Geotechnical Investigation Report

6 Shackleton Terrace, Lyttelton, Christchurch

Submitted To:

DRISS ADAM TAYBI & OLIVIA JOY FLAMANK

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1 Executive Summary

Wiley Geotechnical Limited (WGL) was requested by Driss Taybi & Olivia Flamank to provide a geotechnical investigation and assessment for the proposed residential development at 6 Shackleton Terrace, Lyttelton (herein referred to as “the site”). The result of our desktop study, investigation and assessment are documented in this report. Our findings and conclusions are summarised in the table below:

Table 1: Summary of Findings

Site Sub-soil Conditions			
GNS mapped geology:	Loess and loess colluvium overlying volcanic rock	**Soil Classification (NZS 1170.5:2004)**	Class C
CERA zone:	Green	**MBIE Technical Category**	Port Hill
Groundwater Level	Greater than 10 m	**Site Specific Technical Category**	NA- Port Hill
Geotechnical Hazards			
Subsidence	No obvious evidence of ground subsidence, other than small localised subsidence due to rotational failure of the retaining walls.		
Slippage	No clear evidence of land slippage. The site is outside of the cliff collapse and mass movement zones.		
Falling Debris	No evidence of falling debris and/or rock boulders upslope of the site or within the site		
Erosion	Very minor erosion due to vegetation cover, however, loess soils are highly susceptible to erosion by both surface runoff, and by internal perched water erosion forming tunnel-gully features. The site is not subject to coastal erosion.		
Inundation/Flood	Inundation is unlikely due to the sloping nature of the site. The site is outside of CCC flood management zone.		
Foundation Recommendations			
• NZs3604 Standard Foundations (provide stable building platform) • Non-Compliance Engineered Foundation			

2 Introduction

At your instruction, we have undertaken a site-specific geotechnical investigation and assessment at 6 Shackleton Terrace, Lyttelton. This geotechnical report summarises our findings and assessment as per the brief given to us by our client. The purpose of the geotechnical investigation was to evaluate ground conditions, assess potential geohazards and provide foundation recommendations.

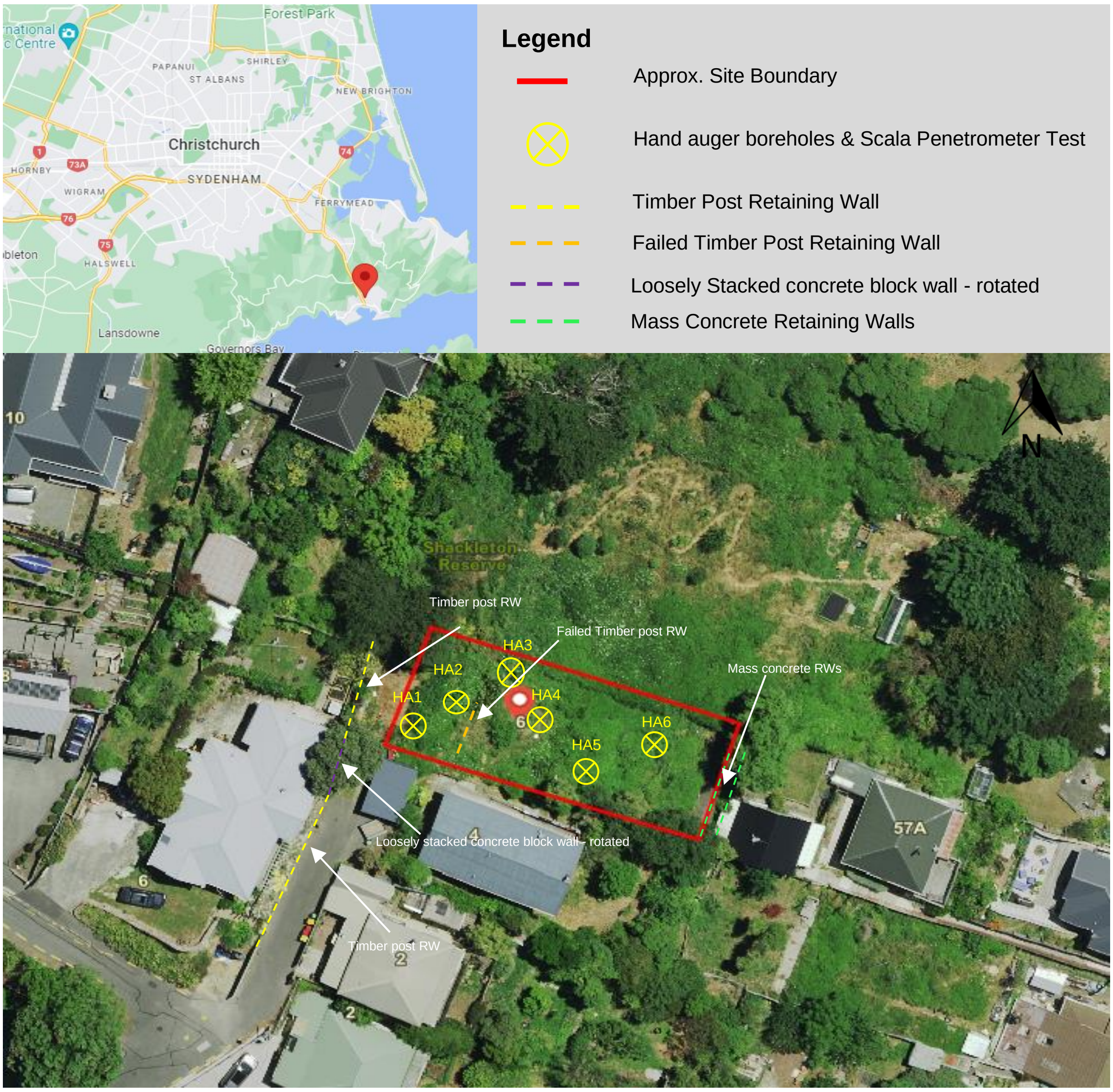
The report may be used by our clients' appointed consultants for design purposes and by the local council/authority for corresponding consent application.

