

GEOTECHNICAL INVESTIGATION REPORT

# Coastal Development

**KIRI Pt Sec 88E  
TOKERAU TAPER  
ARORANGI DISTRICT  
RAROTONGA  
COOK ISLANDS**

**REF: E2112**

**TURANGI** Geotechnical Services

30 May 2021

Brett Baudinet

Rarotonga

Cook Islands

## **GEOTECHNICAL INVESTIGATION FOR PROPOSED COASTAL DEVELOPMENT ARORANGI, RAROTONGA, COOK ISLANDS**

### **Introduction**

As requested, we have completed a geotechnical investigation for the above site, where it is currently proposed to construct multi-storey hotel adjacent to the Arorangi beach.

Preliminary concept plans were made available; the plans were received on 27 March 2021.

The purpose of our investigation was to assess subsoil conditions so that the suitability for development can be confirmed and recommendations with regard to development addressed. The findings of our investigation are presented herein.

### **Site Description**

The property is located along the western coastal plains of Rarotonga, it is located within the Arorangi village, adjacent to residential dwellings. The *Are Manu* veterinary clinic is nearby.

The property is directly access by a sealed access road, this road links to the *Ara Tapu* (main road).

The property field is legally described as **Kiri Pt Sec 88E, Tokerau Tapere, Arorangi District, Rarotonga**, the property is irregular in shape and occupies an area of **4,237m<sup>2</sup>**.

The property is situated along the Arorangi foreshore on a natural beach ridge formation, the beach and lagoon occupies the western side.

Much of the property is covered in short grass, recent site clearing has removed large trees that once occupied the western, center and eastern side of the property. The cleared trees were stockpiled, dried and burnt at the western side of the property.

A 14m by 19m residential house has also been demolished and cleared. This building occupied the eastern side of the property.

Sand mining had once occurred on the property, the approximate date was not known. It is understood that the white coral sand was mined (excavated out) for construction purpose and volcanic soils from the Arorangi hillside was imported to backfill the excavated area. The sand mining works was undertaken by S&T Contractors.

## **Geology**

Reference has been made to the published report titled 'Geology of the Cook Islands, Bulletin N0. 82 prepared by the New Zealand Geological Survey, 1970'. The report along with the Geological Map of Rarotonga, indicates that the site is underlain by coastal sedimentary deposits of the Holocene Age, this is a distinct soil type described as *Muri Soils*, and its physiography is a *Beach Ridge*.

The beach ridges are derived from the weathering of the coral rocks (sand) and storm surge deposits/cyclones (coral rock boulders). The 'Muri Soils' sands are coarse and usually clayey with limonite stain zones and minor occurrence of volcanic tuff and weathered siltstone, often solid coral limestone can be found at shallow depth extending towards the reef.

## **Liquefaction Hazard**

In the Cook Islands *Earthquake* hazard is classified as very low, accordingly there is a less than 2% chance of earthquake trembling occurring; the main impact associated with earthquake hazard is that of earthquake induced tsunami.

The Cook Islands Building Code (currently under review) *Part 5 – Earthquake Actions* has stated that due to the low risk of earthquakes in the Cook Islands, no earthquake forces need be considered. Soil liquefaction test is rarely undertaken in the Cook Islands.

## Site Investigations

Investigation at the site comprised nine hand augerholes, AH1 to AH9, and five scala penetrometer test, SP1 to SP5, these test were carried out at selected locations to depths between 0.3m and 2.0m below existing ground level.

The test locations and relevant site features are shown on the attached Site Plan. It should be noted that the test locations were measured in by tape from existing site features and inferred boundaries without survey control and are therefore approximate only.

A tape and clinometer survey was undertaken through the locations of the augerholes to obtain a representative ground surface profile. The results of the tape and clinometer survey are shown on the attached Cross-Section Profile.

The groundwater table was not encountered on the day of the investigation, 27 March 2021 and is shown on the field logs.

Scala Penetrometer testing was undertaken from the surface adjacent at selected location across the property, specifically in the areas of the new coastal development, the Scala Penetrometer testing was undertaken in order to obtain a strength profile at depth.

A visual – tactile field classification of the subsoils encountered during drilling was carried out in accordance with the “Field Description of Soil and Rock - Guidelines for the Field Classification and Description of Soils and Rocks for Engineering Purposes”, issued by the New Zealand Geotechnical Inc (2005).

## Subsoil Conditions

Subsoil conditions have been interpolated between the test locations and therefore localized variations between and away from the test locations may exist.

