3 PIGEON MOUNTAIN ROAD, HALFMOON BAY, AUCKLAND, PROPOSED RESIDENTIAL DEVELOPMENT

Geotechnical Investigation Report

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Prepared For: HND HMB Ltd

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1. Introduction

Total Ground Engineering Ltd have been engaged by HND HMB Ltd to carry out a Geotechnical Investigation for the proposed residential development at 3 Pigeon Mountain Road, Halfmoon Bay, Auckland. The location of the site is shown in Figure 1.

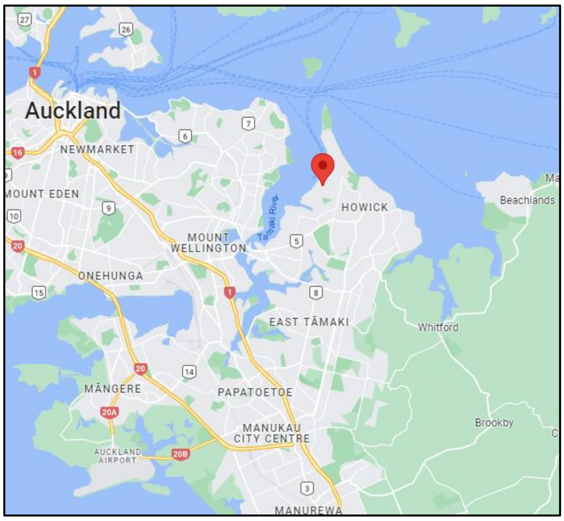


Figure 1, Locality Plan.

We understand that an approximate eighty townhouse residential development is proposed comprising two and/or three-storey light-weight timber structures. Minor earthworks are expected on the basis of a terraced development suited to the existing site topography.

Figure 2 shows a hand sketched scheme plan, extracted from (appendix A)

Figure 2, Hand sketched preliminary site plan.

This report has been prepared for HND HMB Ltd and presents the results of site investigations and engineering recommendations in support of resource consent applications to Auckland Council. Additional investigations and interpretation will be required for detailed design and Building Consent application.

2. Site Description

The site, legally described as Lot 1 DP 212125, is trapezoidal in shape covering an area of 1.4073 hectares. The site is located at the intersection of Compass Point Way and Pigeon Mountain Road and slopes gently to the north, away from Compass Point Way, toward Pigeon Mountain Road, at a gradient of approximately 1V:13H (approximate 4.4 degrees). Beyond the northern boundary, the slope steepens elevating the site approximately 3m above Pigeon Mountain Road.

The site is currently occupied by a school comprising five large school buildings located centrally with playgrounds, basketball court and carparking elsewhere with the remainder of ground coverage consisting of sports grounds. A sanitary sewer transects the site east to west, in the southern side of the site as shown in Figure 3.

Figure 3, Aerial view of site (Source, AC Geomaps)

3. Investigations

3.1 Previous Land Use

In order to help interpret the borelogs, we have investigated the land use history of the site from Auckland Council Geomaps. Figure 4 shows that the site was grassland without any buildings with the northern boundary being the edge of the foreshore. The land reclamation work for the half moon bay marina was completed before 1996. The reclamation filling extended onto the northern lower-lying portion of the site to construct Ara-Tai Road as clearly shown in Figure 5. The provided property files indicate the school development was completed in 2002 and as shown in Figure 6.

Figure 4, Aerial view of site in 1959 (Source, AC Geomaps)

Figure 5, Aerial view of site in 1996 (Source, AC Geomaps)

Figure 6, Aerial view of site in 2006 (Source, AC Geomaps)

3.2 Regional Geology

Reference has been made to the New Zealand Geology Web Map on the GNS website, http://data.gns.cri.nz/geology/, accessed on 10th June 2022 (refer Figure 7).

The maps indicate that the site is underlain by Tuff of the Auckland Volcanic Field (AVF, coloured purple in Figure 7). The AVF tuff comprises comminuted pre-volcanic materials with basaltic fragments, and unconsolidated ash and lapilli deposits. These volcanic materials can be spatially variable in terms of material types, often with abrupt end to ash deposits, with well sorted lapilli, tuff, ash and breccia at the margins.

The map indicates a geological boundary to the north of the site, mapped as East Coast Bays Formation (ECBF, coloured orange in Figure 7) of the Waitemata Group. The ECBF comprises alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grit beds.

The ECBF typically weathers at the surface forming stiff to very stiff silts and clays which can contain reactive clay mineralogy and be prone to shrinking and swelling due to varying moisture content conditions.

Figure 7, Snapshot of NZ Geological Map.

3.3 Fieldwork

Total Ground Engineering carried out a field investigation from 16 June to 21 June 2022 comprising the following:

- Eight hand augered boreholes and associated in-situ testing (i.e. shear vane and/or scala penetrometer testing), and;
- Scala penetrometer tests from the base of each borehole to refusal:
- Two soil samples collected for shrink-swell laboratory tests.
- Installed two standpipe piezometers and carried out groundwater monitoring.

The location of the hand augers and soil samples are shown in Figure 8 extracted from the *Test Location Plan* attached in Appendix B.

Soil conditions were logged by a TGE Engineering Geologist, in accordance with the New Zealand Geotechnical Society's, *Guideline for the Description of Soil and Rock for Engineering* Purposes (2005). The borelogs are attached in Appendix B.

In-situ shear vane tests were carried out at 0.5 m intervals to measure the undrained shear strength of fine-grained cohesive materials. Vane shear tests were carried out in accordance with the New Zealand Geotechnical Society Guideline for handheld shear vane test, (2001). Peak and remoulded shear strength values shown on field logs have been factored in terms of BS1377. The vane shear test results ranged between 53 kPa to 200+ kPa.

Dynamic Cone Penetrometer (Scala) testing was carried out at selected depths within the hand augured boreholes to determine soil density. Scala testing was carried out in accordance with NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer. The returning values ranging between 3 blows to 20+ blows per 100 mm penetration.

Detailed descriptions are given on the attached logs (Appendix B).

Figure 8, Investigation Plan.

4. Findings

4.1 Site Seismicity

For the purposes of deriving seismic loadings for the site in accordance with NZS 1170.5:2004 the site subsoil is considered Class C – Shallow soil site. This classification is based on depths of the residual soils inferred to be within the limits of Table 3.2 of the reference standard.

4.2 Geological Findings

Our investigations generally confirm the geology reported in the available literature. We have developed a geological cross section AA along the alignment shown in Figure 8.

Fill, associated with the marina reclamation, up to 4.0 m deep along the Pigeon Mountain Road boundary was encountered across the site. The composition and strength of the fill indicates that it can be considered as engineered fill.

AVF tuff was locally found in the southeast corner of the site (HA01, HA03 and HA04) and up to 2.5 m deep underlying the existing fill. The shear strength ranges from 100 kPa to 190+ kPa.

Puketoka formation, comprising stiff to very stiff silty clays and clayey silts, was encountered underlying the fill/AVF layer up to 5.0 m deep. This unit was not predicted by the geological maps. However, the engineering characteristics of the Puketoka Formation is similar to that of residually weathered ECBF.

The residual ECBF soils of sandy silt was only found in HA02 up to 5.0 m deep and not encountered in the rest of the investigation holes.

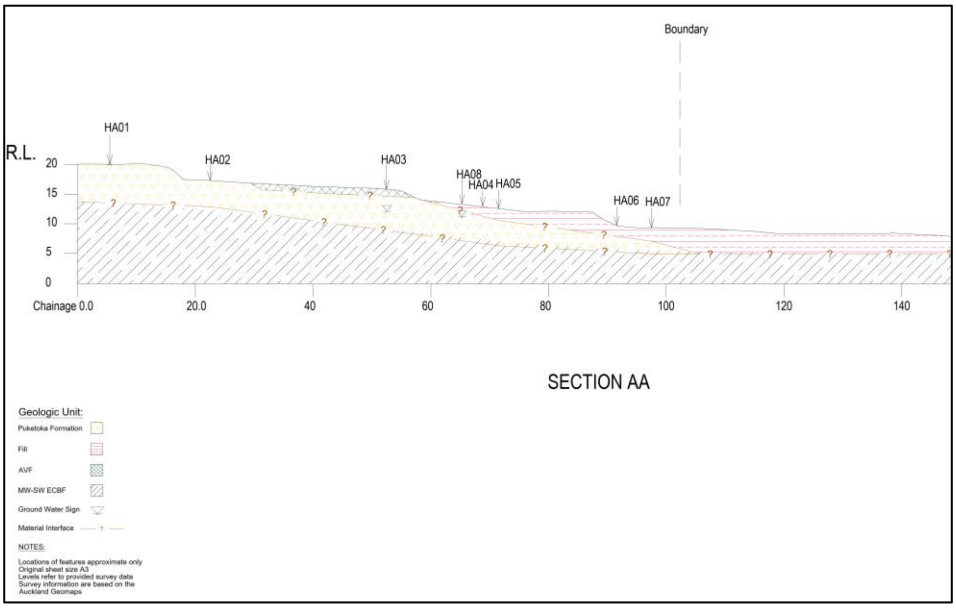


Figure 9. Geological Section AA.