3 Site Description

Table 2: Site Description

Site Area:	433 m^3
Legal description	Lot 1 DP 572501
Topography:	Hill Side with moderate to steep slope facing towards the east & south east direction
Site/Area Description:	The site is located on the Port Hill in the suburb of Lyttelton, Christchurch. The Shackleton Reserve is located on the north side of the property. Other residential properties are located on the south, east and west side of the site. The site is approximately 500 m from the Lyttelton Port.

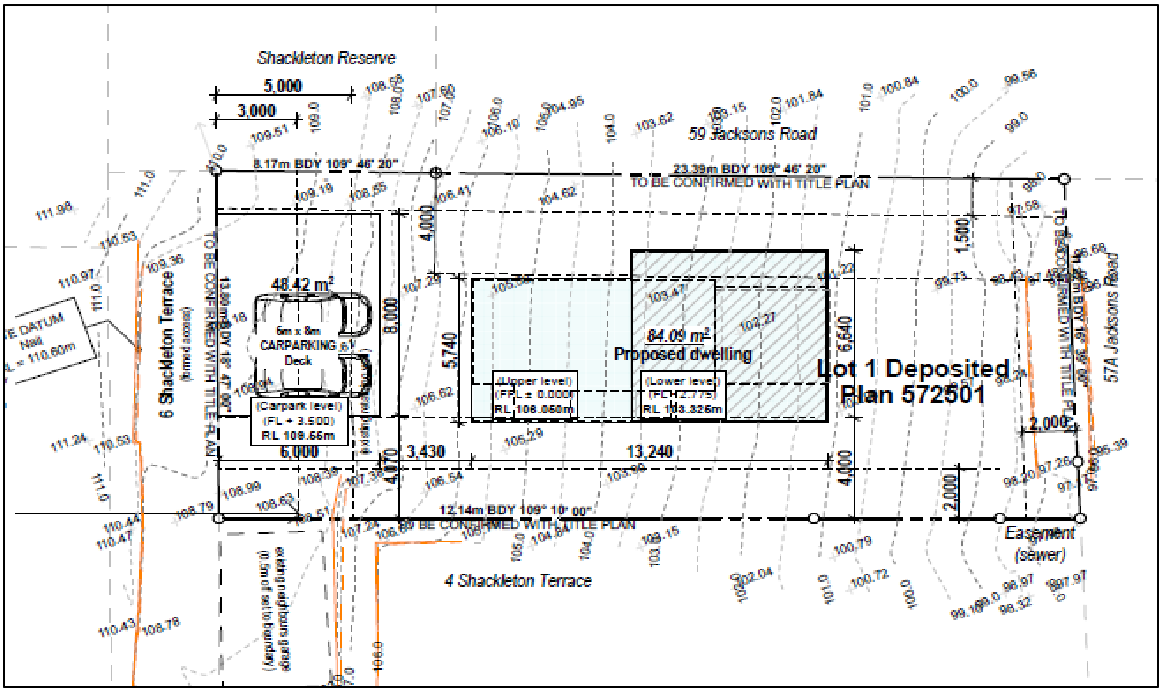
Figure 1: Site Location Plan



4 Site Development Plan

Based on the architectural concept plan, it is our understanding a two-storey dwelling and car parking deck are proposed as shown in Figure 2.

Figure 2: Proposed Development Plan



Source: Architectural Concept Plan by Detailed Consultancy

5 Desktop Study

5.1 Geology

The site has been regionally mapped by GNS (Forsyth et al., 2008 and Weeber et al., 1992) to be underlain by yellow-brown windblown silt (loess) and loess colluvium overlying volcanic rock.

5.2 Review of Nearby Geotechnical Report

We have been given a geotechnical report for 57A Jackson Road and 4 Shackleton Terrace by the client and reviewed the nearby subsurface information. The report was issued by Soil & Rock Ltd, dated May 2015. We summarise the following relevant geotechnical information:

- There are no known or mapped faults in the immediate area of the site, however the site may be at risk of ground shaking induced by movement of proximal or distal faults.
- No evidence of slope instability or erosion was noted on the site during our walkover inspection.
- No exposed rock face or boulders were observed on or in the vicinity of the site during our walkover.
- The shallow soil investigation encountered relatively uniform surficial deposits across the site comprising non-engineered fill or topsoil over loess deposits. Volcanic Rock was inferred to underlie the loess at a depth of approximately 5.0m to 6.0m.
- Groundwater was not recorded within the hand auger boreholes.

- Slope stability analysis was undertaken and has shown minimum factor of safety above its requirements.

5.3 Natural Hazards

We have reviewed Christchurch City Council's (CCC) District Planning Maps for the site.

5.3.1 Liquefaction Hazard

The site is mapped outside the "liquefaction management area".

5.3.2 Slope Stability

The site is mapped within the "slope instability management area".

5.3.3 Rockfall Hazard

The site is mapped outside the "rockfall management area".

5.3.4 Cliff Collapse

The site is mapped outside the "cliff collapse management area".