Our investigations revealed that Coastal Sedimentary Deposits that are overlain in places by a surficial layer of fill.

- **Topsoil.** The depth of topsoil 100mm was generally encountered at most test locations. The depth of topsoil reduce towards the recent cleared vegetation and previous building side. Typically the topsoil layer was distinctive in some test locations,

whereas at other locations it tended to merge in with the underlying clayey silt non-engineered fill material.

- **Fill.** Non-Engineered Fill was encountered at all test locations, depth ranging from 0.5m to excess of 2.0m below current ground level. The fill comprised clays, silts, coral sand and cobble. There was no organic or unsuitable materials encountered during our soil investigation, the fill layer was general densely packed. The intermixed clays, silts, sands, gravels (coral and basalt) proved difficult for the hand auger to penetrate through, test bores were often collapsing at depth resulting in poor sample recovery. Vane shear strengths were in excess of 207kPa and Unable To Penetrate (UTP).
- **Coastal Sedimentary Deposits.** Natural deposits were encountered underlying the Fill. The Natural Deposits comprised silts, sands (coral), gravels and cobbles. The alternating strata of silty sands and cobble gravel matrix proved difficult for the hand auger to penetrate through, test bores were often collapsing at depth resulting in poor sample recovery. Vane shear strengths were in excess of 207kPa and Unable To Penetrate (UTP)
- **Scala Penetrometer Tests.** Scala Penetrometer tests were carried out from the surface at five test locations to establish the soil strength profile with depth. Results of the test indicated dense layers at approximately 1.2m and 2.0m below ground level; some test could not penetrate this dense layer.
- **Groundwater Table.** The groundwater table was not encountered on 27 March 2021. The composition of the soils is relatively permeable and the close proximity to the lagoon would suggest that the ground water would likely be influenced by the tides, we would expect natural (surface and sub-surface) flows towards the beach and lagoon without water ponding.

**Table 1**  
**Summary of Subsurface Conditions**

Test	Depth to Base of Test	Depth of Fill	Depth to end of Scala Penetrometer Test	Depth to Groundwater Table
All depths measured in meters below current ground level				
AH1	0.50	+0.50	NT	NE
AH2	1.20	+1.20	NT	NE
AH3	0.80	+0.80	NT	NE

Test	Depth to Base of Test	Depth of Fill	Depth to end of Scala Penetrometer Test	Depth to Groundwater Table
AH4	0.60	+0.60	NT	NE
AH5	1.00	+1.00	NT	NE
AH6	0.50	+0.50	NT	NE
AH7	0.30	+0.30	NT	NE
AH8	1.80	0.60	NT	NE
AH9	1.00	0.50	NT	NE
SP1	2.00	-	2.00	-
SP2	1.20	-	1.20	-
SP3	2.00	-	2.00	-
SP4	2.00	-	2.00	-
SP5	1.40	-	1.40	-

NE Not Encountered  
NT Not Tested

## Foundations

Based on the subsoil conditions encountered at the site and the nature of the structure, we consider conventional strip and pad footings to be an appropriate foundation solution.

All strip and pad foundations should be embedded a minimum of 600mm below final ground level. Results of the scala penetrometer tests has confirmed dense soil material to 2.0m depths, however due to the unknown nature and lack of information regarding the placement of the non-engineered fill, construction using compacted hardfill should be utilized as backfill to achieve the design subgrade level.

### Strip and Pad footings -

#### (i) Working Load Design

An **Allowable Bearing Capacity of 100kPa** is available for Working Load Design under static load conditions. This value may be increased by 50% under seismic load conditions.

#### (ii) Ultimate Limit State Design

A **Dependable Bearing Capacity of 150kPa** to be used in conjunction with **Ultimate Bearing Capacity of 300kPa** is available for Ultimate Limit State Design carried out in accordance with ASNZS 1170: 2002. A Strength Reduction Factor of  $\phi = 0.5$  has been used to determine the Dependable Bearing Capacity.

Footings designed in accordance with these bearing capacity values should experience total and differential settlements that are tolerable for a structure of this nature.

All footing excavations should be subject to inspection at the time of construction by a Registered Engineer who is familiar with the site conditions and recommendation findings of this report.

### **Observation of Construction**

The recommendations given in this report are based on limited site data from discrete locations. Variations in ground conditions could exist across the site. It is in the interests of all parties that we be retained to inspect excavations and foundation conditions exposed during construction, so that ground conditions can be compared with those assumed in formulating this report. In any event, we should be notified of any variations in ground conditions from those described or assumed to exist.