Detailed investigation descriptions are given in the attached logs (Appendix B).

4.3 Groundwater

Groundwater was encountered at 3.0 m and 1.0 m deep at HA03 and HA08 respectively during the investigation and not encountered in the rest of the boreholes. It should be noted that groundwater levels/pressures can rise following periods of rainfall or fall during drier times.

Two standpipe piezometers, screened to 5 m depth were installed at HA02 and HA07. These are yet to be dipped.

4.4 Laboratory testing

Two samples at HA02 and HA07 were retrieved to carry out expansive soil tests by the testing laboratory to confirm the soil expansive soil class. The testing results are summarised in Table 1 and the detailed testing results are included in Appendix C. The interpretation of the test results is provided in Section 6.

Table 1. Expansive Soils Shrink-Swell Test Results.

Sample ID	Sample Depth (m)	Swelling Strain ε_{sw} (%)	Shrinkage Strain ε_{sh} (%)	Shrink-Swell Index I_{ss} (%)
SS01	0.8-1.0	4.0	13.9	8.8
SS02	0.4-0.6	0.7	4.8	2.8

5. Geohazard Evaluation

Section 106 of the Resource Management Act 1991, outlines hazards to be assessed by a Territorial Authority in considering a development application. Based on our desktop investigations and inspection of the site we make the following comments in regard to the geohazards.

5.1 Erosion

Council's Geomaps indicate only a small overland flow path from onsite runoff. Runoff from above the site is contained by Compass Point Way. Erosion is not considered a risk for the proposed development.

5.2 Falling debris

The land above is developed residential with no appreciable slope gradient so falling debris is not considered a risk.

5.3 Subsidence

The subsoils are engineered fill overlying puketoka formation and /or volcanic tuff with a bedrock of ECBF. Based on the fine-grained nature of the site soils, the age of the geological unit and the low seismic hazard of the Auckland region, the soils are not considered susceptible to liquefaction. The proposed structures are lightweight and there is no indication of deep filling required, so there is no significant risk of subsidence. However, as mentioned above, reactive clay minerals may cause seasonal shrink/swell which can be mitigated effectively during detailed design for building consent.

5.4 Slippage

The general site slope gradient is approximately 1V:13H, much gentler than the 1V:4H criteria for slope stability analysis suggested in *"Earthworks and Geotechnical Requirements" of the Auckland Council Code of Practice for Land Development & Subdivision.* On the basis of our site observations and review of the geomorphology evident from aerial photographs, there are no indicators of slope instability at the site or in the general area.

5.5 Inundation

According to the Auckland Council's Geomap, the site is not located within a floodplain or overland flow path, and inundation is not considered a risk.

6. Engineering Recommendations

6.1 Foundation Design

We understand the proposed structures will be a maximum of three-storeys high comprising lightweight timber frames and cladding. Shallow pad/slab foundations will generally be suitable, although piled foundations may be required for concentrated loads or bridging across pipelines.

The following geotechnical design parameters are provided for preliminary design to support financial planning and resource consent application. The geotechnical design parameters recommended below are provided in limit state format and should not be exceeded by factored limit state loads.

6.1.1 Shallow Foundations

We recommend the following design parameters for shallow pad foundations.

- Geotechnical Ultimate Bearing Capacity 300 kPa
- Partial strength factor 0.45
- Geotechnical Design Bearing Capacity 135 kPa

On the basis of our investigation and lab testing results, we consider the near surface residual soil to be extremely reactive and susceptible to moisture fluctuations and seasonal soil shrinkage and swelling (Class E, AS 2870:2011). Foundation design in expansive soil may be carried out in accordance with NZS3604 with reference to AS2870 for foundation design in expansive soils.

6.1.2 Piled Foundations

We recommend the following design parameters for piled foundations in combination with strength reduction factors for both static and seismic scenarios:

- Geotechnical Ultimate End-Bearing Capacity 600kPa
- Geotechnical Ultimate Skin Friction 80kPa
- Strength Reduction Factor 0.5(Static) /0.8 (Seismic)

Skin friction should be ignored for the upper 1.5m of the pile and the pile should be embedded at least three pile diameters in order to generate the end-bearing.

If deeper piles are required then end-bearing parameters could be increased to account for embedment into weathered ECBF rock. Further advice can be provided if required.

6.2 Retaining Walls

Although the detail architecture and civil design drawings are not provided at this stage, minor earthworks may be required to form the terraced building platforms with retained heights between terraces.

We envisage standard masonry retaining walls on pad foundations or timber soldier piled walls, to be subject to detailed design for building consent.

The following soil parameters may be assumed for retaining wall design:

- Unit Weight of the soil 18 kN/m^3
- Active earth pressure coefficient K_a 0.33
- At-rest earth pressure coefficient K_o 0.5
- Undrained shear strength (to calculate pole embedment) 70 kPa
- Coefficient of sliding resistance (i.e. tanδ) 0.36

Walls which are integral to structures should be designed for at-rest earth pressures and retaining walls which are independent of structures may be designed for active earth pressures. Retaining walls should also be designed accounting for surcharge loads and batter-slopes above or below the wall.

Appropriate load factors should be applied in accordance with the building code and a strength reduction factor of 0.5 should be applied to the passive resistance and 0.8 for sliding resistance. For gravity walls, bearing capacity can be determined as per recommendations in Section 6.1.1.

6.3 Pipe Bridging

Where structures are required to bridge across sewers, piled foundations should be designed in accordance with the design parameters provided in Section 6.1.2 and proportioned to isolate the sewer from the structure as required by the infrastructure owner.

6.4 Pavement Design

Based on the shear vane tests we recommend a CBR value of 5% for pavement design. The clays and silts may be sensitive to trafficking during construction and the construction methodology should account for this. It is recommended that topsoil and any existing fill should be stripped from the pavement footprint and scala penetrometer tests or Clegg hammer tests should be carried out to confirm CBR values when constructing the pavements.

6.5 Earthworks

We recommend that all earthworks are carried out in accordance with the following documents:

- New Zealand Standard Code of Practice for Earthworks for Residential Development, NZS4431.1989.
- Section 2 “Earthworks and Geotechnical Requirements” of the Auckland Council Code of Practice for Land Development & Subdivision (Version 1.6 dated 24 September 2013)

Fill should be appropriately monitored and tested during placement and compaction and its suitability for final residential development confirmed by a suitably qualified geotechnical engineer. Cuts and fills greater than 600mm depth should be assessed at the detailed design stage by a geotechnical engineer familiar with the contents of this report.

6.5.1 Filling

Investigations indicate the existing fill with variable depth across the site. Any unsuitable fill material should be removed after stripping the topsoil and replaced with clean, inorganic clays and silts or approved engineering fill. Fill testing should be carried out to verify compaction to engineer-certified standards.

Earthworks should be undertaken with conventional plant in accordance with the following subdivision and building development standards:

- NZS 4404 “*Land Development and Subdivision Engineering*”
- NZS 4431 “*Code* of *Practice for Earth Fill for Residential Development”*

We recommend that earthwork excavations are carried out during the dry months. However, excavations should be carried out with temporary drainage channels to intercept any groundwater ingress. These temporary drains should lead to sumps and a mechanism for sediment retention prior to discharging to the Council system. Appropriate permits will be necessary from the Council for such works.

Temporary excavations greater than 1.0m should be battered no steeper than 1H:1V, while excavations of less than 1.0m in height may generally be cut vertical. These recommendations are provided as guidelines only for situations where excavations are well clear of existing structures, boundaries, neighbouring retaining walls, or any other form of surcharge. In these instances, staged excavations, shallower batters, temporary retaining etc. may be required. However, it should be understood maintenance of temporary stability is the responsibility of the contractor.

All permanent cuts and fills at this site can be battered at 1V:4H. Once the batter slopes have reached their finished geometry, they should be stabilized with topsoil and/or root binding vegetation.

6.5.2 Hardfill compaction:

All fill should be placed on suitable subgrade, free of any topsoil or unsuitable materials. At this stage we recommend the use of hardfill (GAP65) as opposed to site-won silts and clays as it is more practical to compact effectively. The compaction of the hardfill should be undertaken using a heavy plate compactor or smooth-drum vibrating roller. Filling should be placed in layers not exceeding 200 mm lifts. Compaction specifications are provided in Table 2.

