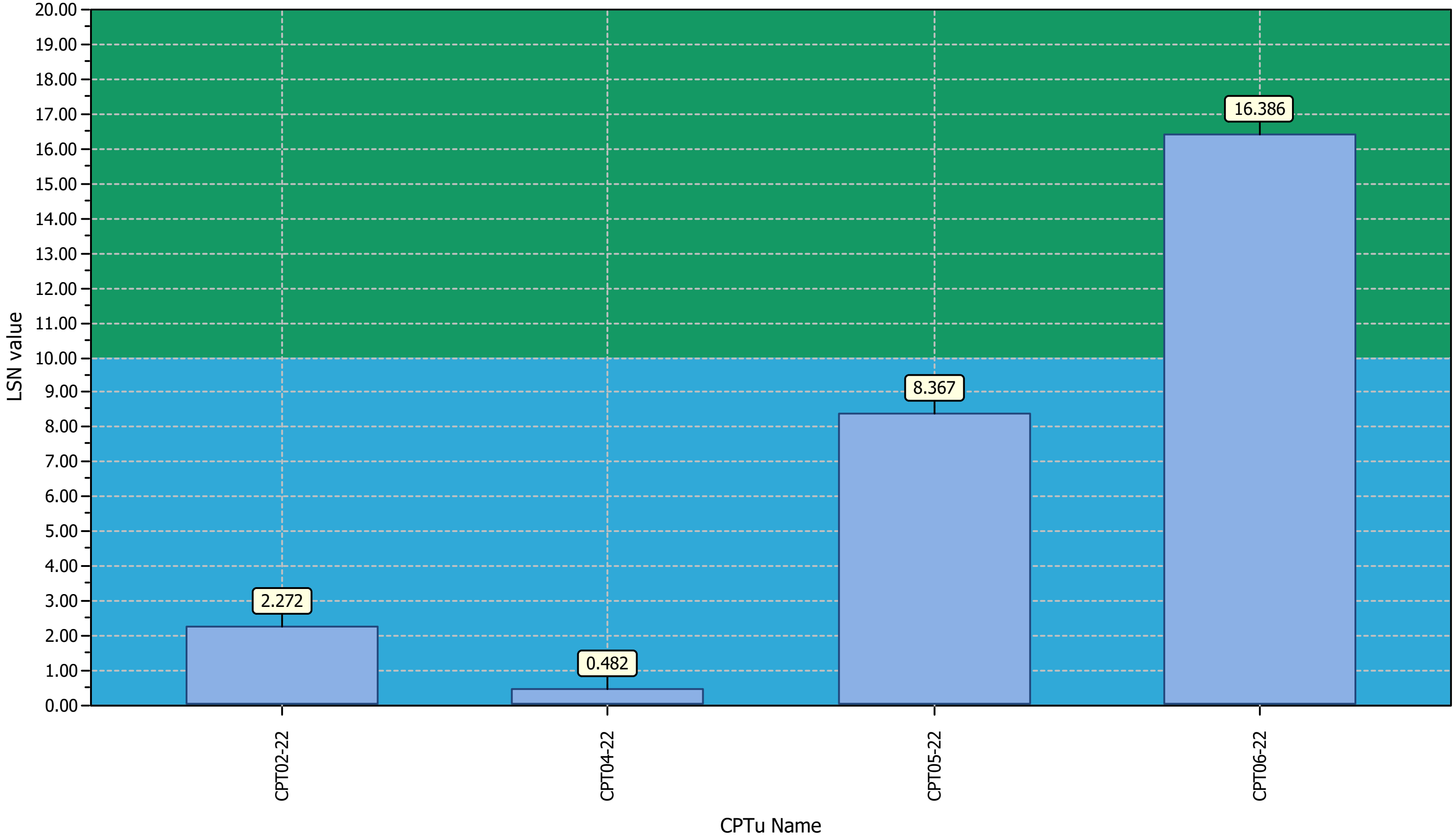
Basic statistics

Total CPT number: 4
100% low risk
0% high risk
0% very high risk

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

75% little liquefaction

25% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

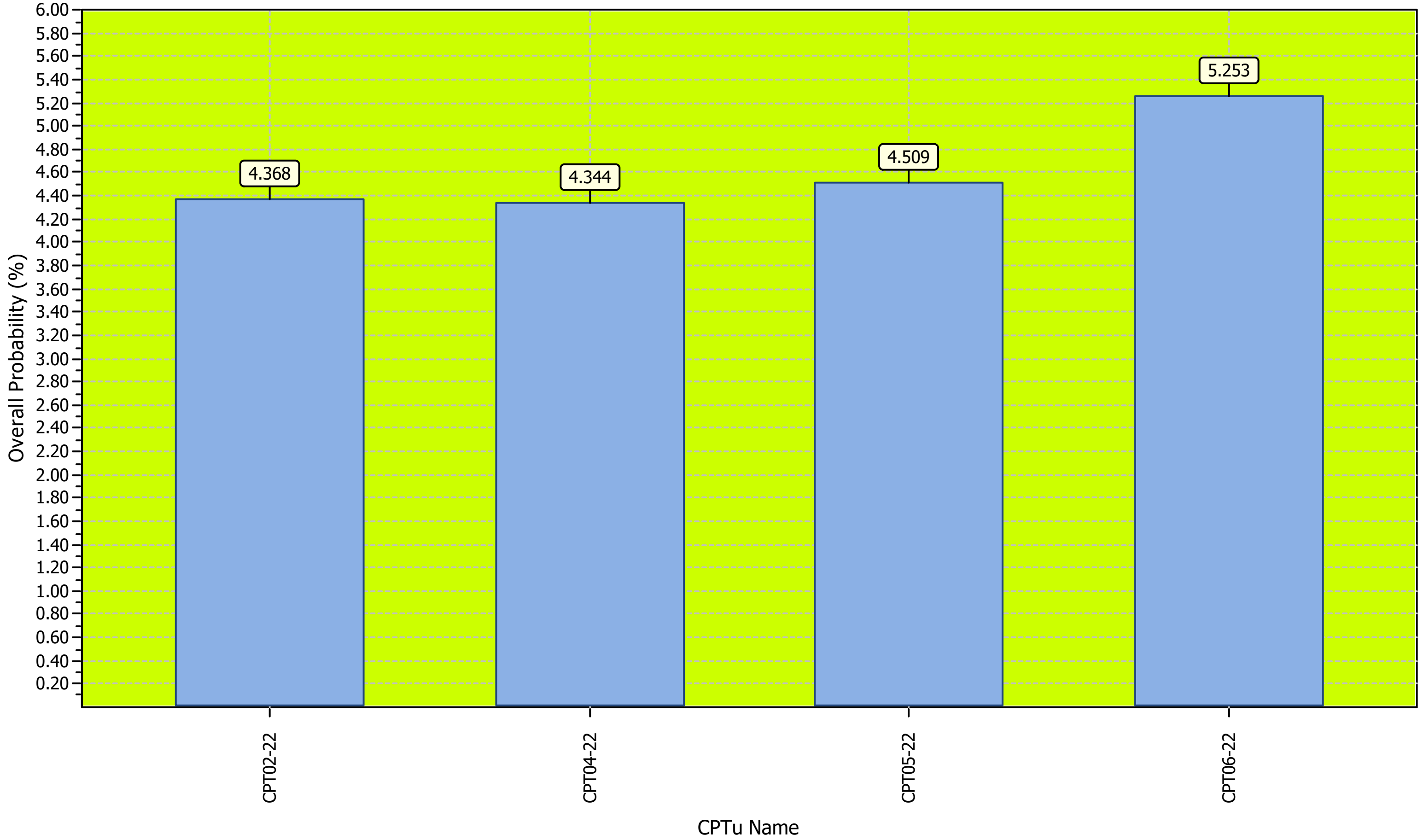
0% major liquefaction

0% severe liquefaction

Project title :

Location :

Overall Probability for Liquefaction report



Probability color scheme

- Very High Probability
- High Probability
- Low Probability

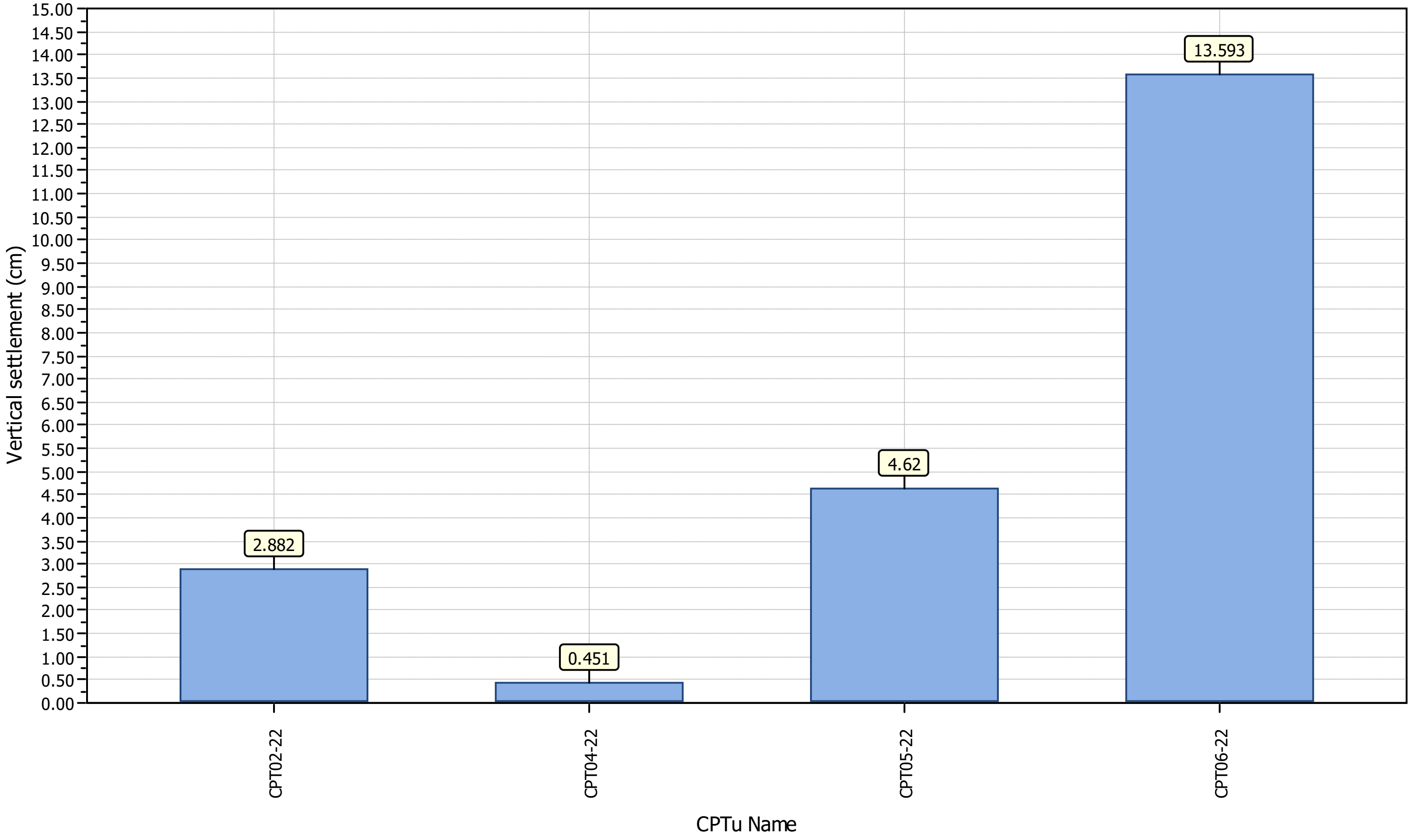
Basic statistics

Total CPT number: 4
100% low probability
0% high probability
0% very high probability

Project title :

Location :

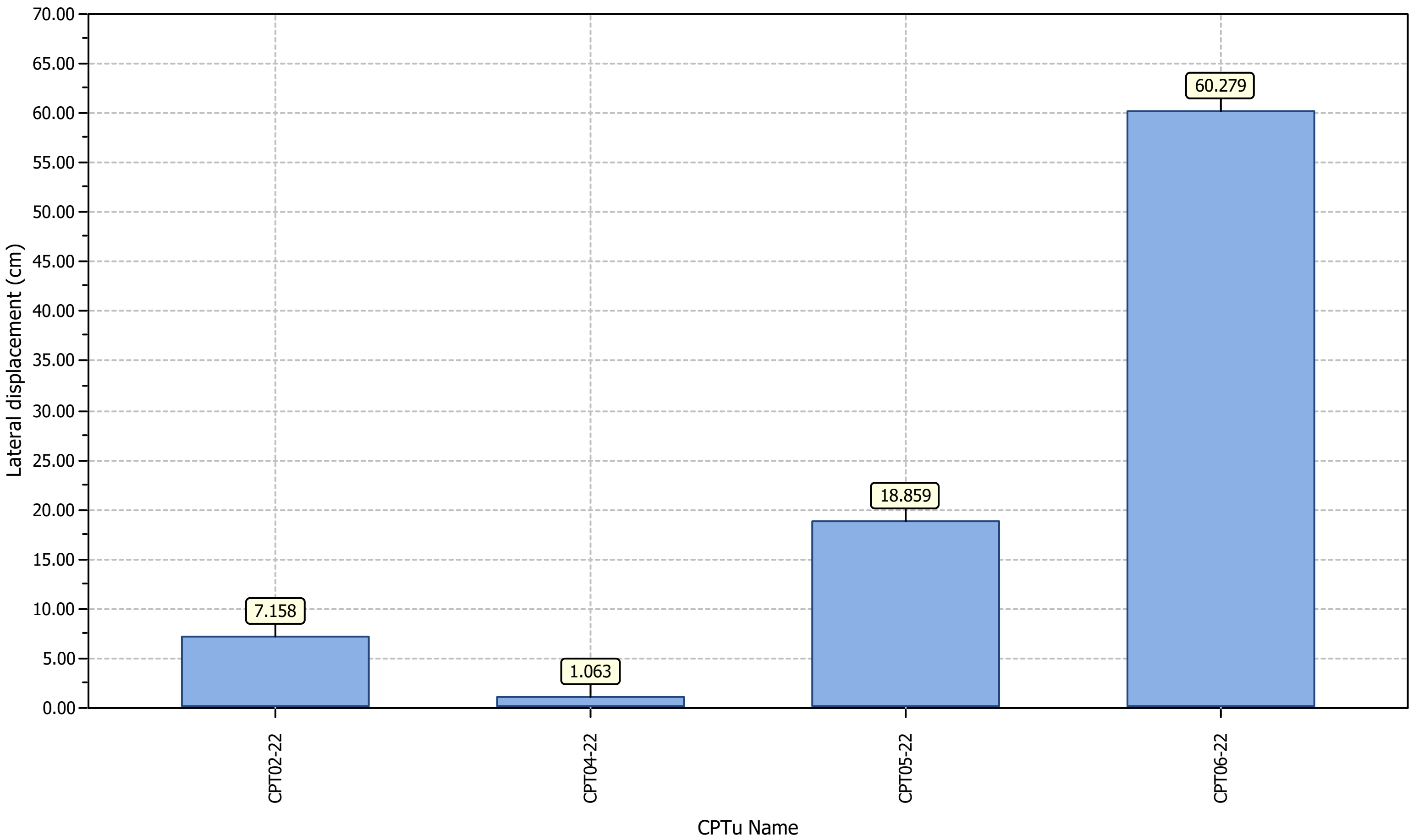
Overall vertical settlements report



Project title :

Location :

Overall lateral displacements report



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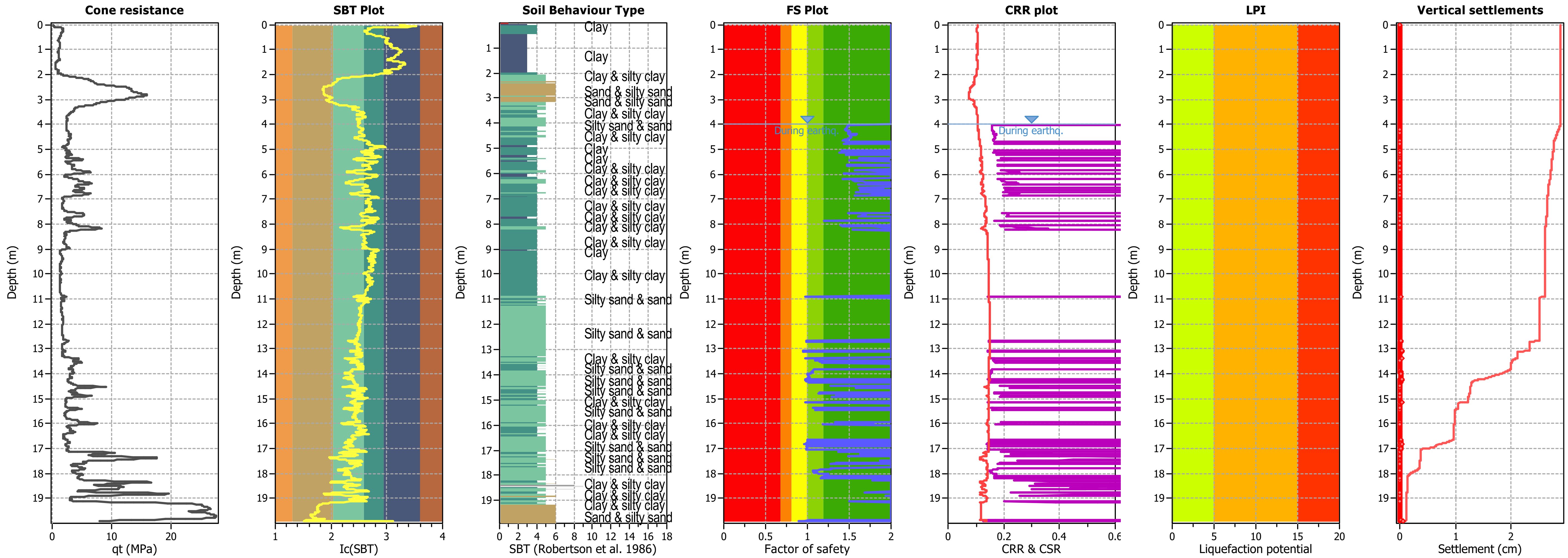
Project:
Location:

CPT: CPT02-22
Total depth: 19.91 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.00 m	Use fill:	No	Clay like behavior applied:	.
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 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:	20.00 m
Earthquake magnitude M_w:	6.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.19	Unit weight calculation:	Based on SBT	K_o applied:	Yes		

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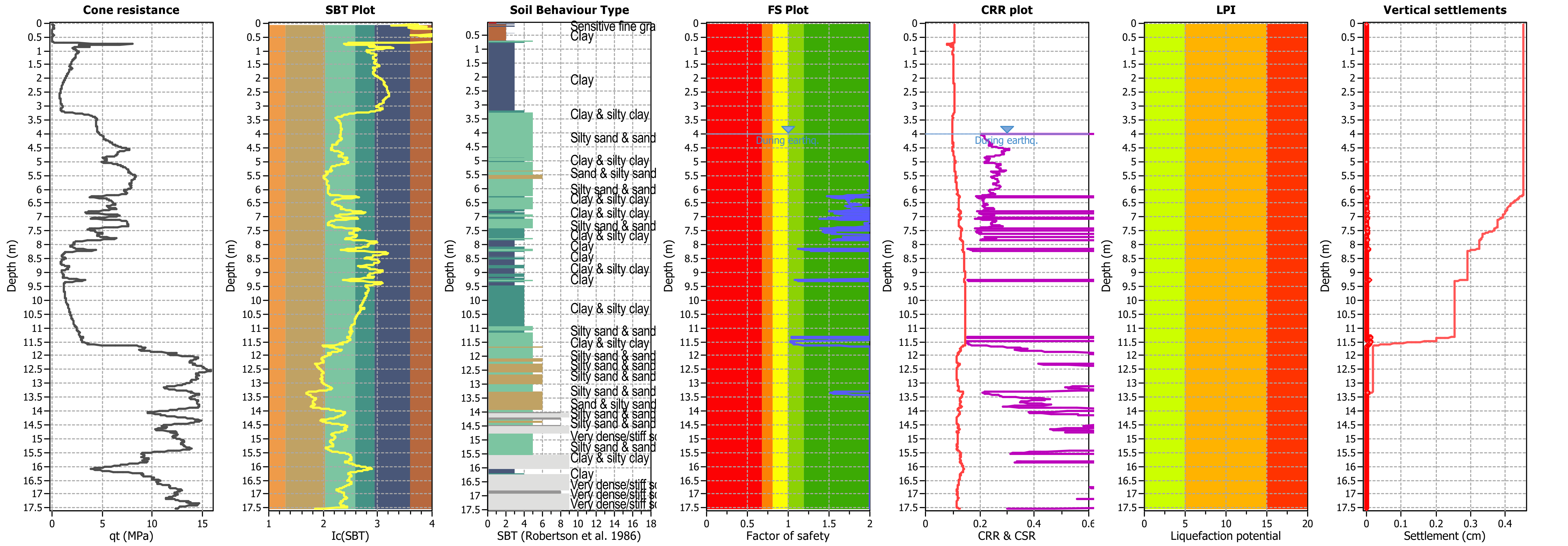
Project:
Location:

CPT: CPT04-22
Total depth: 17.52 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.00 m	Use fill:	No	Clay like behavior applied:	.
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 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:	20.00 m
Earthquake magnitude M_w:	6.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.19	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

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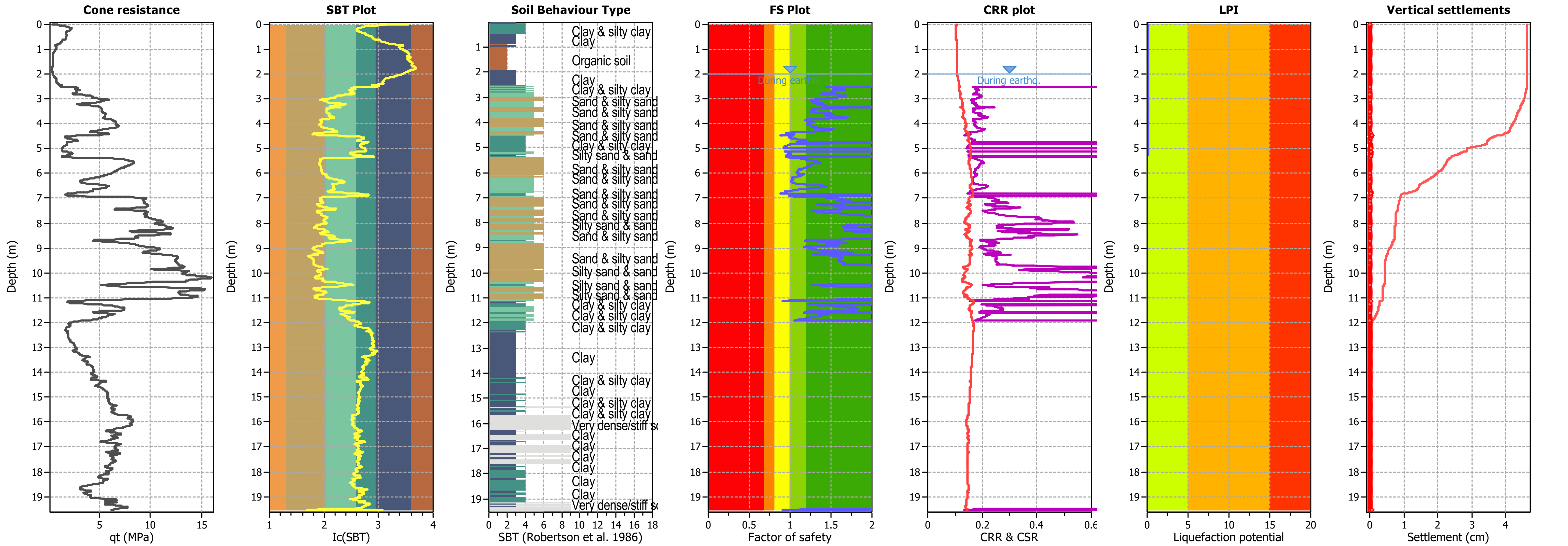
Project:

Location:

CPT: CPT05-22

Total depth: 19.54 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	.
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	6.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.19	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

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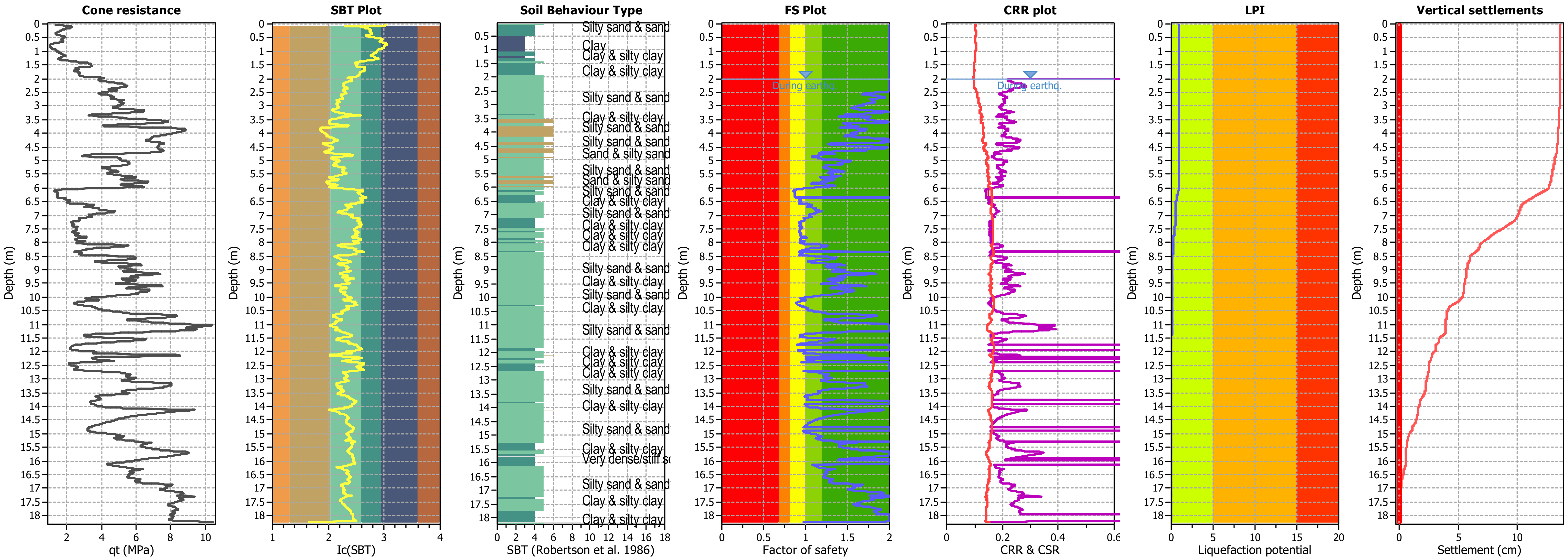
Project:

Location:

CPT: CPT06-22

Total depth: 18.24 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	.
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	6.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.19	Unit weight calculation:	Based on SBT	K_o applied:	Yes		