### **Limitations**

This report has been prepared for the sole benefit of **Brett Baudinet** for the presently proposed development. It will be used in design by appointed Consultants. It is not to be relied upon or used out of context by any other person without reference to the undersigned.

We trust that the above is satisfactory. If you have any queries or require further information please do not hesitate to contact the undersigned at your convenience.

**TURANGI** Geotechnical Services



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**Paul Teariki Maoate**  
Geotechnical Engineer  
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# **Appendix A**

## **Site Plan & Cross Section**





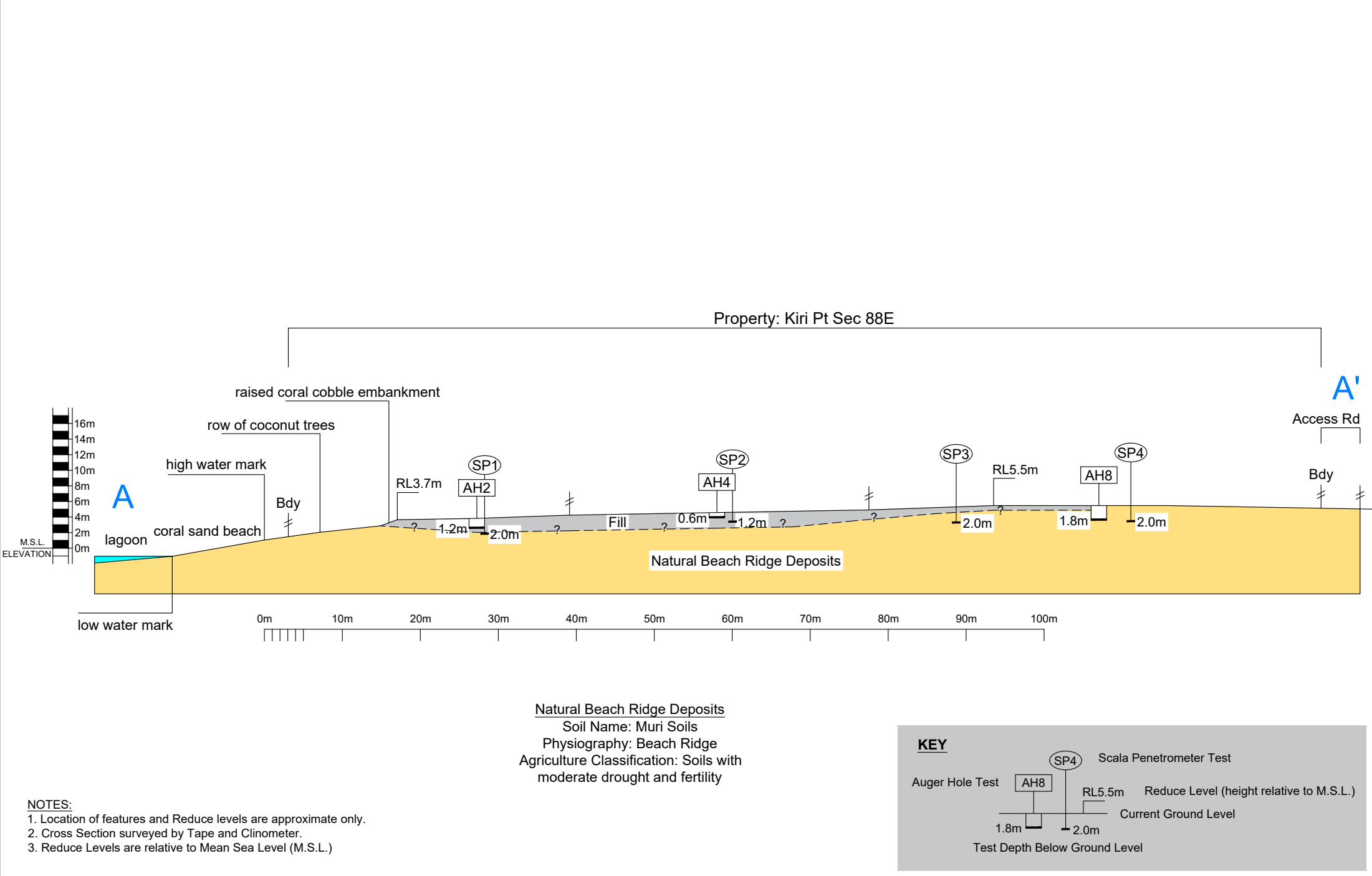
REVISION:	BY:	APPD:	DATE:	PROJECT TITLE:	DRAWING TITLE:	CLIENT: B.Baudinet	JOB REF: E2112	DATE	SHEET No.	Total No. of SHEETS:		
				Coastal Developement	Slte Plan - Property Boundary		DRAWN BY:	PZ	29/05/21	S01	S04	
						CAD REF:	E2112.dwg	CHECKED:				
						SCALE:	N.T.S.	APPROVED:				