Table 2. Required CIV Values for hardfill compaction

Foundation Support	Equivalent Clegg Impact Value (CIV)	
	Minimum	Average
Foundation/ Footing/ Beams/ Slabs	15	20

7. Further Geotechnical Involvement

7.1 Detailed Design and Building Consent

A suitably qualified geotechnical engineer familiar with the findings of this reports should be engaged to review the final drawings of the proposed development, prior to submission to the Auckland Council for building consent. Further geotechnical investigation, analysis, design, or reporting may be warranted at this stage subject to the specifics of the proposal.

7.2 Construction Observations

A suitably qualified geotechnical engineer familiar with the findings of this report should be engaged to carry out observations during construction to confirm subsurface conditions are consistent with those described in this report.

8. Closure

For resource consent purposes our investigations and assessment of hazards confirms that the development is feasible and not exposed to any significant geohazards.

Shallow pad or deep foundations are suitable and should be designed in accordance with the recommendations contained in this report. Retaining walls should be specifically designed in accordance with the recommendations in this report and temporary support of excavations should be specifically designed to isolate neighbouring structures from the effects of the earthworks.

We trust this report meets your requirements. Please contact the undersigned if you have any questions.

Prepared by:

Jared Healey

Engineering Geologist

BSc(Geology), PGDipSci(Earth Science)

Total Ground Engineering

Reviewed and Authorised by:

Neil Jacka
Principal Geotechnical Engineer
BE(Hons), CMEngNZ, IntPE

Total Ground Engineering

Appendices

Appendix A. Reference Information
Appendix B. Investigation Location Plan & Borelogs
Appendix C Laboratory Results

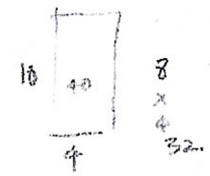
Limitations

This report has been prepared by Total Ground Engineering for our client's use in accordance with the proposed development plan and agreed scope of work. Any use or reliance by any other person, to which Total Ground Engineering has not given its prior written consent, is at that person's own risk.

The findings, recommendations and comments presented in this report are based on common methods of site investigation. The site investigation has been undertaken at discrete locations and ground conditions away from these locations could vary.

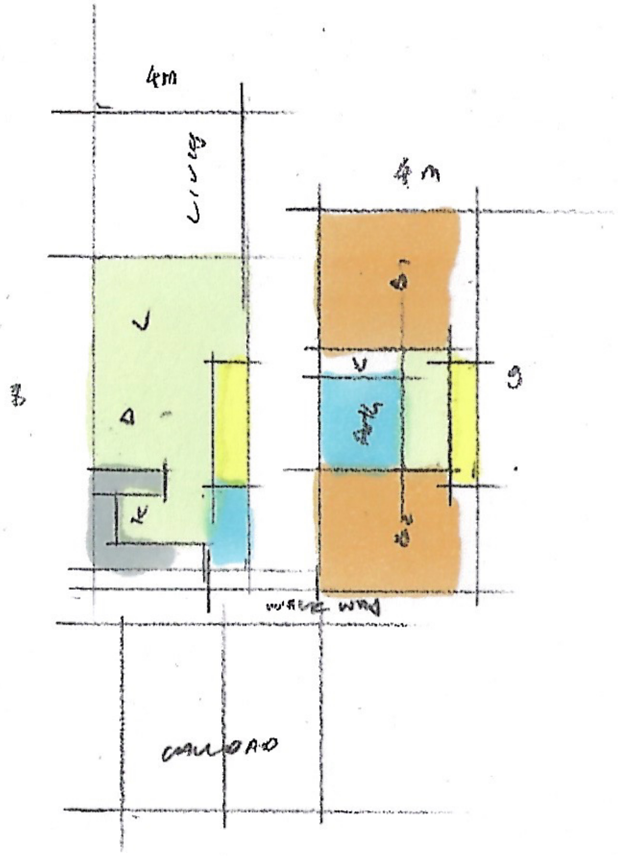
Appendix A
Reference Information (Archi Scheme Sketches)

4



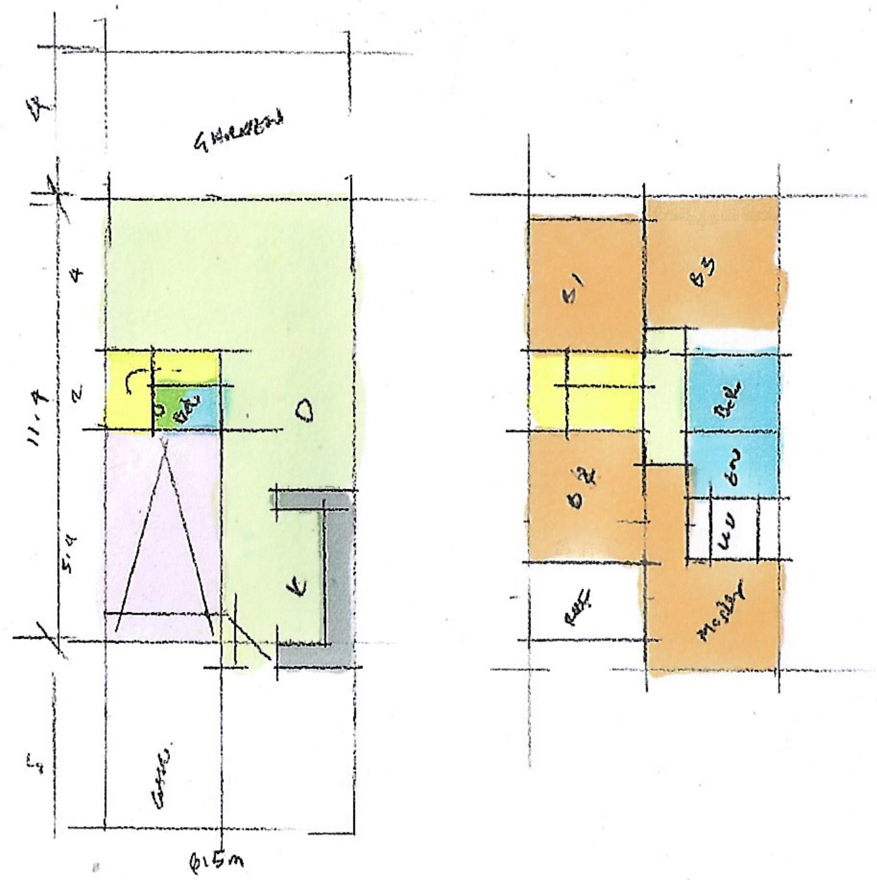
TYPE A	4.0 2STOREY - 2B 1 CAR PAD 70SQM	19
TYPE B	4.5M 2STOREY - 3BED 2 CAR PAD 99SQM	28
TYPE C	4.5m 2STOREY 3BED 1 GARAGE + 1 CAR PAD	4
TYPE D	6.5M WIDE 4BED 2 STOREY 1 GARAGE + 1 CAR PAD 157SQM.	22
TYPE E	6.5M ++ 4BED PLUS 2 STOREY 4BED DOUBLE GARAGE 190	6
		79 units

2STOREY OPTION

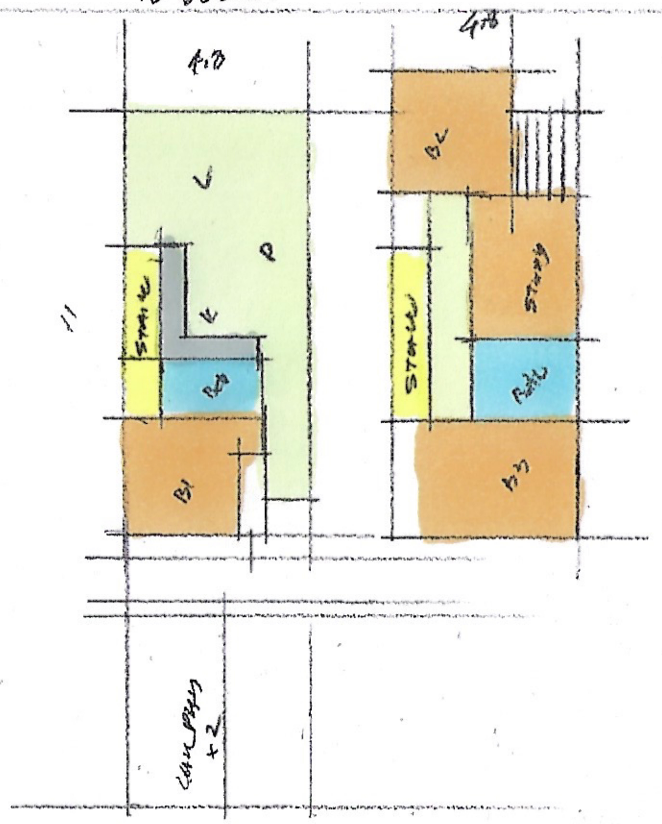


TYPE A 4.0 2BED

L0 – 32
L1 – 36
= 68 SQM.