5.3.5 Seismicity

We have reviewed the GNS Active Faults Database, which shows that no active faults are located on the site. The nearest known active fault is the Greendale Fault, located approximately 28 km west of the site. The Greendale Fault is a dextral fault with an expected recurrence interval of between 10,000 to 20,000 years. While no other active faults are mapped within 28 km of the site, the epicentres of the February and June 2011 earthquake events were centred 4.1 km north west and 4.5 km north of the site, respectively.

5.3.5 Flood

The CCC Floor level Map indicates that the site is located outside the CCC Flood Management area. The site has not been assessed for either a 1 in 50-year flood level or a 1 in 200-year flood level.

5.3.6 Coastal Erosion

The CCC coastal hazards online portal indicates that the site is not subject to coastal erosion.

6 Geotechnical Site Investigation

6.1 Geotechnical Visual Assessment

WGL visited the site on 3 August 2023 and made the following observations (see attached photos):

- The site is vacant and has recently had some vegetation removed.

- The site is generally moderately to steeply sloping (approx. 25-35°) towards the east-southeast. Driveway access is via Shackleton Terrace to the upper part of the slope, where there is a small area of relatively flat ground.

- There are several retaining walls supporting and protecting the slope:

  - On the upslope side of the driveway access there are two timber walls (approximately 1.2 m to 1.4 m high) that appear relatively intact and undamaged.
  - A third wall on the upslope side of the driveway is of similar height, however it has been constructed from loosely stacked concrete blocks (without mortar). The wall is bulging and has rotated beyond vertical by several degrees. The wall may impede access to the site if it fails.
  - On the downslope side of the driveway (at the edge of the relatively flat area, at the top of the site) there is a timber post wall that has failed and rotated. The wall is approximately 0.8 m to 1 m high. There is an area of ground behind the wall that has slumped with one tension crack up to 200 mm wide, the area of slumping is limited to the area behind the wall and appears to be associated with the failure of the wall.
  - On the downslope side of the site, near to the south eastern boundary, there are two mass in-situ concrete retaining walls. From what could be seen of these two walls they appear to be approximately up to 1.5 m high

- There are no obvious signs of significant land instability indicate deep seated failure, other than a small area of subsidence due to the deformation of timber post retaining wall near the top of the slope.
- No rock outcrops or evidence of fallen rock boulders or debris were observed upslope of the site, or within the site.

Figure 3: Site Photographs

Photo 1: East side of the site, looking west (upslope).

Photo 2: North side of the site, looking across mid-slope towards the south.

Photo 3: Relatively flat area at the top (west) of the site where there is driveway access. An intact timber post retaining wall is shown on the upslope side.

Photo 4: Looking across top (west) part of the slope towards number 4 Shackleton Tce, failed/rotated timber post retaining wall is circled.

Photo 5: Mass concrete retaining walls on downslope (east) side of the site, appear intact and upright and appear to be owned by the neighbour to the east.

Photo 6: Loosely stacked concrete block retaining wall, west side of the site. The wall is retaining soil above the driveway

6.2 Hand Auger Boreholes & Scala Penetrometer Tests

WGL carried out a shallow subsurface investigation consisting of six hand augers boreholes with associated Scala Penetrometer (DCP) and shear vane tests at the site.

Two hand auger boreholes (HA01 - HA02) on the western (upslope) side of the site reached a maximum depth of 2.6 m bgl. The hand augers encountered topsoil underlain by uncontrolled fill material to 1.2 m below ground level (bgl).

The other four hand auger boreholes (HA03 - HA06) were undertaken on the mid and lower slope, near the centre and eastern sides of the site. The borehole and Scala tests reach a maximum depth of 3.1 m bgl. The result of our testing indicated topsoil underlain by loess material.

Standing water was not encountered in the test locations.

Test locations are presented in Figure 1 and a summary of the subsurface conditions is presented in Table 3 & 4.

Hand auger logs with associated Scala penetrometer results are presented as an attachment to this report and are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (NZGS, 2005).

6.3 Summary of Subsurface Condition

Based on the subsurface investigations completed at the site, and other nearby geotechnical data, ground conditions encountered in on-site subsurface investigations are summarised in Table 3 and 4.

Table 3: Summary of Subsurface Condition (Upper Slope)

Depth (m)	Soil Description	Consistency/Density
0-0.2	SILT [TOPSOIL]	Very Soft to Soft
0.2-1.2	SILT [FILL]	Very Soft to Soft
1.2-2.6	SILT [LOESS]	Stiff to Hard

Table 4: Summary of Subsurface Condition (Mid & Lower Slope)

Depth (m)	Soil Description	Consistency/Density
0-0.4	SILT [TOPSOIL]	Very Soft to Soft
0.4-3.1	SILT[LOESS]	Stiff to Hard

6.3.1 Groundwater

Standing water was not encountered in the test locations. Based on the understanding of the hydrogeological condition, we expect the groundwater at much greater depth. The soil is generally wet to moist due to surface or perched water runoff. Subsurface runoff in loess deposits can contribute to tunnel gullies and erosion, therefore, appropriate surface water management and stormwater control measures are essential to reduce or prevent water ingress into the native loess.

7 Geotechnical Assessment

7.1 Soil Classification

Based on published geologic mapping and nearby and on-site soil testing, in line with NZS 1170.5:2004, we consider the soil classification to be ‘Class C – Shallow Soil Sites’.

7.2 Slope Stability

Based on our site walk over, we have not observed evidence i.e., scarps, tension cracks, tunnel gullies, to suggest instability of the slope. As per our desktop study, the site is outside of mapped mass movement areas and there is no record indicating any deep-seated failure.

Due to the topographical features of the site, new retaining walls should be constructed to maintain the stability of the driveway and building platform. These retaining walls should be designed by a qualified professional engineer, as per our recommendations.

7.3 Bearing Capacity

Scala penetrometer tests were undertaken at the site to assess the subsurface strength profile and to determine if ground beneath the site meets the requirements of ‘good ground’, defined in NZS 3604:2011.

We consider “Good Ground” can be found within the native loess material on a stable building platform. Based on shear vane testing results, we recommend a geotechnical ultimate bearing capacity of 300 kPa can be assumed at native loess below topsoil and fill layers.

8 Geotechnical Recommendations

We consider the site to be geotechnically suitable for the development of the new residential dwelling, subject to the following recommendations.

8.1 Foundation

Based on the architectural plan, the proposed dwelling is located in the mid slope area, where native loess material was encountered at 0.4 m bgl. After conducting our assessment, we recommend the following foundation types to be suitable for the proposed residential development.

8.1.1 NZs3604 Standard Timber Framed Building Foundation

We recommend the use of standard shallow foundations as per NZs 3604 on a stable building platform protected by an engineered retaining wall. All topsoil and unsuitable material should be removed and the foundation should be supported on “good ground” defined by the standard.

The foundation should be supported on similar types and strength of material to reduce the risk of differential settlement.

8.1.2 Non-Compliant Design

In the case of non-compliant design (the design does not comply with NZs 3604:2011), we recommend a geotechnical ultimate bearing capacity (UBC) of 300 kPa can be assumed for the design of foundation within the native loess (silt), anticipated at 0.4 m or greater in the mid and lower slope area. A strength Reduction Factor (Φbc) of 0.5 should be applied to the UBC, which should then equal or exceed the factored Ultimate Limit State design actions. NZS 3604:2011-compliant designs automatically meet this recommendation.

We understand your structural engineer may have alternative specific engineering design foundation solutions that may be applicable to the site, other than those outlined in this report i.e. deep pile foundation. In this case, collaboration between Structural and Geotechnical engineers is required during the detailed design stage. We recommend WGL is contacted to discuss the alternatives with your Structural Engineer early in the design process. The alternative foundation design drawings should be reviewed by WGL to ensure that the geotechnical aspects of the foundation design are considered before submitting the building consent application to the council.

8.2 Retaining Wall

New retaining walls may be required to replace some the existing retaining walls or provide a secure building platform and maintain long term stability of the slope.

New retaining walls should be designed to resist both lateral loads imposed by earth pressures, and any additional loads from surcharges behind the walls. For the design of a rigid structural retaining wall (i.e., where calculated deflection at the top of the wall is not permitted), an ‘’at-rest’’ lateral earth pressure coefficient (Ko) shall be used.

Based on our understanding of the ground conditions, we recommend the use of following geotechnical parameters in Table 5 to calculate the earth pressure.

Table 5: Soil Parameter for Retaining Wall Design

Soil Types	Unit Weight (KN/m3)	Effective Friction Angle (degrees)	Undrained Shear Strength (kPa)
Silt [Loess]*	18	30	200
Engineered Fill**	21	35	NA

Note: *The recommend design parameters are suitable for native hard silt material.
** The recommended design parameters only apply to well graded engineered fill not uncontrolled fill material.
NA = not applicable.

Allowances should be made for potential traffic, backslope and seismic loads. The void between the wall and the ground (if any) should be filled with lightly compacted granular backfill.

All retaining walls should be provided with back drain facilities which outlet to approved stormwater system.

Seismic design parameters should be determined by Module 6 Earthquake Resistance Retaining Wall Design from Earthquake Geotechnical Engineering Practice guidance.

At concept design stage, we suggest that the designated retaining wall design engineer engage in a discussion with the project's geotechnical engineer to ensure that the chosen retaining wall types do not have any adverse effects on the slope's stability. Alternatively, retaining walls can be designed by a geotechnical engineer who has a good understanding of the geological conditions of the slope at the site.

8.3 Earthwork Operation

These guidelines should be followed for any earthworks operation associated with development on the site:

- No unretained fill should be placed on or at slopes greater than 26° unless approved by a Chartered Professional Engineer practicing in geotechnical engineering;

- All fill placed on the existing slope should be designed by geotechnical/civil professional to be keyed and benched into good soil and drainage provided. The project geotechnical engineer should be given the opportunity to review the design, if the earthworks are designed by other professional disciplines;
- Unretained temporary cuts must adhere to specific slope angles: no steeper than 1V:1H in fill material and 2V:1H for firm to hard loess (silt). Should site limitations lead to a steeper cut slope angle, it is imperative to engage the project's geotechnical engineer for expert guidance. In these instances, the potential implementation of temporary shoring or alternative stabilisation methods should be considered.
- Permanent unsupported cuts should not be formed any steeper than 26° (1V:2H) in native loess soil, unless approved by a Chartered Professional Engineer practicing in geotechnical engineering; and
- Vertical cuts higher than 1.5 m in soil or rock should be supported with a specifically designed retaining wall and will need to be approved by a Chartered Professional Engineer practicing in geotechnical engineering.

8.4 Surface Water Management

The following measures should be undertaken to maintain stability of the site:

- Stormwater from roofs and paved areas shall be taken in a piped system and disposed of into an approved stormwater system. Uncontrolled discharge onto land or disposal via in-ground systems must be avoided;
- All service trenches in loess soil shall be backfilled with low permeability materials (including lime stabilisation if loess material is used) so that excavations do not become points of entry for surface run-off;
- Surface cut-off drains or appropriate stormwater flow paths shall be maintained up slope to divert water away from any buildings; and

Any exposed soil should be vegetated with deep rooting plants (flaxes or native shrubs) to help maintain ground stability and reduce erosion.

8.5 Safety in Design

We recommend that ‘Safety in Design’ principles are included during the design of the proposed structure and development. It should be noted that all parties involved in construction, including the client have responsibilities under the current ‘Health and Safety at Work Act 2015’. This includes ensuring that the chosen contractor is both competent and suitably qualified / experienced to undertake the commissioned works.

8.6 Future Geotechnical Involvements

8.6.1 Geotechnical Engineer Review

A geotechnical professional familiar with the findings of this report should be engaged to review the foundation, earthworks and retaining wall drawings of the proposed development prior to submission to the Council. This is to ensure the geotechnical recommendations of this report have been implemented correctly.

8.6.2 Geotechnical Construction Observation

The recommendations given in this report are based on limited site data from discrete locations. It is important to acknowledge the potential for variations in ground conditions throughout the area. In the collective interest of all stakeholders, the continuous engagement of the project's geotechnical expert throughout the construction process is highly recommended to ensure the construction does not have adverse effects on the stability of the slope. This engagement provides careful monitoring by the geotechnical professional, ensuring that geotechnical engineering aspects related to earthworks, retaining walls, and foundations are in line with our recommendations and can be carried out safely and practically.

9 References

Brown, L.J. & Weeber, J.H. (1992). Geology of the Christchurch Urban Area 1:250,000. CGD5122. Institute of Geological and Nuclear Sciences.

Forsyth, P., Barrell, D. J., & Jongens, R. (2008). Sheet 16 - Geology of the Christchurch Area 1:250,000. Lower Hutt: Institute of Geological and Nuclear Sciences.

The Ministry of Business, Innovation, and Employment. (2012). Guidance-Repairing and rebuilding houses affected by the Canterbury earthquakes. Christchurch: The Ministry of Business, Innovation, and Employment.

Ministry of Business, Innovation and Employment (2013). “Guidance for building in toe slump areas of mass movement in the Port Hills (Class II and Class III)”. November 2013.

Ministry of Business, Innovation and Employment (2014). “Guidance on the seismic design of retaining structures for residential sites in Greater Christchurch”. July 2014.

NZGS (2005). “Guidelines for the Classification and Field Description of Soils and Rocks in Engineering”. NZ Geotechnical Society Inc, Wellington, New Zealand.

Kramer, S. (1996). Geotechnical Earthquake Engineering, Prentice Hall, Upper Saddle River, NJ, USA.

NZGS & MBIE (2021). “Earthquake geotechnical engineering practice – Module 6: Earthquake resistance retaining wall design”. Published date November 2021.

NZS1170.0:2004. Australia/New Zealand Standard, Structural Design Actions, Part 0: General Principals. Standards New Zealand, Wellington, New Zealand.

NZS1170.5:2004. Australia/New Zealand Standard, Structural Design Actions, Part 5: Earthquake Actions – New Zealand. Standards New Zealand, Wellington, New Zealand.

NZS 3604:2011. New Zealand Standard, Timber Framed Buildings. Standards New Zealand, Wellington, New Zealand.

NZS 4431:2022.” Engineered fill construction for lightweight structures”. Standards New Zealand, Wellington, New Zealand

10 Limitations

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

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

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

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

v. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned, if you require any further information.

Raymond

Zeb Paterson, *MEngNZ*
Senior Engineering Geologist

Raymond Su, *CPEng, CMEngNZ, IntPE(NZ)*
Principal Geotechnical Engineer

APPENDIX 1:

Hand Auger Boreholes and Scala Penetrometer Tests

WILEY GEOTECHNICAL LTD

Borehole No. HA01

SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

Sheet 1 of 6

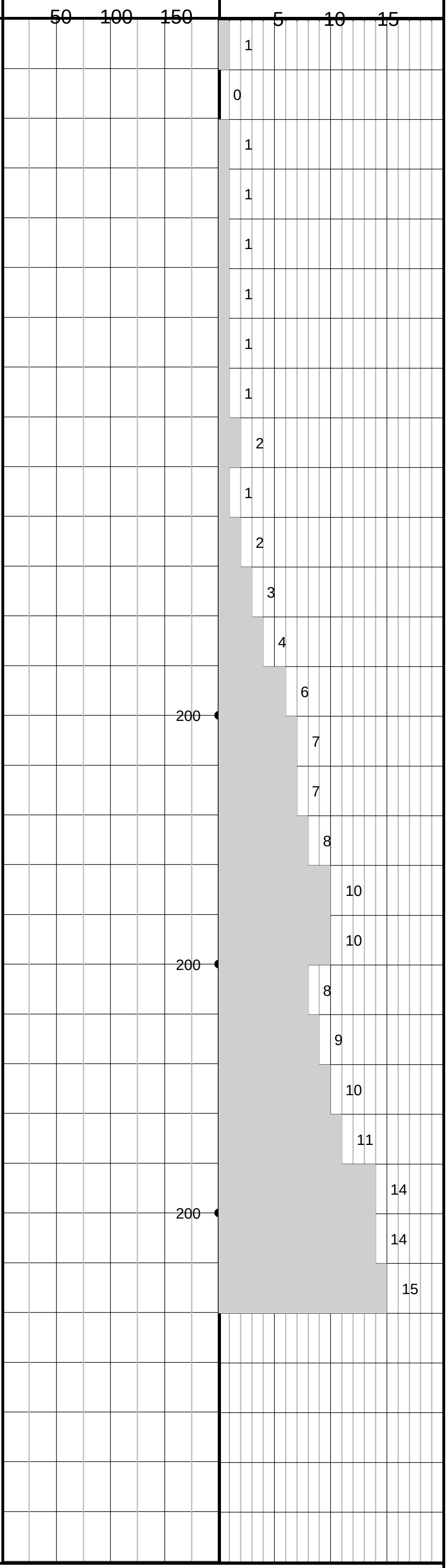
GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with trace rootlets; brown. Low plasticity [TOPSOIL].			VS	W	
FILL	ML	SILT with trace gravel, charcoal, brick and organics. Low plasticity [FILL].			VS-S		
LOESS	ML	SILT; yellowish brown. Low plasticity [LOESS]. 1.6 Becomes moist from 1.6 m.			VSt-H	M	
		EOH: 2.6 m					

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

SCALA PENETROMETER BLOWS / 100 mm



NOTES: Groundwater was not encountered

Hand auger met refusal at 2.6 m depth on hard material.

Scala penetrometer met refusal at 2.6 m depth.

LOGGED BY: RB

DATE DRILLED: 3/08/2023

DRILL METHOD: 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

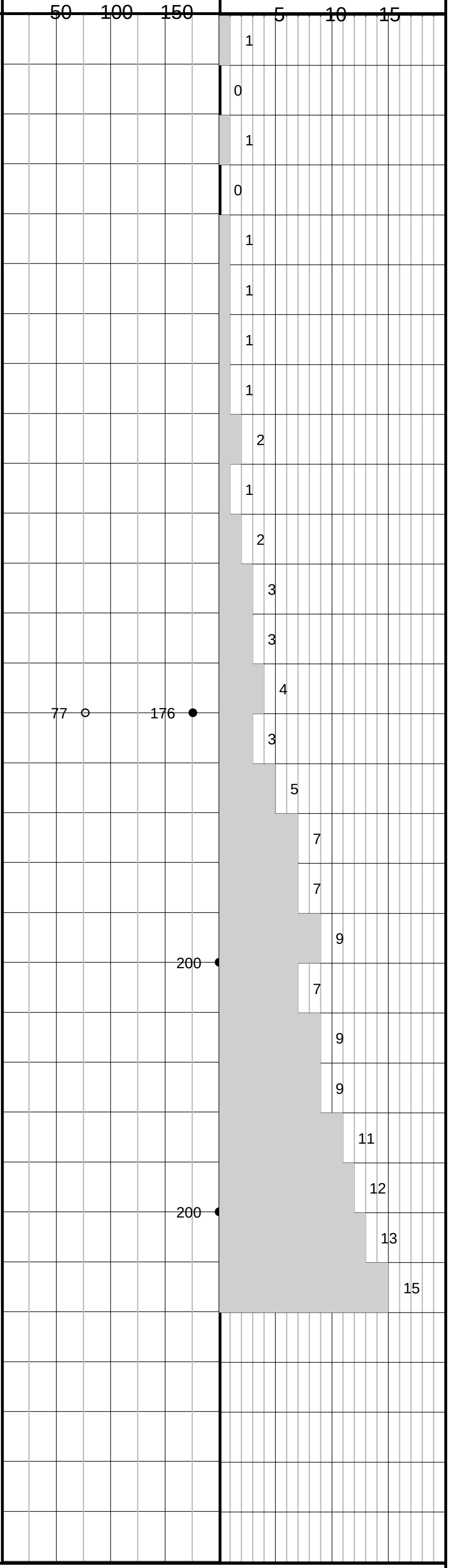
SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

Borehole No. HA02

Sheet 2 of 6

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with trace rootlets; brown. Low plasticity [TOPSOIL].	0 – 0.2	VS	W	
FILL	ML	SILT with trace gravel and organics; brown. Low plasticity [FILL].	0.2 – 1.1	VS-S	W	
LOESS	ML	SILT; yellowish brown. Low plasticity [LOESS]. 1.7 Becomes moist from 1.7 m.	1.1 – 2.6	VSt-H	W M	
		EOH: 2.6 m				



NOTES: Groundwater was not encountered
Hand auger met refusal at 2.6 m depth on hard material.
Scala penetrometer met refusal at 2.6 m depth.

LOGGED BY: RB
DATE DRILLED: 3/08/2023
DRILL METHOD: 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

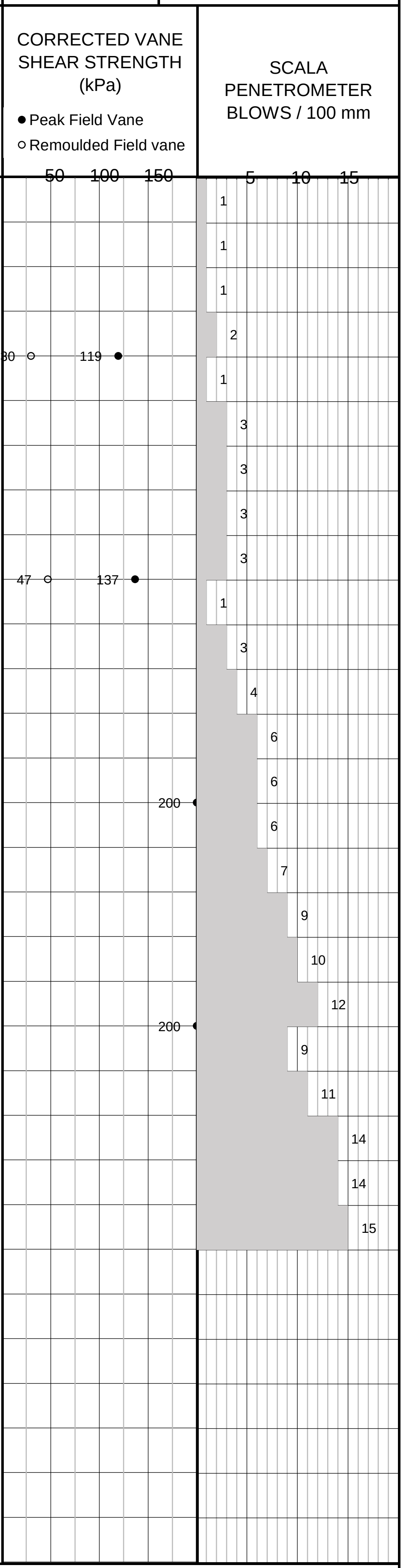
Borehole No. HA03

SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

Sheet 3 of 6

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with trace rootlets; brown. Low plasticity [TOPSOIL].			S	W	
LOESS	ML	SILT; yellowish brown. Low plasticity [LOESS]. 1.3 Becomes moist from 1.3 m.		1 2	F-H	W M	
		EOH: 2.4 m		3			



NOTES: Groundwater was not encountered
Hand auger met refusal at 2.4 m depth on hard material.
Scala penetrometer met refusal at 2.4 m depth.

LOGGED BY: RB
DATE DRILLED: 3/08/2023
DRILL METHOD: 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

BOREHOLE No. HA04

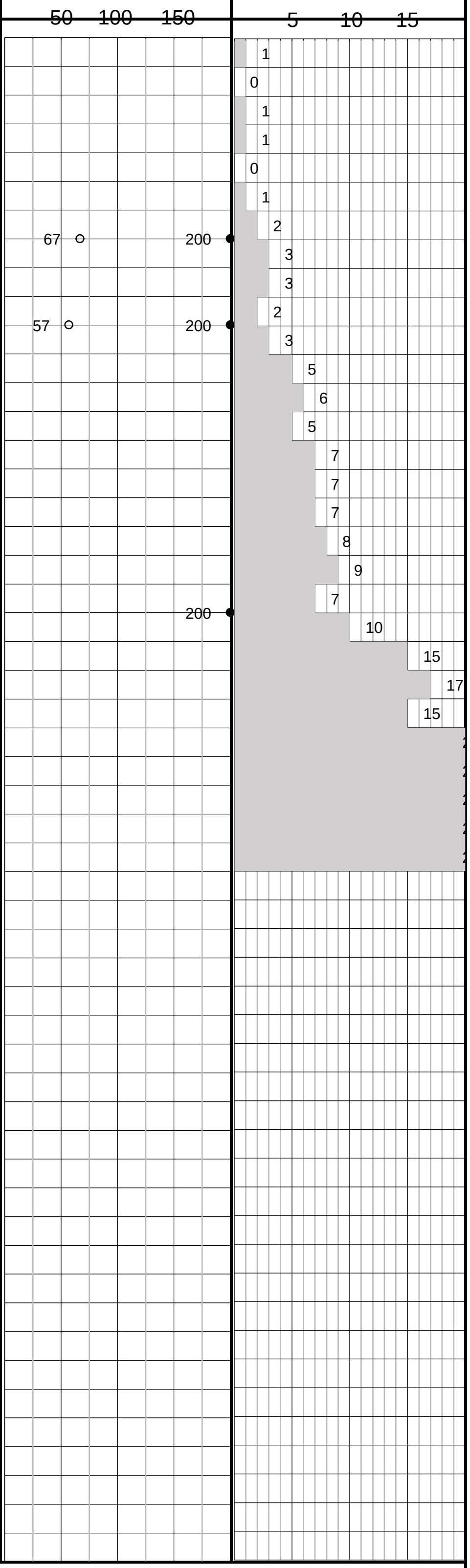
Sheet 4 of 6

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with minor organics, trace sand and rootlets; dark brown, moist. Low plasticity. [TOPSOIL]			VS -S	M	
LOESS	ML	SILT, brown, moist. Low plasticity.[LOESS]		1 2	VS-S St-H		
		EOH: 2.6 m		3 4 5			

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane
○ Remoulded Field vane

SCALA PENETROMETER BLOWS / 100 mm



NOTES Groundwater was not encountered
Hand auger met practical refusal at 2.6 m depth due to hole suction.
Scala penetrometer met refusal at 2.9 m depth.

LOGGED BY: Z
DATE DRILLE 25/08/2023
DRILL METHO 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

BOREHOLE No. HA05

Sheet 5 of 6

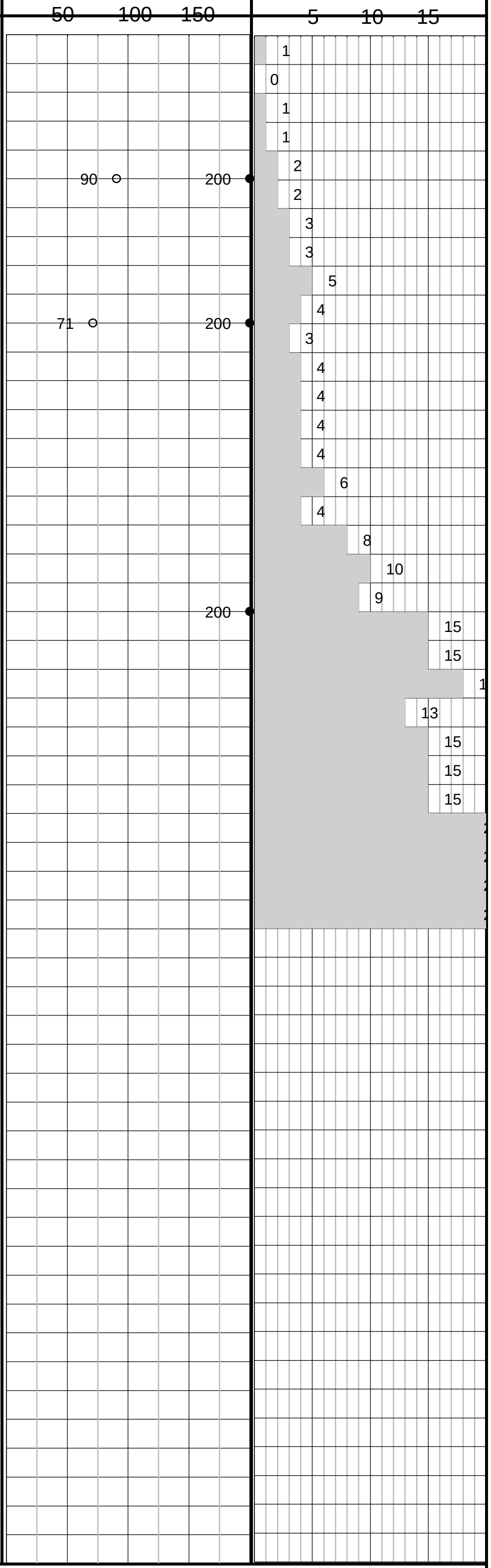
GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with minor organics, trace sand and rootlets; dark brown, moist. Low plasticity. [TOPSOIL]		VS-S	M	
LOESS	ML	SILT, brown, moist. Low plasticity. [LOESS]	1 2	St-H		
		EOH: 2.9 m	3 4 5			

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

SCALA PENETROMETER BLOWS / 100 mm



NOTES Groundwater was not encountered

Hand auger reached target depth at 2.9 m.

Scala penetrometer met target at 3.1m depth.

LOGGED BY: ZP

DATE DRILLED: 25/08/2023

DRILL METHOD: 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

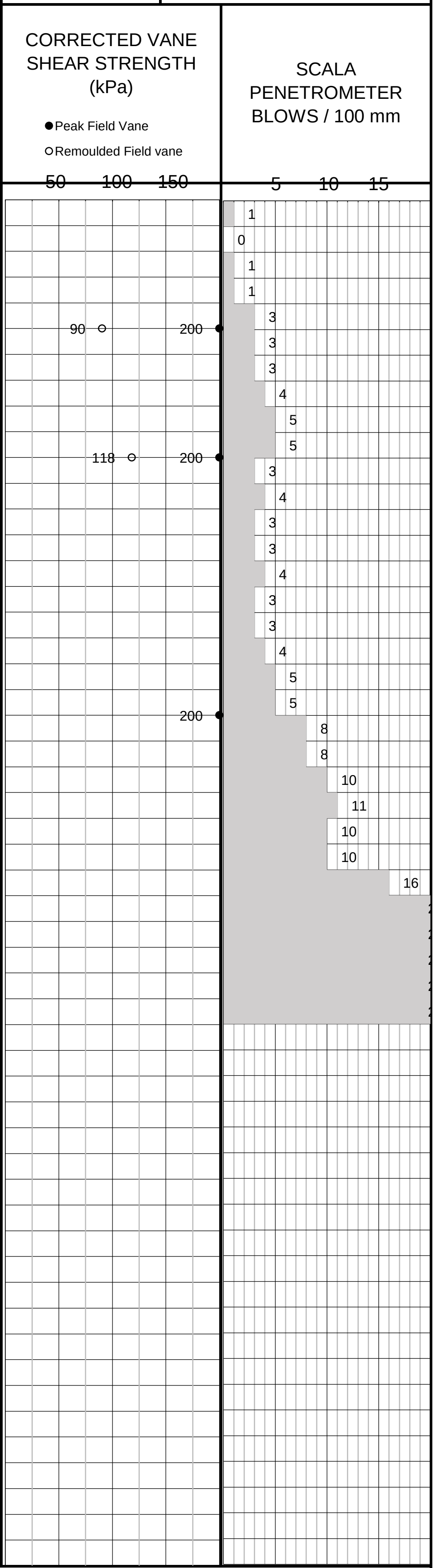
SITE: 6 Shackleton Terrace Lyttelton

REF: C23080

BOREHOLE No. HA06

Sheet 6 of 6

GEOLOGY	USCS SYMBOL	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	Consistency/Density	Moisture Condition	WATER LEVEL
TOPSOIL	ML	SILT with minor organics, trace sand and rootlets; dark brown, moist. Low plasticity. [TOPSOIL]			VS-S	M	
LOESS	ML	SILT, brown, moist. Low plasticity. Sand is fine. [LOESS]		1 2	St-H		
		EOH: 2.7 m		3 4 5			



NOTES Groundwater was not encountered

Hand auger met practical refusal at 2.7 m depth due to hole suction.

Scala penetrometer met refusal at 3.2 m depth.

LOGGED BY: ZP

DATE DRILLED: 25/08/2023

DRILL METHOD: 50 mm Hand Auger