REVISION:	BY:	APP'D:	DATE:	PROJECT TITLE:	DRAWING TITLE:	CLIENT:	JOB REF:	DATE	SHEET No.	Total No. of SHEETS:
				Coastal Development	Cross Section Profile	B.Baudinet	E2112		S04	S04
							DRAWN BY:	PZ		
						CAD REF:	E2112.dwg	CHECKED:		
						SCALE:	N.T.S.	APPROVED:		

## **Appendix B**

### **Augerhole Test Logs**


JOB No: E2112		Client Details: Brett Baudinet		AUGERHOLE LOG		AH 1					
Section: Kiri Pt Sec 88E											
Tapere: Tokerau											
District: Arorangi											
SURFACE CONDITION: Level, slight slope, short grass				GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●				
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"							Remoulded Vane Shear Strength (kPa) ☒				
TOPSOIL					0	0 50 100 150 200					
Intermixed brown and pale grey, sandy SILT, sand fine to coarse, some coral gravels Ø20-40mm, closely packed, dry, friable (NON-ENGINEERED FILL)											
EOB 0.5m (Too dense to auger)						UTP					
1	Note: Obstructed by infer densely packed coral gravel and sand matrix, poor sample recovery				1						
2					2						
3					3						
4					4						
5					5						
OBSERVATION: Ground water not encountered 27 March 2021											
DATE: 27 March 2021		Shear Vane No: GEO 1273									
LOGGED BY: PM, WR & TT		Shear Vane Calib Factor: 1.480									
DRILLING METHOD: Hand Auger		Date of last calibration: 16 March 2018									

JOB No: E2112		Client Details: Brett Baudinet		AUGERHOLE LOG		AH 2					
Section: Kiri Pt Sec 88E											
Tapere: Tokerau											
District: Arorangi											
SURFACE CONDITION: Level, slight slope, short grass				GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●				
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"							Remoulded Vane Shear Strength (kPa) ☒				
	TOPSOIL				0						
	Intermixed brown and pale grey, sandy SILT, sand fine to coarse, some coral gravels Ø20-40mm, closely packed, dry, friable (NON-ENGINEERED FILL)										
	0.7m Occasional coral gravels, Ø20-600mm sub angular									UTP	
1					1					UTP	
	EOB 1.2m (Too dense to auger)									UTP	
2				2							
3				3							
4				4							
5				5							
OBSERVATION: Ground water not encountered 27 March 2021											
DATE:		27 March 2021		Shear Vane No:		GEO 1273					
LOGGED BY:		PM, WR & TT		Shear Vane Calib Factor:		1.480					
DRILLING METHOD:		Hand Auger		Date of last calibration:		16 March 2018					

JOB No: E2112	Client Details: <div>Brett Baudinet</div>	AUGERHOLE LOG		AH 3
Section:	Kiri Pt Sec 88E			
Tapere:	Tokerau			
District:	Arorangi			
SURFACE CONDITION:	Level, slight slope, short grass		GRAPHIC LOG	DEPTH (m)
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"			GROUNDWATER	Peak Vane Shear Strength (kPa) ● Remoulded Vane Shear Strength (kPa) ☒
TOPSOIL			0	0 50 100 150 200
Intermixed brown and pale grey, sandy SILT, sand fine to coarse, some coral gravels Ø20-40mm, closely packed, dry, friable (NON-ENGINEERED FILL)				
EOB 0.8m (Too dense to auger)				UTP
Note: Obstructed by infer densely packed coral gravel and sand matrix, poor sample recovery				UTP
1			1	
2			2	
3			3	
4			4	
5			5	
OBSERVATION:	Ground water not encountered 27 March 2021			
DATE:	27 March 2021	Shear Vane No:	GEO 1273	
LOGGED BY:	PM, WR & TT	Shear Vane Calib Factor:	1.480	
DRILLING METHOD:	Hand Auger	Date of last calibration:	16 March 2018	