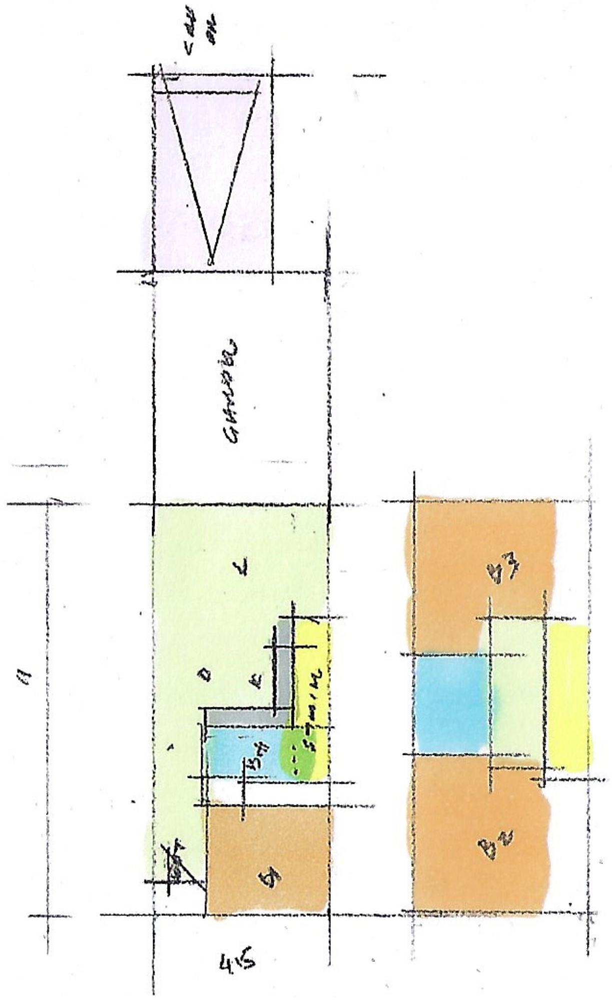


TYPE D — L0 31
L1 77
157m²



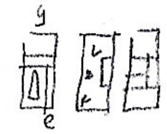
TYPE B 4.8 3BED

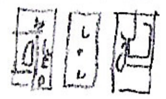
L0 = 52.8
L1 = 53.8
= 105.6 SQM



TYPE C — 3BED L0 65
L1 49
114 SQM

TYPOLOGY FOR 2STOREY
OPTION

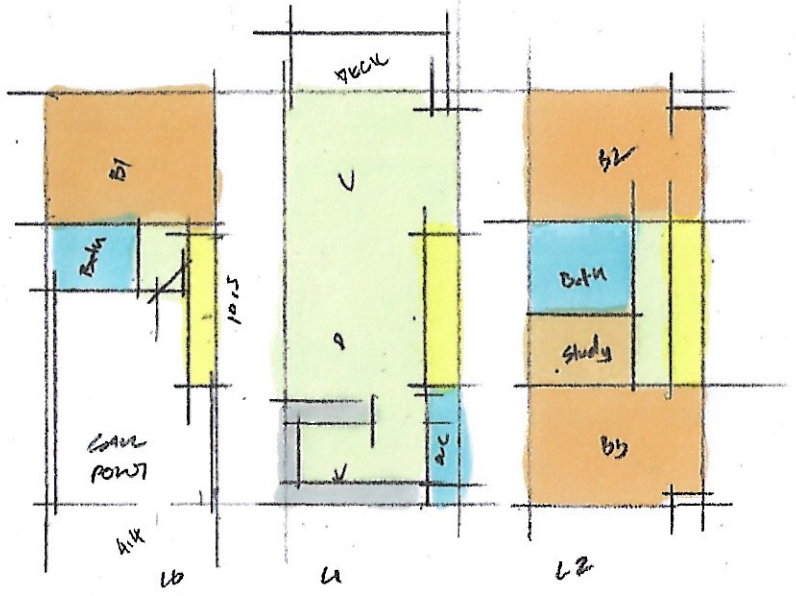




TYPE A	4.5M WIDE 3STOREY – 3BED+STUDY 1 CAR GARAGE 120 SQM	15
TYPE B	5M WIDE 3 STOREY – 3BED + 1STUDY 1 GARAGE + 1 CARPAD 1140	27
TYPE C	5M WIDE 160 3 STOREY – 4 BED + Family 1 GARAGE + 1 CARPAD	2
TYPE D	5.5M WIDE 150 3 storey 4BED + STUDY 1 CAR GARAGE + CARPAD	33
TYPE E	5.5+ WIDE 160 3 STOREY 4BED DOUBLE GARAGE	4
		81 units

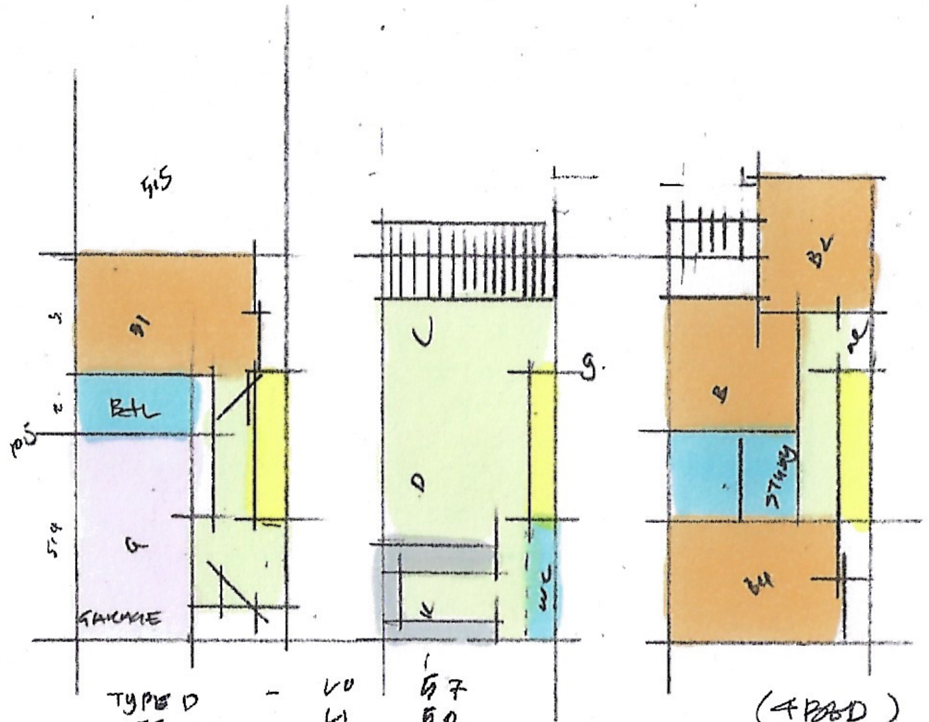
3 STOREY OPTION

3



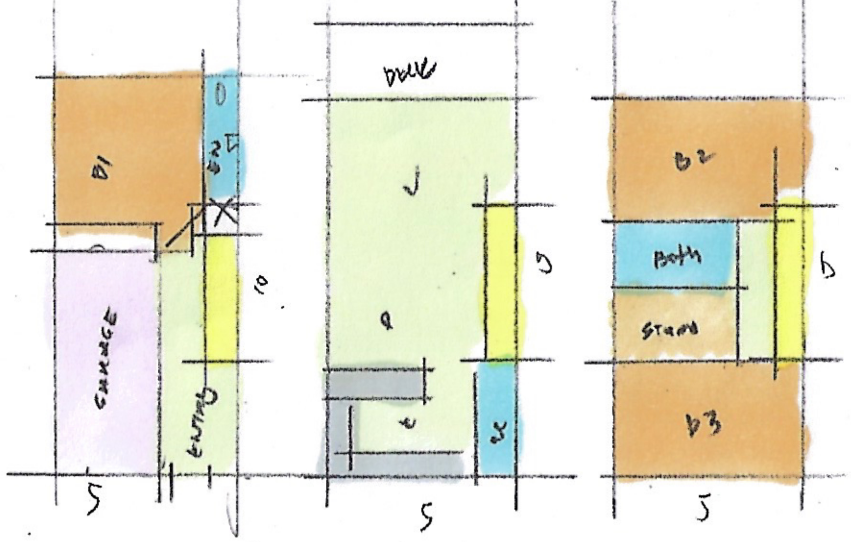
TYPE A — L0 44
4.4m L1 44
L2 40
128 SQM + 8 SQM D

3 storey — 1 car garage
— 3+1 BED



TYPE D — L0 57
5.5m L1 50
L2 52
159 SQM + 8 SQM DECK

(4 BED)

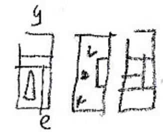


TYPE B — L0 - 50
5m L1 45
L2 45
140 + 8 SQM

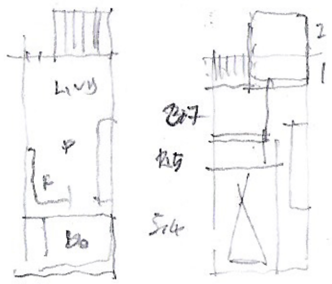
3 storey 1 GARAGE + 1 CAR PAD
3+1

3 STOREY TERRACE
HOUSE TYPOLOGY

75




TYPE A	4.5M WIDE 3STOREY — 3BED+STUDY 1 CAR GARAGE 120 SQM	14	
TYPE B	5M WIDE 3 STOREY — 3BED + 1STUDY 1 GARAGE + 1 CARPAD 1140	25	
TYPE C	5M WIDE 160 3 STOREY — 4 BED + FAMILY 1 GARAGE + 1 CARPAD	3	
TYPE D	6M WIDE 160 3 storey 4BED + STUDY 1 CAR GARAGE + CARPAD	30	
TYPE E	6M WIDE 180 3 STOREY 4BED DOUBLE GARAGE	5	
		77 units	



3
3
2
5.4
13.4

LARGE 3 STOREY OPTION

5×13.4=

Appendix B
Investigation Plan and Borelogs

TOTAL GROUND ENGINEERING	27C WAIPAREIRA AVENUE HENDERSON PH: 027 557 7234 njacka@tge.co.nz	PROJECT 3 PIGEON MOUNTAIN HALF MOON BAY AUCKLAND	DRAWING TITLE INVESTIGATION PLAN

Date:	JUL 2022
Cad Ref:	J00538 r2.dwg
Designed	BL
Drawn	BL
Checked	NJ

Issue	Date	Issue Description	By
-	-	-	BL
A	07.04.2022	ISSUED FOR INFORMATION	BL

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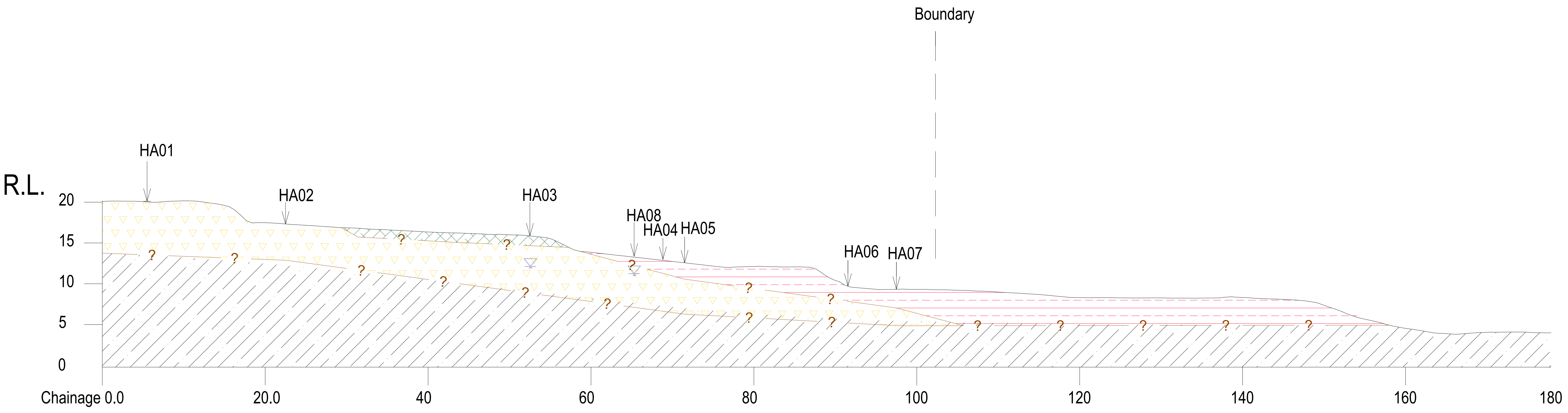

SECTION AA

Geologic Unit:

- Puketoka Formation
- Fill
- AVF
- MW-SW ECBF
- Ground Water Sign
- Material Interface

NOTES:

Locations of features approximate only
Original sheet size A3
Levels refer to provided survey data
Survey information are based on the Auckland Geomaps

TOTAL GROUND ENGINEERING	27C WAIPAREIRA AVENUE HENDERSON PH: 027 557 7234 njacka@tge.co.nz	PROJECT 3 PIGEON MOUNTAIN HALF MOON BAY AUCKLAND	DRAWING TITLE GEOLOGICAL SECTION AA

Date:	JUL 2022
Cad Ref:	J00538 r2.dwg
Designed	BL
Drawn	BL
Checked	NJ

Issue	Date	Issue Description	By
-	-	-	BL
A	07.04.2022	ISSUED FOR INFORMATION	BL

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PAPER SIZE	A3	JOB No. J00538	DWG No. 101	REV A
SCALE	1:500			

TOTAL GROUND ENGINEERING

Client:	HND HMB Ltd	Augerhole No.	HA01
Project:	Geotechnical Investigation for Proposed Residential Development	Sheet No.	1 of 1
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland		

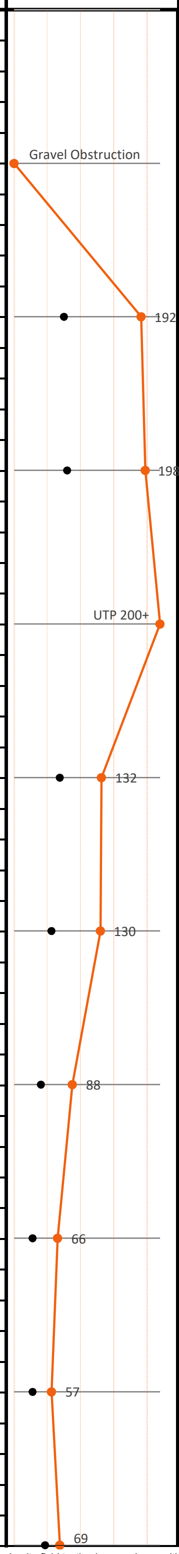
Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769285.17 N5916423.99	Shear Vane No:	2982
Date Started:	15-Jun-22	Ground Conditions:	Slightly sloping, Grass	Calibration Factor:	1.571
Date Finished:	15-Jun-22	Groundwater Level (m):	Not Encountered (15-Jun-22)	Calibration Date:	18-Sep-20

Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005

Stratigraphy	Depth (m)	Soil description	Groundwater Level (m)
FILL	0.0 – 0.8	SILT, minor fine to coarse sand, minor fine sub-angular gravel, brown and brownish orange intermixed, stiff, moist, non-plastic [FILL]	Not Encountered
AUCKLAND VOLCANIC FIELD	0.8 – 2.2	SILT, minor to some clay, some fine to medium sand, brownish-orange with grey bands, very stiff, moist, slightly plastic [TUFF] no clay, hard, non-plastic trace clay, light grey with orange and black mottles	
PUKETOKA FORMATION	2.2 – 5.0	Clayey SILT, trace fine sand, light grey with dark orange bands, very stiff, moist, moderately to highly plastic [PUKETOKA FORMATION] minor fine to medium sand	
	5.0	End of Augerhole 5.0m [TARGET DEPTH]	

In-situ Field Testing

Shear Strength (kPa)



Dynamic Cone (Scala) Penetrometer

Depth (m) | Blow Count | Scala Blow Count / 100mm

0

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

TOTAL GROUND ENGINEERING

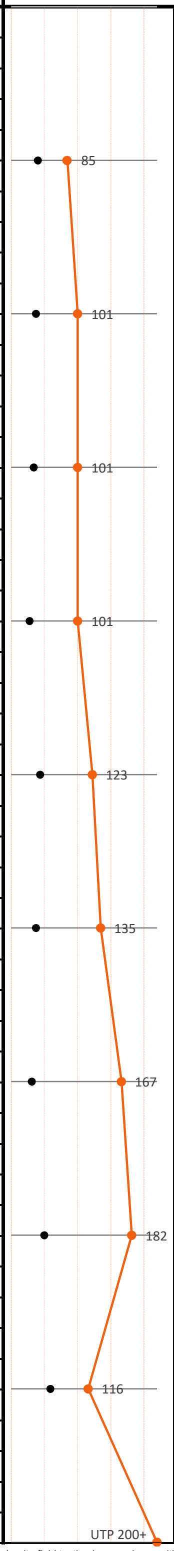
Client:	HND HMB Ltd	Augerhole No.	HA02
Project:	Geotechnical Investigation for Proposed Residential Development	Sheet No.	1 of 1
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland		

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769250.13 N5916486.75	Shear Vane No:	2982
Date Started:	16-Jun-22	Ground Conditions:	Near level, Grass	Calibration Factor:	1.571
Date Finished:	16-Jun-22	Groundwater Level (m):	Not Encountered (16-Jun-22)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005	Groundwater Level (m)
TOPSOIL/FILL	0.0–0.7	SILT, trace fine to coarse sand, minor clay, dark brown, stiff, moist, slightly plastic [TOPSOIL/FILL]	
PUKETOKA FORMATION	0.7–1.3	Silty CLAY, trace fine sand, light grey with light orange streaks, stiff, moist, highly plastic [PUKETOKA FORMATION]	
	1.3–2.8	SILT, some clay, some fine to medium sand, light grey with orange streaks, stiff, moist, slightly plastic minor clay orange with light grey bands	Not Encountered
EAST COAST BAYS FORMATION	2.8–4.7	Fine to medium sandy SILT, light grey with orange bands, very stiff, moist, non to slightly plastic [EAST COAST BAYS FORMATION] grey	
	4.7–5.0	SILT, some clay, trace fine sand, dark grey, hard, moist, slightly plastic	
		End of Augerhole 5.0m [TARGET DEPTH]	

In-situ Field Testing

Shear Strength (kPa) — Peak / Remoulded



Dynamic Cone (Scala) Penetrometer — Depth (m) / Blow Count / Scala Blow Count / 100mm

Depth (m): -0.1 to -5.0 (no blow counts recorded)

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

Total Ground Engineering Ltd. 27C Waipareira Ave, Henderson, 0610
PO Box 27294, Glen Eden, 0604, Auckland, New Zealand
Phone: +64 9 216 7330
Website: www.totalgroundengineering.com

TOTAL GROUND ENGINEERING	
Client:	HND HMB Ltd
Project:	Geotechnical Investigation for Proposed Residential Development
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland
Augerhole No.	HA03
Sheet No.	1 of 1

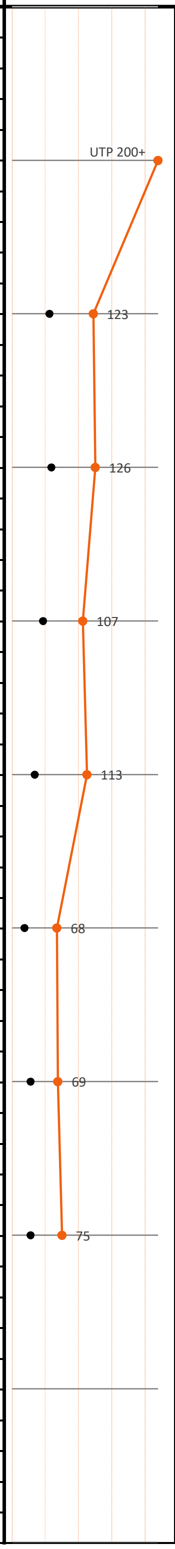
Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769323.22 N5916452.24	Shear Vane No:	2982
Date Started:	15-Jun-22	Ground Conditions:	Near level, Grass	Calibration Factor:	1.571
Date Finished:	15-Jun-22	Groundwater Level (m):	3.0m (15-Jun-22)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes* , NZ Geotechnical Society Inc., 2005
TS/FILL	0.0 – 0.3	SILT, minor fine sand, trace clay, brown, stiff, moist, non-plastic [TOPSOIL/FILL]
AUCKLAND VOLCANIC FIELD	0.3 – 1.0	SILT, some fine sand, trace clay, orange with grey bands, hard, dry, non-plastic [TUFF]
PUKETOKA FORMATION	1.0 – 2.6	Clayey SILT, minor fine to medium sand, light grey with orange streaks, very stiff, moist, slightly to moderately plastic [PUKETOKA FORMATION] trace decomposed organic mottles
PUKETOKA FORMATION	2.6 – 4.0	Fine to medium sandy SILT, minor clay, light grey with orange streaks, stiff, moist, moderately plastic
PUKETOKA FORMATION	4.0 – 5.0	Silty fine to medium SAND, light grey, loose, saturated
		End of Augerhole 5.0m [TARGET DEPTH]

Groundwater Level (m): GW = 3.0m (15-Jun-22)

In-situ Field Testing

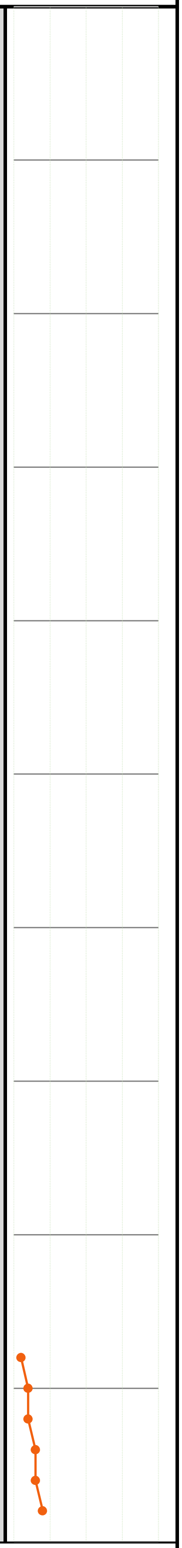
Shear Strength (kPa) — Peak / Remoulded



Depth (m)	Shear Strength, Peak (kPa)
0.5	UTP 200+
1.0	123
1.5	126
2.0	107
2.5	113
3.0	68
3.5	69
4.0	75

Dynamic Cone (Scala) Penetrometer

Depth (m)	Blow Count
-0.1	
-0.2	
-0.3	
-0.4	
-0.5	
-0.6	
-0.7	
-0.8	
-0.9	
-1.0	
-1.1	
-1.2	
-1.3	
-1.4	
-1.5	
-1.6	
-1.7	
-1.8	
-1.9	
-2.0	
-2.1	
-2.2	
-2.3	
-2.4	
-2.5	
-2.6	
-2.7	
-2.8	
-2.9	
-3.0	
-3.1	
-3.2	
-3.3	
-3.4	
-3.5	
-3.6	
-3.7	
-3.8	
-3.9	
-4.0	
-4.1	
-4.2	
-4.3	
-4.4	1
-4.5	2
-4.6	2
-4.7	3
-4.8	3
-4.9	4
-5.0	



In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

TOTAL GROUND ENGINEERING	Client: HND HMB Ltd Project: Geotechnical Investigation for Proposed Residential Development Address: 3 Pigeon Mountain Road, Half Moon Bay, Auckland	Augerhole No. HA04 Sheet No. 1 of 1

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769362.55 N5916428.41	Shear Vane No:	2982
Date Started:	15-Jun-22	Ground Conditions:	Near level, Grass	Calibration Factor:	1.571
Date Finished:	15-Jun-22	Groundwater Level (m):	Not Encountered (15-Jun-22)	Calibration Date:	18-Sep-20

Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005

Stratigraphy	Depth (m)	Soil description	Groundwater Level (m)
FILL	0.0 – 0.8	SILT, minor clay, minor fine to coarse sand, trace fine sub-angular gravel, brown, grey and orange intermixed, stiff, moist, non to slightly plastic [FILL]	Not Encountered
AUCKLAND VOLCANIC FIELD	0.8 – 2.3	SILT, trace clay, minor fine to coarse sand, greyish brown with light orange mottles, very stiff, dry, non-plastic [TUFF] dark orange and greyish orange intermixed some fine to medium sand	
PUKETOKA FORMATION	2.3 – 3.5	Silty CLAY, trace fine sand, grey, very stiff, moist, highly plastic [PUKETOKA FORMATION] light whitish grey	
PUKETOKA FORMATION	3.5 – 5.0	Clayey SILT, minor fine to medium sand, light whitish-grey with yellow streaks, very stiff, moist, moderately to highly plastic some fine to medium pumiceous sand	

End of Augerhole 5.0m
[TARGET DEPTH]

In-situ Field Testing

Shear Strength (kPa) — Peak / Remoulded (0, 50, 100, 150, 200)

Depth (m)	Peak Shear Strength (kPa)
0.5	110
1.0	159
1.5	UTP 200+
2.0	107
2.5	110
3.0	110
3.5	107
4.0	91
4.5	96
5.0	91

Dynamic Cone (Scala) Penetrometer — Depth (m), Blow Count, Scala Blow Count / 100mm (0)

Depth (m): -0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7 -0.8 -0.9 -1.0 -1.1 -1.2 -1.3 -1.4 -1.5 -1.6 -1.7 -1.8 -1.9 -2.0 -2.1 -2.2 -2.3 -2.4 -2.5 -2.6 -2.7 -2.8 -2.9 -3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.6 -3.7 -3.8 -3.9 -4.0 -4.1 -4.2 -4.3 -4.4 -4.5 -4.6 -4.7 -4.8 -4.9 -5.0

In-situ field testing in accordance with the following Standards:
Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer
Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

Total Ground Engineering Ltd. 27C Waipareira Ave, Henderson, 0610
PO Box 27294, Glen Eden, 0604, Auckland, New Zealand
Phone: +64 9 216 7330
Website: www.totalgroundengineering.com

TOTAL GROUND ENGINEERING

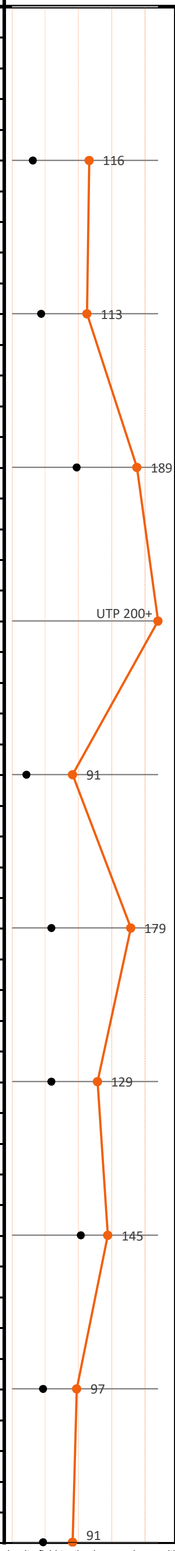
Client:	HND HMB Ltd
Project:	Geotechnical Investigation for Proposed Residential Development
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769315.7 N5916485.41	Shear Vane No:	2982
Date Started:	16-Jun-22	Ground Conditions:	Near level, Grass	Calibration Factor:	1.571
Date Finished:	16-Jun-22	Groundwater Level (m):	Not Encountered (16-Jun-22)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005	Groundwater Level (m)
TS/F	0.0–0.2	SILT, trace clay, minor fine to coarse sand, brown, stiff, moist, non-plastic [TOPSOIL/FILL]	Not Encountered
FILL	0.2–1.5	Clayey SILT, minor fine to coarse sand, trace fine to medium sub-angular gravel, light brown, grey and orange intermixed, stiff, moist, moderately plastic [FILL]	
FILL	1.5–2.5	SILT, some clay, minor fine to coarse sand, trace fine sub-angular gravel, brownish-orange and light grey intermixed, very stiff, moist, slightly to moderately plastic, trace rootlet inclusions no clay, no gravel, no rootlet inclusions, orange	
FILL	2.5–3.2	Silty CLAY, trace fine sand, light grey with orange streaks, stiff, wet, highly plastic light grey with black and dark orange mottles, trace rootlet inclusions	
FILL	3.2–4.0	Clayey SILT, minor fine to medium sand, bluish grey, grey and orange intermixed, stiff, moist, moderately plastic, trace rootlet inclusions	
PUKETOKA FORMATION	4.0–5.0	Silty CLAY, minor fine to medium sand, light bluish grey with orange streaks, very stiff, wet, highly plastic [PUKETOKA FORMATION]	
		End of Augerhole 5.0m [TARGET DEPTH]	

In-situ Field Testing

Shear Strength (kPa) — Peak / Remoulded



Depth (m)	Peak shear strength (kPa)
0.5	116
1.0	113
1.5	189
2.0	UTP 200+
2.5	91
3.0	179
3.5	129
4.0	145
4.5	97
5.0	91

Dynamic Cone (Scala) Penetrometer

Depth (m) | Blow Count | Scala Blow Count / 100mm

0

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

TOTAL GROUND ENGINEERING

Client:	HND HMB Ltd	Augerhole No.	HA06
Project:	Geotechnical Investigation for Proposed Residential Development	Sheet No.	1 of 1
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland		

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769355.93 N5916465.98	Shear Vane No:	2982
Date Started:	16-Jun-22	Ground Conditions:	Sloping, Grass	Calibration Factor:	1.571
Date Finished:	16-Jun-22	Groundwater Level (m):	Not Encountered (16-Jun-22)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Graphic Log	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes* , NZ Geotechnical Society Inc., 2005	Groundwater Level (m)	Depth (m)	In-situ Field Testing: Shear Strength (kPa) Peak: / Remoulded: 0 50 100 150 200	Dynamic Cone (Scala) Penetrometer: Depth (m)	Blow Count	Scala Blow Count / 100mm 0
FILL			SILT, minor fine to medium angular gravel, trace clay, dark brown, stiff, moist, non-plastic [FILL]				-0.1		
							-0.2		
							-0.3		
							-0.4		
	0.5		End of Augerhole 0.4m [GRAVEL OBSTRUCTION]		0.5		-0.5		
							-0.6		
							-0.7		
							-0.8		
							-0.9		
	1.0				1.0		-1.0		
							-1.1		
							-1.2		
							-1.3		
							-1.4		
	1.5				1.5		-1.5		
							-1.6		
							-1.7		
							-1.8		
							-1.9		
	2.0				2.0		-2.0		
							-2.1		
							-2.2		
							-2.3		
							-2.4		
	2.5				2.5		-2.5		
							-2.6		
							-2.7		
							-2.8		
							-2.9		
	3.0				3.0		-3.0		
							-3.1		
							-3.2		
							-3.3		
							-3.4		
	3.5				3.5		-3.5		
							-3.6		
							-3.7		
							-3.8		
							-3.9		
	4.0				4.0		-4.0		
							-4.1		
							-4.2		
							-4.3		
							-4.4		
	4.5				4.5		-4.5		
							-4.6		
							-4.7		
							-4.8		
							-4.9		
	5.0				5.0		-5.0		

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

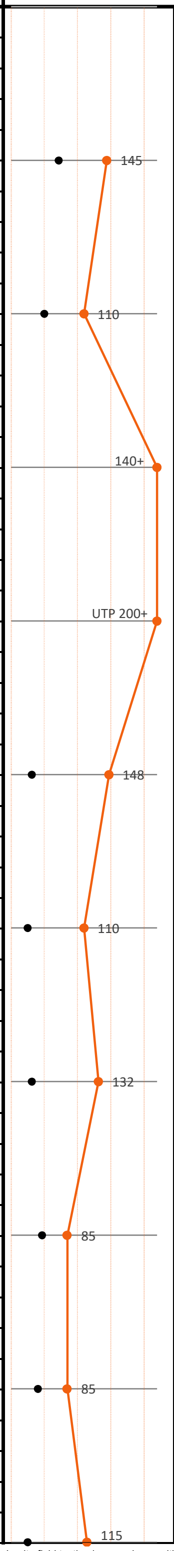
TOTAL GROUND ENGINEERING	Client: HND HMB Ltd Project: Geotechnical Investigation for Proposed Residential Development Address: 3 Pigeon Mountain Road, Half Moon Bay, Auckland	Augerhole No. HA07 Sheet No. 1 of 1	

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769333.95 N5916508.07	Shear Vane No:	2982
Date Started:	16-Jun-22	Ground Conditions:	Near level, Grass	Calibration Factor:	1.571
Date Finished:	16-Jun-22	Groundwater Level (m):	Not Encountered (16-Jun-22)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005	Groundwater Level (m)
FILL	0.0–0.5	SILT, minor clay, some fine to coarse sand, trace fine sub-rounded gravel, brown, very stiff, moist, non-plastic [FILL]	Not Encountered
FILL	0.5–3.9	Clayey SILT, minor fine to coarse sand, trace fine sub-angular gravel, brownish grey, light grey and orange intermixed, very stiff, moist, moderately plastic	
	3.4	orange with brownish-grey bands, trace rounded limonite gravel	
PUKETOKA FORMATION	3.9–5.0	Fine to medium sandy SILT, some clay, light grey with minor decomposed silt inclusions as black bands, stiff, wet, slightly plastic	
	4.3	trace medium angular basalt gravel	
		End of Augerhole 5.0m [TARGET DEPTH]	

In-situ Field Testing

Shear Strength (kPa) — Peak / Remoulded



Depth (m)	Shear Strength Peak (kPa)
0.5	145
1.0	110
1.5	140+
2.0	UTP 200+
2.5	148
3.0	110
3.5	132
4.0	85
4.5	85
5.0	115

Dynamic Cone (Scala) Penetrometer — Depth (m) -0.1 to -5.0; Blow Count; Scala Blow Count / 100mm: 0

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

TOTAL GROUND ENGINEERING

Client:	HND HMB Ltd	Augerhole No.	HA08
Project:	Geotechnical Investigation for Proposed Residential Development	Sheet No.	1 of 1
Address:	3 Pigeon Mountain Road, Half Moon Bay, Auckland		

Drill Type:	50mmØ Hand Auger	Project No:	J00538	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1769257.06 N5916543.39	Shear Vane No:	2982
Date Started:	16-Jun-22	Ground Conditions:	Slightly sloping, Grass	Calibration Factor:	1.571
Date Finished:	16-Jun-22	Groundwater Level (m):	1.0m (16-June-22)	Calibration Date:	18-Sep-20

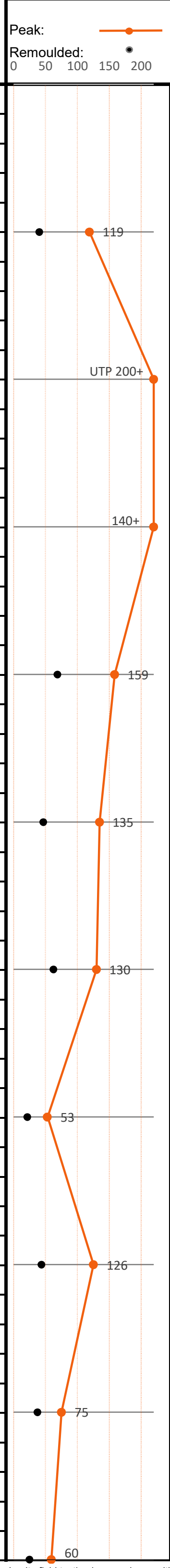
Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes* , NZ Geotechnical Society Inc., 2005

Stratigraphy	Depth (m)	Soil description
FILL	0.0	SILT, minor clay, trace fine to coarse sand, trace fine sub-angular gravel brownish-grey with orange mottles, stiff, moist, non-plastic [FILL]
	1.0	saturated
	1.3	some clay, orange with light grey bands, hard, saturated, slightly to moderately plastic, trace charcoal inclusions
	1.8	minor fine to coarse sand, trace fine angular gravel, brown, brownish orange and dark grey intermixed
PUKETOKA FORMATION	2.3	Silty CLAY, minor fine to medium sand, light grey with light orange streaks, trace fine sub-rounded limonite gravel, very stiff, saturated, highly plastic [PUKETOKA FORMATION]
	2.8	SILT, some clay, minor fine to coarse sand, trace fine sub-rounded gravel, grey, blue, brown and orange intermixed, very stiff, wet, moderately plastic
	3.5	Organic SILT, some clay, trace fine sand, black, stiff, saturated, moderately plastic [AMORPHOUS PEAT]
	3.8	Fine to coarse sandy SILT, minor silty clay bands, trace shell fragments to 20mm, trace fine to medium sub-rounded gravel, grey, brown, green and orange intermixed, stiff, saturated, slightly plastic [MARINE DIPOSITS]
	5.0	End of Augerhole 5.0m [TARGET DEPTH]

Groundwater Level (m): GW = 1.0m (16-June-22)

In-situ Field Testing

Shear Strength (kPa) — Peak / Remoulded



Depth (m)	Shear Strength Peak (kPa)
0.5	119
1.0	UTP 200+
1.5	140+
2.0	159
2.5	135
3.0	130
3.5	53
4.0	126
4.5	75
5.0	60

Dynamic Cone (Scala) Penetrometer

Depth (m) | Blow Count | Scala Blow Count / 100mm

-0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7 -0.8 -0.9 -1.0 -1.1 -1.2 -1.3 -1.4 -1.5 -1.6 -1.7 -1.8 -1.9 -2.0 -2.1 -2.2 -2.3 -2.4 -2.5 -2.6 -2.7 -2.8 -2.9 -3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.6 -3.7 -3.8 -3.9 -4.0 -4.1 -4.2 -4.3 -4.4 -4.5 -4.6 -4.7 -4.8 -4.9 -5.0

0

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

TOTAL GROUND ENGINEERING

Client: HND HMB Ltd
Project: Geotechnical Investigation for Proposed Residential Development
Address: 3 Pigeon Mountain Road, Half Moon Bay, Auckland

Scala Penetrometer Testing

Date tested: 16-June-2022

Tested By: JH

Test ID	HA01	Cont…	HA02	HA03	HA04	Cont…	HA05	HA07	Cont…	
Test from (m)	5.0	7.0	5.0	5.0	5.0	7.0	5.0	5.0	7.0	
Depth (m)	Blows/100mm penetration									
0.1	1	20	3	5	3	17	1	1	16	
0.2	1	20+	5	6	3	16	2	2	18	
0.3	1		8	6	4	16	4	2	20	
0.4	3		9	8	5	17	5	4	20+	
0.5	4		12	8	6	17	6	3		
0.6	4		17	8	7	18	7	4		
0.7	4		20	10	9	17	8	5		
0.8	4		20+	10	8	17	9	7		
0.9	6			9	9	20	10	6		
1.0	6			9	9	20+	13	4		
1.1	6			15	9		13	5		
1.2	8			14	10		15	9		
1.3	7			14	9		18	7		
1.4	8			15	11		23	11		
1.5	10			15	13		20+	12		
1.6	12			18	13			13		
1.7	13			19	14			13		
1.8	15			20	14			15		
1.9	14			20+	14			14		
2.0	14				14			12		
Test depth (m)	7.0	7.2	5.8	6.9	7.0	8.0	6.5	7.0	7.4	

In-situ field testing in accordance with Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Appendix C
Lab testing results

BGL
Babbage Geotechnical Laboratory

Babbage Geotechnical Laboratory
Level 4
68 Beach Road
Auckland 1010
P O Box 2027
New Zealand
Telephone 64-9-367 4954
E-mail wec@babbage.co.nz

Please reply to: W.E. Campton

Total Ground Engineering Ltd.
PO Box 27294,
Glen Eden 0604

Job Number: 65048#L
BGL Registration Number: 2940
Checked by: WEC

Attention: **JARED HEALEY**

30th June 2022

SHRINK-SWELL INDEX TESTING

Dear Sir,

Re: 3 PIGEON MOUNTAIN ROAD, HALF MOON BAY

Report Number: 65048#L/SS 3 Pigeon Mountain Road

The following report presents the results of Shrink-swell Index testing at BGL of 54mm diameter undisturbed push-tube soil samples delivered to this laboratory on the 20th of June 2022. The test standards used were:

Water Content:	NZS4402:1986:Test 2.1
Shrink-swell Index:	AS1289:Test 7.1.1 - 2003

Sample Descriptions (*not part of BGL IANZ Accreditation*)

HA02 / SS01 / 0.80 – 1.00m: CLAY, very stiff, highly plastic, grey with brown streaks, moist.

HA07 / SS02 / 0.40 – 0.60m: SILT, clayey, trace fine gravel, very stiff, moderately plastic, mottled light brown & dark brown, moist.

As per the reporting requirements of AS1289: Test 7.1.1 – 2003: the shrink-swell index value has been reported to the nearest 0.1, and water content is reported to the nearest 0.1%. Density & air voids results have been calculated based on the dimensions of the extruded samples. Density results are reported to the nearest 0.01t/m^3, and air voids are reported to the nearest whole number.

For calculating the air voids percentages a solid density of 2.65t/m^3 was assumed for these tests. Note that this assumed value is not part of the IANZ endorsement for this report. Please note that the test results relate only to the samples as-received, and relate only to the samples under test. Any crumbling of the shrinkage samples did not affect final water content readings.

Thank you for the opportunity to carry out this testing. If you have any queries regarding the content of this report please contact the person authorising this report below at your convenience.

Yours faithfully,

Justin Franklin
Signatory (Assistant Laboratory Manager)
Babbage Geotechnical Laboratory

ACCREDITED
TESTING LABORATORY
№ 126

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation. This report may not be reproduced except in full & with written approval from BGL.

SHRINK-SWELL TEST RESULTS			
Site Location		**3 Pigeon Mountain Road, Half Moon Bay**	
BH Number / Sample Number		**HA02 / SS01**	**HA07 / SS02**
Depth (m)		**0.80 – 1.00m**	**0.40 – 0.60m**
SWELL TEST			
Initial Water Content	%	46.8	27.2
Initial Bulk Density*	t/m³	1.74	1.94
Initial Dry Density*	t/m³	1.19	1.53
Initial Air Voids*	%	0	1
Total Swell*	mm	1.0	0.2
Swelling Strain*	%	4.0	0.7
SHRINKAGE TEST			
Water Content*	%	46.1	27.2
Initial Bulk Density*	t/m³	1.75	1.89
Initial Dry Density*	t/m³	1.20	1.48
Initial Air Voids*	%	0	4
Total Shrinkage*	mm	15.1	5.2
Shrinkage Strain*	%	13.9	4.8
Cracking over the drying period		none / ~~slight / moderate / extreme~~	~~none / slight~~ / moderate / ~~extreme~~
Estimated Inert Inclusions (%)		0	5
SHRINK-SWELL INDEX			
SHRINK-SWELL INDEX		**8.8**	**2.8**

**These results are not part of AS1289: Test 7.1.1 – 2003 reporting requirements, and are provided for your information only.*