JOB No:	E2112	Client Details:	Brett Baudinet
Section:	Kiri Pt Sec 88E		
Tapere:	Tokerau		
District:	Arorangi		
SURFACE CONDITION: Level, slight slope, short grass			
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"			
TOPSOIL 50mm			
Dark brown clayey SILT, some basalt gravels, very stiff, moist, slight to moderately plastic (NON-ENGINEERED FILL)			
0.5m Occasional basalt gravels, Ø10-40mm sub angular			
EOB 0.6m (Too dense to auger)			
Note: Obstructed by infer densely packed basalt gravel and sand matrix, poor sample recovery			
OBSERVATION: Ground water not encountered 27 March 2021			
DATE:	27 March 2021	Shear Vane No:	GEO 1273
LOGGED BY:	PM, WR & TT	Shear Vane Calib Factor:	1.480
DRILLING METHOD:	Hand Auger	Date of last calibration:	16 March 2018

JOB No: E2112		Client Details: Brett Baudinet		AUGERHOLE LOG		AH 5					
Section: Kiri Pt Sec 88E											
Tapere: Tokerau											
District: Arorangi											
SURFACE CONDITION: Level, slight slope, short grass				GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●				
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"							Remoulded Vane Shear Strength (kPa) ☒				
	TOPSOIL 80mm				0						
	Dark brown, clayey SILT, some basalt gravels, very stiff, moist, moderately plastic (NON-ENGINEERED FILL)										
	0.8m Occasional basalt gravels, Ø20-50mm sub angular									207+	
1	EOB 1.0m (Too dense to auger)				1					UTP	
	Note: Obstructed by infer densely packed basalt gravel and sand matrix, poor sample recovery										
2					2						
3					3						
4				4							
5				5							
OBSERVATION: Ground water not encountered 27 March 2021											
DATE:		27 March 2021		Shear Vane No:		GEO 1273					
LOGGED BY:		PM, WR & TT		Shear Vane Calib Factor:		1.480					
DRILLING METHOD:		Hand Auger		Date of last calibration:		16 March 2018					

JOB No: E2112	Client Details: <div>Brett Baudinet</div>	AUGERHOLE LOG		AH 6	
Section:	Kiri Pt Sec 88E				
Tapere:	Tokerau				
District:	Arorangi				
SURFACE CONDITION: Level, slight slope, short grass		GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"					Remoulded Vane Shear Strength (kPa) ☒
	TOPSOIL 50mm		0		050100150200
	Dark brown, clayey SILT, some basalt gravels, stiff, moist, moderately plastic (NON-ENGINEERED FILL)				
	EOB 0.5m (Too dense to auger)				UTP
1	Note: Obstructed by infer densely packed basalt and coral gravel, poor sample recovery		1		
2			2		
3			3		
4			4		
5			5		
OBSERVATION: Ground water not encountered 27 March 2021					
DATE:	27 March 2021	Shear Vane No:	GEO 1273		
LOGGED BY:	PM, WR & TT	Shear Vane Calib Factor:	1.480		
DRILLING METHOD:	Hand Auger	Date of last calibration:	16 March 2018		

JOB No: E2112		Client Details: Brett Baudinet		AUGERHOLE LOG			AH 7						
Section: Kiri Pt Sec 88E													
Tapere: Tokerau													
District: Arorangi													
SURFACE CONDITION: Level, recent cleared area, exposed soils						GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●				
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"									Remoulded Vane Shear Strength (kPa) ☒				
Intermixed grey and brown, clayey SILT, some gravels, closely packed, moist, slight to moderately plastic (NON-ENGINEERED FILL)							0						
EOB 0.3m (Too dense to auger)								UTP					
Note: Obstructed by infer densely packed basalt and coral gravel, poor sample recovery							1						
							2						
							3						
							4						
							5						
OBSERVATION: Ground water not encountered 27 March 2021													
DATE: 27 March 2021		Shear Vane No: GEO 1273											
LOGGED BY: PM, WR & TT		Shear Vane Calib Factor: 1.480											
DRILLING METHOD: Hand Auger		Date of last calibration: 16 March 2018											

JOB No: E2112		Client Details: Brett Baudinet		AUGERHOLE LOG			AH 8				
Section: Kiri Pt Sec 88E											
Tapere: Tokerau											
District: Arorangi											
SURFACE CONDITION: Level, recent cleared area, exposed soils				GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●				
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"							Remoulded Vane Shear Strength (kPa) ☒				
	Intermixed grey and brown, sandy SILT, some clay, occasional gravels, very stiff, dry, non plastic (NON-ENGINEERED FILL)				0						
	Banded yellow and white, silty SAND, occasional coral gravels, sand coarse, closely packed, dry to moist, non-plastic (NATURAL BEACH RIDGE DEPOSITS)									UTP	
1					1						UTP
	1.3m Becoming saturated, wet										UTP
											UTP
											UTP
2	EOB 1.8m (Too dense to auger)			2							
	Note: Obstructed by infer densely packed coral gravel and cobble, poor sample recovery										
3				3							
4				4							
5				5							
OBSERVATION: Ground water not encountered 27 March 2021											
DATE: 27 March 2021		Shear Vane No: GEO 1273									
LOGGED BY: PM, WR & TT		Shear Vane Calib Factor: 1.480									
DRILLING METHOD: Hand Auger		Date of last calibration: 16 March 2018									

JOB No: E2112	Client Details: Brett Baudinet	AUGERHOLE LOG		AH 9	
Section: Kiri Pt Sec 88E					
Tapere: Tokerau					
District: Arorangi					
SURFACE CONDITION: Level, recent cleared area, exposed soils		GRAPHIC LOG	DEPTH (m)	GROUNDWATER	Peak Vane Shear Strength (kPa) ●
Soil description in accordance with the NZ Geomechanics Society Publication "Guidelines for the Field Description of Soils and Rocks in Engineering use"					Remoulded Vane Shear Strength (kPa) ☒
	Intermixed grey and brown, sandy SILT, some clay, occasional gravels, very stiff, dry (NON-ENGINEERED FILL)		0		0 50 100 150 200
	Banded yellow and white, silty SAND, occasional coral gravels, sand coarse, closely packed, dry to moist, non-plastic (NATURAL BEACH RIDGE DEPOSITS)				
1	EOB 1.0m (Too dense to auger)  Note: Obstructed by infer densely packed coral gravel and cobble, poor sample recovery		1		UTP
2			2		
3			3		
4			4		
5			5		
OBSERVATION: Ground water not encountered 27 March 2021					
DATE:	27 March 2021	Shear Vane No:	GEO 1273		
LOGGED BY:	PM, WR & TT	Shear Vane Calib Factor:	1.480		
DRILLING METHOD:	Hand Auger	Date of last calibration:	16 March 2018		

## **Appendix C**

### **Scala Penetrometer Test**

# **SCALA PENETROMETER SHEET - TABLE OF BLOWS PER INCREMENT**

SITE:

**Proposed Development**  
**Kiri Pt Sec 88E, Arorangi District, Rarotonga**

REF No.

**E2112**

TESTED BY:

**WR & TT**

DATE TESTED: **01 May 2021**

Test Location	SP1	SP2	SP3	SP4	SP5				
DEPTH START	0.0m	0.0m	0.0m	0.0m	0.0m				
50 mm	1	1	1	1	2				
100	2	1	1	3	2				
150	1	2	2	3	2				
200	2	2	2	4	3				
250	2	2	2	3	3				
300	3	1	2	4	3				
350	4	1	2	5	5				
400	2	2	2	5	6				
450	4	3	2	4	7				
500	4	3	3	3	6				
550	10	3	4	2	4				
600	4	8	2	2	3				
650	8	7	2	4	3				
700	7	7	2	2	3				
750	8	13	3	3	2				
800	11	9	3	3	2				
850	6	7	3	2	2				
900	7	10	2	2	3				
950	3	12	1	2	3				
1000	3	9	2	1	2				
1050	6	8	2	1	3				
1100	4	14	2	1	2				
1150	3	13	2	1	3				
1200	2	15+	2	2	4				
1250	5		2	3	4				
1300	9		2	2	5				
1350	10		2	2	10				
1400	5		2	2	15+				
1450	2		2	2					
1500	2		3	2					
1550	3		3	2					
1600	4		2	2					
1650	4		2	2					
1700	2		2	1					
1750	3		3	2					
1800	4		4	2					
1850	8		5	3					
1900	14		3	3					
1950	8		4	2					
2000	15+		3	2					
DEPTH END	<b>2.0m</b>	<b>1.2m</b>	<b>2.0m</b>	<b>2.0m</b>	<b>1.4m</b>				

Testing Method: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer