

15 January 2020

TRIG & BRIGHAM CREEK ROAD

69 Trig Road, 151 Brigham Creek Road, 155-157

Brigham Creek Road

GEOTECHNICAL INVESTIGATION REPORT

Neil Construction Ltd
AKL20 9 0040AD Rev 0

AKL2019-0040AD		^
Date	Revision	Comments
19 December 2019	Α	Initial draft for internal review
07 January 2020	В	Updated for internal review
15 January 2020	0	Final issue to support Resource Consent Application

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#### **EXECUTIVE SUMMARY**

This report presents the results of a geotechnical investigation and geohazards assessment for the proposed development at Trig and Brigham Creek Roads in Whenuapai, which is being considered for the construction of a residential and industrial subdivision.

The site comprises a total area of approximately 15.5 hectares and is located at 69 Trig Road, 151 Brigham Creek Road, and 155-157 Brigham Creek Road. The site is characterised by an alluvial terrace with moderate gradients. Two gullies with associated overland flow paths and streams are present towards the north and south eastern section of the site, with an existing culvert crossing located on 155-157 Brigh m Creek Road. The site is bound to the north by Brigham Creek Road, and to the south east and west by neighbouring rural residential properties. It has historically been used and is currently used for agri ultural purposes.

The current development proposal is to create 24 industrial lots of varying size in the southern portion of the site and 36 residential lots in the northern portion, with five associated access roads/road rese ves extending from Brigham Creek Road and Trig Road. The original landform is being modified by raising the south eastern gully with fill depths of up to 5m and the embankment along the creek with fill depths of up to 3m. Cuts of up to 2m are proposed within the central portion of the site. This will form a gently graded site with fill embankment along the edge of the northern stream alignment.

Based on the investigation results, the site is underlain by Puk toka Formation alluvial deposits, with Waitemata Group deposits located below the alluvium.

Design details for geotechnical aspects of future development are summaris d as follows:

- The subsoils encountered as part of this investigation are generally consistent with the published geological records;
- Some historic uncertified filling was encountered as part of this investigation in the southeast corner
  of 69 Trig Road, the central northern portion of 151 Brigham Creek Road and the northern portion
  of 155-157 Brigham Creek Road. These existing uncertified fills will need to be inspected by the
  Geotechnical Engineer following site stripping. It is anticipated that the fill will need to be undercut,
  reworked and placed to engineering standards;
- Slope stability analyses results show factors of safety above the minimum Auckland Council
  requirements for the existing and proposed ground profiles across the four cross sections analysed;
- Given the geological age of the sibsoils and specific plasticity index laboratory testing carried out, there is considered to be a low risk of liquefaction at this site;
- Proposed fill embankments and / or future building loads outside of the proposed cut areas will
  induce settlements within the underlying subsoils, predominantly toward the southern portions of
  the site. Preloads of up to 1.0m may be considered within areas of either minimally earthworked
  g ound or across the deepest fills. Settlement monitoring of the underlying soils during fill placement
  s recommended;
  - Following the works, a Geotechnical Ultimate Bearing Capacity of 300kPa should be available for NZS3604 type structures on shallow foundations;
- The combination of construction dead loads and industrial floor loads should be limited to 20kPa. Loads over this will require specific analyses and design;
- Based on our visual and tactile observations during investigations, we anticipate the AS2870 Site Class for the development site to be M (moderate) to H1 (high).

CMW Geosciences Ref. AKL2019-0040AD Rev 0

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## 1 INTRODUCTION

# 1.1 Project Brief

CMW Geosciences (CMW) was engaged by Neil Construction Ltd to carry out detailed geotechnical investigation of three adjoining sites located at Trig and Brigham Creek Road, encompassing 69 T g Road, 151 Brigham Creek Road and 155-157 Brigham Creek Road, which are being considered for the construction of a residential and industrial subdivision.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKL2019-0040AC Rev.0, dated 31 October 2019.

This report is to support a Resource Consent application to Auckland Council.

## 1.2 Scope of Work

As detailed in our proposal letter, the instructed scope of work to be conducted by CMW was defined as follows:

- Desktop study of available information relevant to the proposed development;
- Arrange and execute a detailed geotechnical site investigation (SI);
- Evaluate and develop an appropriate geological and geotechnical model, including seasonal groundwater variations;
- Identify any geohazards to the proposed development, including liquefaction, static settlements, sensitive soils and groundwater issues, and provide strategies to mitigate;
- Recommendations for the design of t mporary works, incl ding excavation support, dewatering requirements, earthworks requirements;
- Provide appropriate geotechnical parameters for the design of proposed building foundations, floor slabs, pavements and retaining walls;
- Compile all of the above detail into a concise geotechnical investigation report, incorporating relevant plans, field investigation data, laboratory test data and calculations.

## 2 SITE DESCRIPTION

#### 2.1 Site Location

The site comprises a total area of approximately 15.5 hectares and is located at 69 Trig Road, 151 Brigham Creek Road, and 155-157 Brigham Creek Road, legally described as Lot 5 DP 101583 and Lot 3 DP 101583, Lot 4 DP 101583, and Lot 2 DP 334953 respectively, as shown on Figure 1 below.

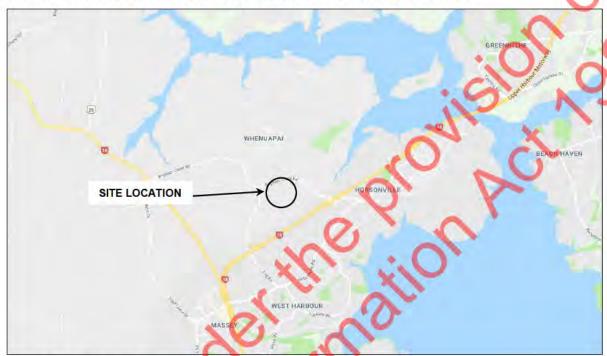


Figure 1: Site Location Plan (Google Maps)

## 2.2 Landform

The current general landform, together with associated features located within and adjacent to the site is presented on the att\_ched Site Investigation Plan as **Drawing 01**.

The site is char cterised by an alluvial terrace that grades moderately from approximately RL35m in the south western co ner to RL15m at the south eastern corner and RL13m at the north and eastern corners of the site.

Two gul ies with associated overland flow paths and streams are present. One is located within and adjacent to the south eastern corner of the site while the second runs through the northern quarter of the site.

The site is bound to the north by Brigham Creek Road, and to the south, east and west by neighbouring rural residential properties. An existing residential dwelling is located at the site on 151 Brigham Creek Road with a culver across the adjacent stream providing access to this dwelling. Two existing dwellings are also located on 149 Brigham Creek Road, which is incorporated in the northern corner of 151 Brigham Creek Road.

There are no residential dwellings present on 69 Trig Road or 155-157 Brigham Creek Road, however there is an existing culvert crossing in the northern gully located on 155-157 Brigham Creek Road.

The site has historically been used and is currently used for agricultural purposes.

#### 3 PROPOSED DEVELOPMENT

The current development proposal, as shown on the draft scheme plan provided by Neil Construction Ltd and depicted on the appended **Drawing BCR-SP-01 V9**, is to create 24 industrial lots of varying size in the

southern portion of the site (2087m² to 2.3583 ha in area) and 36 residential lots of varying size in the northern portion of the site (283m² to 2067m²), with five associated access roads/road reserves extending from Brigham Creek Road and Trig Road, a drainage reserve along the alignment of the existing northern stream and a recreational reserve along the northern boundary of 155-157 Brigham Creek Road.

As shown on *Drawing 447-01-BE-201*, the original landform is being modified by raising the south-eastern gully with fill depths of up to 5m and constructing an embankment along the northern stream with fill depths of up to 3m. Cuts of up to 2m are proposed within the central portion of the site. This will form a gently graded site with a fill embankment along the edge of the northern stream alignment. Batter slopes along the stream embankment of up to 1 in 3 (V:H) and gradients across the south eastern gully fill of up to 1 in 2.5 (V:H) are proposed.

Development plans provided by Neil Construction Ltd are attached to this report in Appendix A.

# 4 INVESTIGATION SCOPE

# 4.1 Desktop Study

A desktop study was carried out before commencing fieldwork. This included online research through Auckland Council Geo Maps, Dial Before You Dig, aerial photographs and an undergro and services search, as well as a review of our previous Geotechnical Investigation Report that was carried out for due diligence purposes, referenced AKL2019-0040AB Rev.0, dated 28 March 2019.

Based on our previous geotechnical investigations, historical use of the site as agricultural land and surrounding land levels, inferred from aerial photographs and recorded history, some reasonable depths of fill are anticipated as a result of soft landscaping and historic earthworks across the site. We understand that uncontrolled fill has been placed in the northen part of 155-157 Brigham Creek Road and the south eastern part of 69 Trig Road, dating back to 2001.

# 4.2 Field Investigation

Following a Dial Before You Dig search, and onsite se vice location, the field investigation was carried out between 25 November 2019 and 27 November 2019. All fieldwork was carried out under the direction of CMW Geosciences in general accordance with the NZGS guidance<sup>1</sup>. The scope of fieldwork completed was as follows:

- An on-site services search was carried out by a specialist contractor to identify the presence of any
  underground obstructions or hazards prior to the field investigation program commencing;
- Two machine oreholes, denoted MH01-19 and MH02-19, were drilled using HQ3 diamond coring drilling tech iques to depths of up to 20m to determine the ground model through and below the proposed earthworks profile Engineering logs and photographs of the boreholes are provided in Appendix B;
- Seven test pits, denoted TP01-19 to TP07-19, were excavated using a 20-tonne hydraulic excavator fitted with a 2m wide blade bucket to depths of between 1.2m and 3.0m below existing ground levels to determine the quality and extent of the fill within the south-eastern corner of 69 Trig Road. TP02-19 was terminated due to encountering an old drainage pipe, while TP01-19 and TP03-19 to TP07-19 were terminated at target depth, below any fill materials. Engineering logs and photographs of the test pits are pre-ented in *Appendix B*;
- El ven hand auger boreholes, denoted HA012-19 to HA22-19, were drilled using a 50mm diameter auger to target depths of up to 5.0m below existing ground levels to visually observe the near surface soil profile and to facilitate in-situ vane shear strength testing. Engineering logs of the hand auger boreholes, together with peak and remoulded vane shear strengths are presented in *Appendix B*;

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<sup>&</sup>lt;sup>1</sup> NZ Geotechnical Society (2005), Field Description of Soil and Rock, Guideline for the field classification and description of soil and rock for engineering purposes.

The approximate locations of the respective investigation sites referred to above, including those undertaken as part of our previous site investigations, are shown on the appended Site Investigation Plan. Test locations were measured using hand held GPS. Elevations were inferred from Auckland Council Geo Maps.

# 4.3 Laboratory Testing

Laboratory testing was carried out generally in accordance with the requirements of NZS4402 (where applicable). Where a test was not covered by a New Zealand standard, a local or International standard was adopted and noted on the laboratory test certificate.

All testing was scheduled by CMW and carried out by Roadtest and Babbage Geotechnical Laboratory, both of which are IANZ registered Testing Authorities.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1.

Table 1: Laboratory Testing Schedule						
Type of Test	Test Method	Quantity				
Water Content	NZS4402 - 1986 2.1	3				
Atterberg Limits	NZS4402 - 1986 2.3 / 2.4 / 2.5	1				
One Dimensional Consolidation	NZS4402 1986 7.1	2				

Certificates for the test results outlined above are presented in Appendix C.

## 5 GROUND MODEL

# 5.1 Published Geology

Published geological maps<sup>3</sup> for the area depict the regi nal geology as comprising Late Pliocene to Mid Pleistocene alluvial deposits of the Puketoka Formation (Pup) as illustrated in Figure 2 below.

<sup>&</sup>lt;sup>2</sup> New Zealand Standard NZS4402 (1986), Methods of testing soils for civil engineering purposes.

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

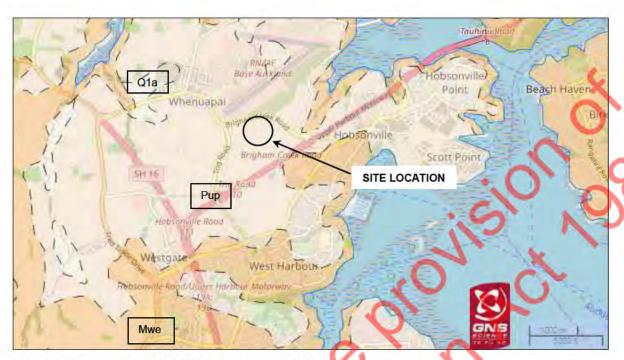


Figure 2: Regional Geology (GNS Science Geology Map)

These alluvial deposits include pumiceous mud sand and gravel with muddy peat and lignite, rhyolitic pumice (including non-welded ignimbrite, tephra and alluvial pumice deposits) and massive micaceous sand beds. Below these upper soil layers, the deeper geological formation is reported to comprise, interbedded muddy sandstones and siltstones of the East Cast Bays Formation (Mwe) within the Waitemata Group.

The main geotechnical hazards within the Puketoka Formation strata are low bearing capacity and settlement from soft/organic soils.

We understand that uncertified fill is present across some areas of the development site.

# 5.2 Stratigraphic Units

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

#### 5.2.1 Topsoil

Topsoil was encountered in all test pits and boreholes excluding HA12-19, to depths of between 0.05m and 0.4m. Topsoil was generally dry to moist across the site.

#### 5.2.2 Uncertified Fill

H storic uncontrolled/uncertified fill was encountered as expected in the southeast corner of 69 Trig Road and northern portion of 155-157 Brigham Creek Road, with a thin veneer also encountered in the central portion of 151 Brigham Creek Road. Uncertified fill was encountered in all recent test pits and boreholes, excluding TP04-19, TP06-19, HA17-19, HA21-19, HA22-19, and MH02-19.

Fill en ountered in the south eastern corner of 69 Trig Road generally comprised grey, brown, orange and black, clays and clay/silt mixtures, with organic material, concrete, old drainage pipes and plastic throughout. Testing throughout this material demonstrated peak shear strengths of between 48kPa and 208kPa.

A thin layer (0.1m) of buried topsoil was encountered at the base of this fill in TP05-19 and TP07-19.

Fill encountered in the northern portion of 155-157 Brigham Creek Road generally comprised stiff to very stiff, orange, brown, yellow, grey, and black, clay/silt mixtures, with trace gravel and sand. Testing throughout this fill demonstrated peak shear strengths of between 61kPa and greater than 178kPa.

A thin lens of up to approximately 200mm depth of non-engineered fill was encountered below the opsoil in HA19-19 and HA20-19. This comprised stiff, dark brown, yellow, orange and grey silty clay.

## 5.2.3 Buried Topsoil

A layer of buried topsoil was also encountered underlying some of the uncertified fill in 69 Trig Road and 155-157 Brigham Creek Road. This topsoil layer was generally encountered from depths of 0.4m up to depths of 2.6m, was generally 50mm to 400mm in thickness, and firm and brown with some gravel throughout.

#### 5.2.4 Alluvium

Alluvial deposits of the Puketoka Formation were encountered in all test pits hand augers and machine boreholes and generally comprised yellow, brown, and grey mottled orange and black, clays and clay/silt and clay/sand mixtures, with some organics and organic staining.

Alluvium was encountered from depths of 0.2m to depths of 10.3m and was generally firm to hard, with peak shear strengths quite variable and ranging from 25kPa to 224kPa.

SPT testing demonstrated N values ranging from 6 to 20 throughout this stratum

## 5.2.5 Residual Waitemata Group Soils

Residual soils of the East Coast Bays Formation (Waitemata Group) were encountered in all hand auger boreholes, excluding HA03-19, HA04-19 and HA12-19, and both machine boreholes, and generally comprised grey, orange and dark grey, clays, clay/silt mixtures sand/silt mixtures and clay/sand mixtures.

Residual soils were encountered from depths of 2.2m up to 12.7m, and were generally stiff to hard, with peak shear strengths ranging from 58kPa to greater than 224kPa.

SPT testing demonstrated N values ranging from 15 to 50+ throughout this stratum.

## 5.2.6 Waitemata Group (Weathering) Trans tion Zone

Transitional soils of the East Coast Bays Formation (Waitemata Group) were encountered in MH01-19 and MH02-19.

Transition zone soils were encountered from depths of 11.5m to depths greater than 20m and generally comprised comp etely to highly weath red, grey, extremely weak, siltstones and sandstones, weathered to sand/silt mixtures.

SPT testing demonstrated N values of 50+ throughout this stratum.

# 5.2 7 Waitemata Group Bedrock

Highly to mode ately weathered, interbedded siltstones and sandstones of the East Coast Bays Formation (Waitemata Group) were encountered in MH02-19.

This Waitemata G oup bedrock was encountered from depths of 13.8m to depths greater than 15.5m and was generally grey and very weak to weak.

SPT testing demonstrated N values of 50+ throughout this stratum.

#### 5 2.8 Summary

The distribution of these units is illustrated on the appended Geological Sections A to D and presented below in Table 2.

	Depth to base (m)		Thickness (m <sup>5</sup>	
Unit	Min	Max	Min	Max
Topsoil	0.05	0.40	0.05	0.40
Uncertified Fill <sup>1</sup> – firm to very stiff, orange, brown, yellow, grey, and black, clays and clay/silt mixtures, with trace gravel, sand, organics and unsuitables.	0.20	2.60	0.20	2.45
Buried Topsoil <sup>2</sup>	0.45	2 70	0.05	0 40
Alluvium – firm to hard, yellow, brown, and grey mottled orange and black, clays and clay/silt and clay/sand mixtures, with some organics and organic staining.	2.20	>5.00	0.50	10.0
Residual Waitemata Group Soils <sup>3</sup> – stiff to hard, grey, orange and dark grey, clays, clay/silt mixtures, sand/silt mixtures and clay/sand mixtures.	11.50	12.70	1.20	5.20
Waitemata Group Transition Zone <sup>3</sup> – completely to highly weathered, grey, extremely weak, siltstones and sandstones, weathered to sand/silt mixtures.	13.80	>20.00	2.30	7.30
Waitemata Group Bedrock <sup>3,4</sup> – highly to moderately weathered, grey, interbedded siltstones and sandstones, very weak to weak.	>15.50	>15.50	-3-1	7

Notes:

- <sup>1</sup> Strata not encountered in TP04\_TP06, HA03-HA11, HA17, HA21, HA22 and MH02.
- <sup>2</sup> Strata only encountered in TP05, TP07, HA13, HA12 and HA15.
- <sup>3</sup> Strata not encountered in test pits or HA03 HA04 and HA12.
- <sup>4</sup> Strata only encountered in MH02.
- <sup>5</sup> Thickness only recorded were base of strata has been confirmed.

# 5.3 Laboratory Test Results

Results of the civil engineering labo atory tests are provided in Appendix C and summarised in Table 3.

Test Lo ation	Depth (mbgl)	LL (%)	PL (%)	(%)	MC (%)
MH01-19	2.5 – 3.0	95	28	67	51.8
MH01-19	5.0 – 5.5	-	4-1		33.2
MH02-19	3.45 – 3.95	4			45.1

Note LL liquid limit, PL = plasticity limit, PI = plasticity index, MC = Natural Moisture Content.

## 5.4 Groundwater

During the investigation, which was completed in late spring conditions (November 2019), groundwater was encountered within the boreholes at the depths provided in Table 4.

		Table 4: Groun	dwater Monitor	ring Data		
Investigation	18 Mar	ch 2019	25 Nover	mber 2019	26 Nover	nber 2019
Location	Depth (mbgl)	Elevation (m RL)	Depth (mbgl)	Elevation (m RL)	Depth (mbgl)	Elevation (m RL)
HA01-19	NE	NE	1 T-20 1			U
HA02-19	2.9	15.1	0.00	3.5	- 1	
HA03-19	NE	NE			. (1)	-
HA04-19	NE	NE	- 0	4		0
HA05-19	NE	NE		- •	5	N
HA06-19	3.1	23.9		- 1	12	1
HA07-19	3.0	21.5	-0-0	~	X	-
HA08-19	3.6	18.9	To regard	O	- (	· .
HA09-19	2.8	20.7		1	1	-
HA10-19	NE	NE	1-11-11-2	<b>)</b>	Y-	2-2-
HA11-19	NE	NE	0.			-
HA12-19	12-7-1		2.8	20.7		1
HA13-19	Tot		2.9	20.1	12	1,
HA14-19	- C	- 1	2.5	18.7	-	-
HA15-19		0	2.2	18.0	4	
HA16-19	Dec 1	NO	2.0	18.1		
HA17-19	19.	O	2.0	15.5		
HA18-19	(	1 . 1	1		2.0	16.6
HA19-19	11			-	2.0	19.4
HA20-19	7	10			2.6	20.8
HA21-19	· O	11	4	-	2.8	22.2
HA22-19				-	2.6	26.0
TP01-19	+ 1		100	1 7 -	NE	NE
TP02-19*	. 6	-	2	1 2	1.0	24.5
TP03-19	CO			1 4	NE	NE
TP04-19	X/,				1.2	21.8
TP05-19	1	-	-	1	2.6	18.8
TP06-19	-		- 2		NE	NE
TP07-19	1 23 4				NE	NE

Notes: mbgl = metres below ground level. NE = Not Encountered. \* = Perched Groundwater Encountered. E evations are approximate and are inferred from Auckland Council GIS.

Although groundwater was measured at the above elevations during investigations, it should be noted that groundwater levels will vary seasonally and with rainfall.

Given the presence of a variable and clayey soil profile, it is also possible that perched groundwater may occur during and following periods of rainfall.

#### 6 GEOHAZARDS ASSESSMENT

#### 6.1 Context

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

The following sections of this report provide an assessment of the geohazards relevant to this site and provide the basis for the Natural Hazards Risk Assessment presented in **Appendix D**.

# 6.2 Liquefaction

#### 6.2.1 General

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

In accordance with NZGS guidance<sup>4</sup> the liquefaction susceptibility of the soils at this site has been considered with respect to geological age and soil fabric

### 6.2.2 Geological Age

The vast majority of case history data compiled in empirical charts for liquefaction evaluation comes from Holocene deposits or man-made fills (Seed and Idriss, 1971). Yo d and Perkins, 1978 also state that young Holocene age (15,000 years) sediments and man-made fills are susceptible to liquefaction. Table 1 of Idriss and Boulanger (extracted from Youd and Perkins (1978)), presents the susceptibility of soil deposits to liquefaction based on geological age, which states that Pleistocene aged alluvium (>12,000 years) has a very low to low risk of liquefaction.

Across the elevated terraces, soils below the water table comprise alluvial deposits of the Puketoka Formation. These soils are defined as being of Late Pliocene to Mid Pleistocene in geological age with a dated age at 71k to 3 6Ma old. These d posits are therefore significantly older than what case history data would suggest as being susceptible to liquefaction.

## 6.2.3 Soil Fabric

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

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

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

<sup>&</sup>lt;sup>4</sup> Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (May 2016)

Specific plasticity index laboratory test results are presented in Section 5.3 above and show that the soils tested provided plasticity indices of much greater than 12 and are therefore not considered liquefiable.

## 6.3 Slope Stability

## 6.3.1 Design Criteria

The stability of cut batters and fill embankments under a range of design conditions is expressed in terms of a factor of safety, which is defined as the ratio of forces resisting failure to the forces causing failure. The following performance standards are recommended for slope stability assessment:

Table 5: Slope Stability Factor of Safety Criteria		O.	0
Condition	Requir	ed Factor	f Safety
Static long-term conditions (normal groundwater)		1.5	
Transient short-term conditions (elevated groundwater)		1.3	
Ultimate Limit State (ULS) seismic condition		1.2	·

#### 6.3.2 Shear Strength Parameters

Drained shear strength parameters for the various geological units that underlie the site were inferred from the field investigation and experience, and are summarised in Table 6 below

Table 6: Summary of Effective Stress Parameters							
Geological Unit	Unit Weight (kN/m³)	Effective Stress Parameters  Back Analysis					
		c' (kPa)	Ø' (deg)				
Engineered Fill	18	5	30				
Uncertified Fill	17	2	27				
Puketoka Formation Alluvium	17	2	27				
Residual Waitemata Group Soils	18	3	30				
Waitemata Group Transition Zone	18	10	30				
Waitemata Group Bedrock	18	10	40				

## 6.3 3 Slope Stabi ity Analyses

Four cross sections (Section A, B, C and D) were analysed, as located on our appended Site Investigation P an.

Slope stability a alyses were undertaken using the Morgenstern-Price method of slices under both circular and translational failure mechanisms using the proprietary software SLIDE Version 8.0. Earthquake loads were calculated in accordance with NZS 1170.5 and NZTA Bridge Manual (BM) Section 6.2.2 for earthquake loads for the assessment of slope stability. An ULS design earthquake return period of 150 years as recommended within the Auckland Council Code of Practice (ACCoP) has been assumed in the assessment. The peak ground acceleration (PGA) for stability analyses was calculated as 0.115g.

Selected stability printouts are attached in *Appendix E* and summarised as follows:

Table 7: Slope Stability Analyses Results							
Location	Slope Stabi	Slope Stability Factor of Safety (Proposed Profile)					
	Prevailing	Transient	Seismic				
Geological Section A-A	2.8	2.4	1.7				
Geological Section B-B	2.3	1.6	1.7				
Geological Section C-C	2.3	1.7	1.6				
Geological Section D-D	1.8	1.4	1.4				

Results show that the slope stability factor of safety criteria are achieved for the proposed landform and assessed ground model conditions described above. However, detailed design will need to take in a account soil creep and proposed working loads. If loads greater than 20kPa are proposed, further analyses will be required.

We note that Section A-A analyses have assumed the existing non-engine red fill remains in place. While acceptable factors of safety are achieved for slope stability, there would be an inherent risk of settlement occurring within this fill if it is not reworked as part of the earthworks operations.

#### 6.4 Erosion

Erosion of cut and fill batters during earthworks is considered to be a high-risk natural hazard and easily addressed during construction. Erosion around batte's may subsequently contribute to slope instability and falling debris. This hazard can be controlled during the design phase by limiting batters to a maximum of 1V:3H gradients and during earthworks via benches geotextiles and stormwater control.

#### 6.5 Load Induced Settlement

## 6.5.1 Design Parameters

The ground conditions around the northern stream are stiff and considered unlikely to be subject to significant settlements under the proposed fill heights and future development loads.

Proposed fill embankments and / or future building loads in the area of the southern gully will induce settlements within the underlying subsoils as well as across adjacent areas of the site subject to minimal excavation to form the final subgrade I vels CPT and oedometer laboratory testing were carried out to assess the soil modulus parameters for load induced settlement analyses.

Results of the laboratory oedometer testing show that the soils are over-consolidated meaning that for the proposed fil embankment / foundation pressures, these soils are not expected to settle significantly, with settlement expected to follow the unload-reload compression (Cr) line.

A summary of the parameters dopted for preliminary design is summarised as follows:

Table 8: Summary of Consolidation Design Parameters							
Parameter	Test Range	Design Value					
Compression Index (Cc)	0.24 - 0.47	0.24					
Recompression Index (Cr)	0.06	0.06					
In tial void ratio (e <sub>0</sub> )	0.88 - 1.303	0.88					
Secondary / Primary Compression Index ratio (Cα/ Cc)	0.05	0.05					
Coefficient of vertical consolidation (Cv – m²/year)	10 - 20	15					

#### 6.5.2 Settlement Predictions

The construction of earthfill embankments over weak alluvial soils will induce consolidation and post construction creep settlements. An assessment of static settlements was completed for the proposed range of fill embankment heights. For the range of proposed fill heights, it is assessed that the imposed loads will be less than the pre-consolidation pressure of the subgrade materials where they will behave in an over-consolidated state following the Cr compression line.

Primary consolidation settlements were assessed using a CMW in house spreadsheet in accordance with the following Terzaghi 1-dimensional consolidation theory for over-consolidated soils:

$$S_{consol} = \frac{C_r}{1 + e_0} \cdot H \cdot \log \left( \frac{\sigma'_v + \Delta \sigma_v}{\sigma'_v} \right)$$

Where  $S_{conso}l$  = consolidation settlement, Cr and e0 are defined in Table 8 above, H = th kness of compressible layer,  $\sigma v'$  = initial vertical stress and  $\Delta \sigma v$  = change in vertical stress or load applied. In construction practice, 90% of the consolidation settlement (t90) is often targeted during the construction phase.

On the basis that t90 settlements are achieved during earthworks construction, subsequent post construction settlements were also estimated, which are made up of the remaining 10% consolidation settlement, additional consolidation due to subsequent building oads and secondary creep settlements due to the original fill embankment loads. Creep settlements (Screep) were estimated in accordance with the following relationship:

$$S_{creep} = \frac{C_{\infty}}{1 + e_0} \cdot H \cdot \log\left(\frac{t}{t_l}\right)$$

Where  $C\alpha$  and  $e_0$  are defined in Table 8 above, H = thickness of compressible layer, t = design life (50 years),  $t_0 = t_{00}$  or construction period, whichever is greatest.

Estimated static settlements are summar sed as follows:

Table 9: Estimated Fi I Induced Static Settlements – Southern Gully						
Embankment Height (m)	Construction Settlement (t <sub>90</sub> , mm)	Additional Settlement due to 20kPa floor load (mm)	Post Construction Settlement (mm)			
1	25	20	30			
3	55	15	35			
5	80	10	40			

Notes: Post construction settlements made up of secondary creep + remaining 10% fill induced consolidation, do not include floor load induced consolidation.

Fill construction using available borrow materials (compacted unit weight = 18kN/m³) assumed, greater settlements will cour if using imported rockfill or sand.

The combination of pr dicted post construction ground settlements and settlements from the anticipated future floor loads are considered as generally appropriate for the proposed development, however specific ground improvement measures may be considered, as discussed in Section 7.2 below, to reduce post construction settlement magnitudes.

#### 6 5 3 Time Rate of Settlement

Stati settlements are expected to be predominantly elastic (immediate) and are therefore considered to be largely built out during construction, with an estimated time to t<sub>90</sub> consolidation of approximately 6 months.

Time rates of settlement are notoriously difficult to estimate due to their depositional environment where there is inherent material composition lateral and depth variability and presence of intermediate sand lenses.

CMW Geosciences Ref. AKL2019-0040AD Rev 0 Reference to coefficient of vertical consolidation (Cv) laboratory data shows a wide scatter of data although a value of 15m<sup>2</sup>/year looks to provide a reasonable lower bound estimate for preliminary design purposes.

It is noted that Cv values measured in the lab represent a particularly small volume of soil and can therefore be conservative as they don't take into account thin sand lenses and other discontinuities within the soil mass. Actual settlement timeframes may therefore be less than those tabulated above.

## 6.6 Expansive Soils

NZS 3604:2011 excludes from the definition of 'good ground', soils with a liquid limit of more than 50% and a linear shrinkage of more than 15% due to their potential to shrink and swell as a result of seasonal fluctuations in water content.

This shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and/ or fo indations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels.

Additional commentary based on our knowledge of this geology and experience with local so s is provided in Section 7.4.2 below.

CMW Geosciences Ref. AKL2019-0040AD Rev 0

#### 7 GEOTECHNICAL RECOMMENDATIONS

# 7.1 Seismic Site Subsoil Category

Based on those ground conditions observed during this investigation, combined with experience working in the surrounding area, the seismic site subsoil category is assessed as being Class C (shallow soil site) in accordance with NZS1170.5.

## 7.2 Ground Improvement for Static Settlement

## 7.2.1 Ground Improvement Options

To minimise post construction static ground settlements, a range of options are often considered, in luding the following:

- Construction of a temporary surcharge or pre-load fill embankment above design finished ground level, to over-consolidate the compressible soils and minimise post construction embankment settlements;
- Use of lightweight geofoam, such as EPS-block materials for embankment construction to keep embankment pressures below pre-consolidation pressures within the compressible soil unit thereby reducing consolidation settlements;
- Undertake ground improvement beneath the embankment foo print, such as stone columns, soil mixed columns, CFA piles, Rammed Aggregate Piers (RAPs) or similar rigid inclusions to transfer loads from the embankment to more competent underlying soils at depth.

#### 7.2.2 Ground Improvement Design

It is expected that pre-loading or surcharging s likely to be the pref rred ground improvement technique for this project to reduce post construction static settlements to acceptable magnitudes, in conjunction with underfill drains where appropriate.

Preliminary pre-load designs were carried out using laboratory derived / best estimate consolidation parameters from our database and knowledge of these typical ground conditions across the region.

Resulting creep settlement magnitudes were est mated using the method described in Mesri et al (1994) based on the following:

- Weak alluvium zo e widespread floor loads = 20kPa, post construction settlement ≤ 50mm;
- 90% consolidation plus additional consolidation from future 20kPa floor loads achieved during pre-load.

Based on those equirements, a 1m surcharge above design building platform level across the southern gully fill and adjacent areas where proposed cuts are less than 1m depth would be recommended.

## 7.2.3 Settlement Monito ing

The above settlement magnitude and time rate estimates are preliminary only based on a limited amount of laboratory test data and have been averaged across the length of the project. As there will inevitably be some variation in soil composition and resulting settlement profiles from one location to the next, it is imperative that settlement monitoring is undertaken during construction to back analyse consolidation settlement parameters and progressively refine the pre-load design.

Due to material composition and depth variability, it is envisaged that regular monitoring points would be required, such as for example, at 50m longitudinal intervals along the southern gully centreline and a set of 3 instruments (centreline and each gully flank) across the section of deepest fill to demonstrate that differential settlement compliance can be achieved.

It is expected that additional surcharge heights may be required at transition points from cut to fill at the margins of gullies.

Monitoring would comprise use of surface settlement plates, placed over the ground surface prior to filling, to assess total settlement magnitudes, which provide a cost-effective robust monitoring technique. In

addition, settlement pins would be installed across the final ground (or surcharge) surface to check fo internal settlement of the deeper fills.

#### 7.3 Earthworks

#### 7.3.1 General

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431 and the requirements of the Auckland Council Infrastructure Development Code under the guidance of a Chartered Professional Geotechnical Engineer.

A Geotechnical Works Specification is provided as **Appendix F** and standard detail dr wings are provided as **Drawings 06** to **07**. Between them, these documents provide the requirements for site prepara ion, fill placement, subsoil drainage, compaction requirements, quality assurance testing and as-built requirements

Those requirements are summarised below.

## 7.3.2 Non-Engineered Fill

Uncontrolled existing fills were observed in the southeast corner of 69 Trig Road, the northern portion of 151 Brigham Creek Road and the northern portion of 155-157 Brigham Creek Road. These existing uncertified fills will need to be inspected by the Geotechnical Engineer following site stripping. It is anticipated that the fill will need to be undercut, reworked and placed to engineering standards, due to the presence of buried topsoil beneath the fill and unsuitable inclusions. Once reworked, the fill material should generally be suitable for placement as engineered fill

#### 7.3.3 Excavatability

Given the stiffness of the units that will be encountered within the roposed earthworks cuts, it is expected that excavation of these materials will be eadily achieved with normal earthworks plant, such as scrapers and bulldozers with scoops.

#### 7.3.4 Subgrade Preparation

Preparation of the subgrade beneath the proposed fill areas should comprise stripping of all vegetation, topsoil, any pre-existing fill materials or soft soils followed by benching of the exposed subgrade where natural slopes beneath the fill exceed gradients of nominally 1:5 (vertical to horizontal). The subgrade should then be scarified and moisture conditioned where necessary, and then proof rolled to verify the subgrade stiffness and consistency.

Where any particularly weak materials are encountered that weave excessively during the proof rolling process, they should be undercut and removed prior to placing engineered fill.

## 7.3.5 Stockpiles

Careful consideration must be given to the location of temporary topsoil / unsuitables stockpiles to ensure that they are not located immediately above steep or unstable slopes or immediately above proposed stormwater pond xcavations.

The location of all temporary stockpiles must be approved by the Geotechnical Engineer prior to placement. Where stockpile cannot be avoided above sloping ground, they should be placed over a wide area with the height restricted under the direction of the Geotechnical Engineer.

## 7 3.6 Underfill Drainage

Underfill drains will need to be installed beneath new fills within low lying tributaries and gully inverts to allow for the continued release of groundwater seepages.

We have provided approximate positions of the underfill drainage network required for the subdivision works based on existing contour data. Details are in the Geotechnical Works Specification (*Appendix F*), Underfill Drainage Plan (*Drawings 06*) and in the Typical Underfill Drain Detail (*Drawing 07*).

Underfill drain locations should be confirmed onsite by the Geotechnical Engineer, particularly once existing uncertified fill has been removed from the south eastern gully area.

## 7.3.7 Compaction

Earthfill must be placed, spread and compacted in controlled 250mm to 300mm thick (loose) lifts under the direction of a Geotechnical Engineer. The fill may comprise either granular or cohesive material subject to being free of any organic material and having no particles greater than 150mm diameter.

Most of the proposed cut material, including the natural and existing fill materials should be suitable for reuse as Engineer Certified Fill. Soil textures and moisture contents will however vary widely, and careful management, conditioning and compaction control will be required.

All earthfill must be placed to ensure adequate knitting of successive fill lifts by ripping any natural subgrade or fill surfaces that have become dry prior to placing the following fill lift.

# 7.3.8 Temporary Sediment Retention Ponds

Temporary sediment retention ponds may be required to store stormwater for significant periods (several months to years) and therefore their construction should be subject to design and observation input from the geotechnical engineer. As a minimum, the following input is recommended from the project geotechnical engineer:

- Advise on pond locations with respect to land stability and seepage potential;
- Structural design of pond fill embankments including ey and compaction specification;
- Observe embankment subgrade conditions and advise on under ut requirements;
- Earthfill QA / QC testing of all embankment materials to ensure compliance with specification.

When decommissioning temporary sediment ponds, all water so tened material in the bases and sides of the ponds shall be removed and undercut to the satisfaction of the Geotechnical Engineer. Backfilling of temporary ponds shall be to the compaction standard for general filling unless otherwise specified.

## 7.3.9 Quality Control

The stripping of existing topsoil cutting of pre existing fill materials and undercutting of organic soils (if encountered), where required from across the site as well as the gully areas must be subject to observation by the project Geotech ical Engineer tensure that all unsuitable materials have been removed.

The source and / or type of material used for engineered fill will dictate the type of quality control testing undertaken.

The recommended specification for the proposed development is presented in the Geotechnical Works Specification in Appendix F

The source of the fill should be discussed with and approved by the project Geotechnical Engineer to verify its ppropriateness and quality control testing requirements.

# 74 Foundation Recommendations

## 7.4.1 Residential Building Platforms

Once bulk earthworks are completed in accordance with the recommendations provided in Section 7.3 abov a preliminary geotechnical ultimate bearing pressure of 300kPa should be available for NZS3604 type structures on shallow strip and pad foundations constructed within both the natural cut ground and engineered fill areas.

There may be areas where localised variations in shear strength within the natural cut ground occur, particularly where the depth of cut varies across the building platforms. Further confirmation of available bearing pressures will be addressed at the time of post earthworks soil testing and preparation of the Geotechnical Completion Report (GCR) for the development.

#### 7.4.2 Expansive Soil Class

NZS3604 recommends that sites with expansive soils are classified according to AS2870 "Residential Slabs and Footings – Construction". AS2870 describes a range of Classes having different levels of characteristic surface movement and provides acceptable foundation solutions for each Class, depending on the construction typology and materials.

On the basis of our visual / tactile assessment we have assessed the AS2870 Site Class for the development to be M (moderate) to H1 (high). Foundation design may be selected in accordance with appropriate solutions for this Class from AS2870 or may be undertaken by specific engineering design. Specific testing for Expansive Site Class will be undertaken at the time of the GCR preparation for the development.

Mitigation of the expansive soil hazard is undertaken by a combination of appropriate foundation design selection at Building Consent stage and appropriate moisture control within subgrade soils during construction. Foundation contractors must be aware of this issue and the need to maintain a propriate moisture contents in the footings and building platform subgrade between the time of excavation and pouring concrete.

Remedial actions that may be appropriate include platform protection with a hard fill layer, pouring of a blinding layer of concrete in footing bases and soaking of the building platform with spr nklers for an extended period.

Future owners must also be aware that the planting of high water demand plants where their roots may extend close to footings can also cause settlement damage

## 7.4.3 Industrial Building Platforms

Based on ground conditions observed in our investigations, specific settlement analyses and earth fills placed under engineering control during the development earthworks, industrial floor construction (including sub-floor fills) loads, plus operational live loads, should be limited to 20kPa.

Should the capacity provided for floor load estrictions above be insufficient for design, further specific investigation and design of foundations should be carried out prior to Building Consent application.

## 7.5 Geotechnical Strength Reduction Factor

As required by section B1/VM4 of the New Zealand Building Code Handbook, a strength reduction factor of 0.5 and 0.8 must be applied to all recommended geotechnical ultimate soil capacities in conjunction with their use in factored design load cases for static and earthquake overload conditions respectively.

## 7.6 Civil Works

# 7.6.1 Subgrade CBR

The subdivision roading is shown as being constructed in a combination of both cut and fill areas. Typical CBR values of between 5% and 6% should be available in fills. In areas of cut natural ground, CBR values as low as 2% or 3% are likely.

Subgrade improvement with lime (if desired) is expected to provide better results than the use of cement due to the clayey nature of the soils.

## 7.6.2 Service Trenches

All of the materials to be exposed during the excavation of service trenches should be readily removed using an excavator.

Services trenches excavated along contour in areas of steep ground may need to be backfilled with engineered filling and if in natural ground, may require a drain coil in the base of the trench connected to the stormwater system. Identification of critical service lines must be made once drawings are available.

#### 7.6.3 Retaining Walls

Design parameters for permanent retaining walls are summarised in Table 102.

Table 102: Retaining Wall Design Parameters					
Soil Unit	Υ (kN/m³)	Ø'(deg)	c′ (kPa)	Su (kPa)	
Engineered Fill	18	30	5	100	
Uncertified Fill	17	27	2	60	
Puketoka Formation Alluvium	17	27	2	60	
Residual Waitemata Group Soils	18	30	3	70	
Waitemata Group Transition Zone	18	30	10	100	
Waitemata Group Bedrock	18	40	10	200	

#### Notes:

- 1. Refer to Table 2 for definition of soil unit levels
- 2. Y soil unit weight; Ø' angle of internal soil friction; c' effective cohesio ; Su undrained shear strength.
- The above parameters are based on the condition of a horizontal ground surface behind the retaining structure. Applicable surcharge loads behind the wall must also be considered in the design.

During detailed design of the walls, allowance must be made to the additional earth pressure due to the surcharges from structures (i.e. any existing or proposed retaining structures and/or buildings) behind the wall

Retaining walls should be designed with appropriate toe drainage and be backfilled with free-draining aggregate.

Temporary stability of any site cuts must also be considered in the construction methodology. This work should not be undertaken in poor or unfavourable weather conditions and cuts/excavations should be backfilled as soon as possible.

Careful consideration of underfill drainage locations should be made during retaining wall construction. Underfill drains should be clearly marked out onsite and piles should be positioned to avoid damaging the draincoil.

If any dainc it is intercepted by excavations or building works, it must be reinstated under the direction of a Char ered Profess onal Engineer to ensure the integrity of the drainage system. Removal of a portion of the drainage scoria is not expected to be problematic provided the draincoil and a quantum of surrounding scoria remains intact.

## 7.6.4 Stormwater Soakage

All of the soils at this site are clayey in nature and have very low coefficients of permeability. Accordingly, rain ga dens / attenuation ponds are not expected to provide any significant ground soakage function.

The us of rain gardens for storage capacity and water quality improvement is not recommended for this site.

## 8 FURTHER WORK

The recommendations provided in Section 7 above are based on the supplied development plans appended to this report. If development plans change significantly from the current development proposal, the matter

should be referred back to CMW or a Chartered Professional Geotechnical Engineer familiar with the contents of this report, who should be given the opportunity to review any changes against recommendations provided within this report.

#### **USE OF THIS REPORT**

Site subsurface conditions cause more construction problems than any other factor and therefore are generally the largest technical risk to a project. These notes have been prepared to help you understand the limitations of your geotechnical report.

## Your geotechnical report is based on project specific criteria

Your geotechnical report has been developed on the basis of our understanding of your project specific requirements and applies only to the site area investigated. Project requirements could include the general nature of the project; its size and configuration; the location of any structures on or around the site; and the presence of underground utilities. If there are any subsequent changes to your project you should seek geotechnical advice as to how such changes affect your report's recommendations. Your geotechnical report should not be applied to a different project given the inherent differences between projects and sites

## Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface investigation, the conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

## Interpretation of factual data

Site investigations identify actual subsurface conditions at points where samples are taken. Additional geotechnical information (e.g. literature and external data source review, labo atory testing on samples, etc) are interpreted by geologists, engineers or scientists to provide an opini in about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can exactly predict what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

## Your report's recommendations require confirmation during construction

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced. For this reason, you should retain geotechnical services throughout the construction stage to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site. A geotechnical designer, who is fully familiar with the background information, is able to assess whether the report's recommendations are valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misiliterpreted.

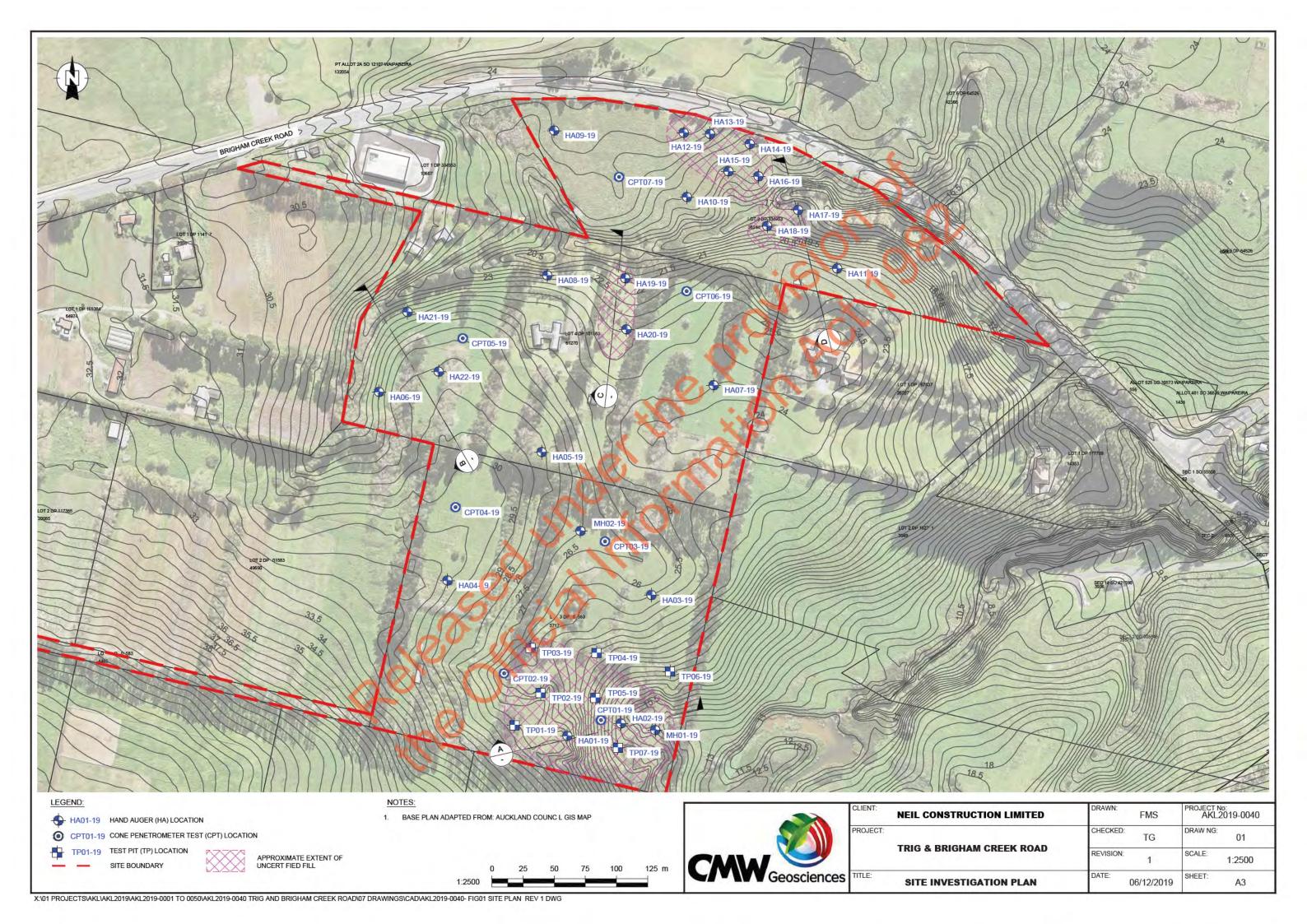
## Interpretation by other design professionals

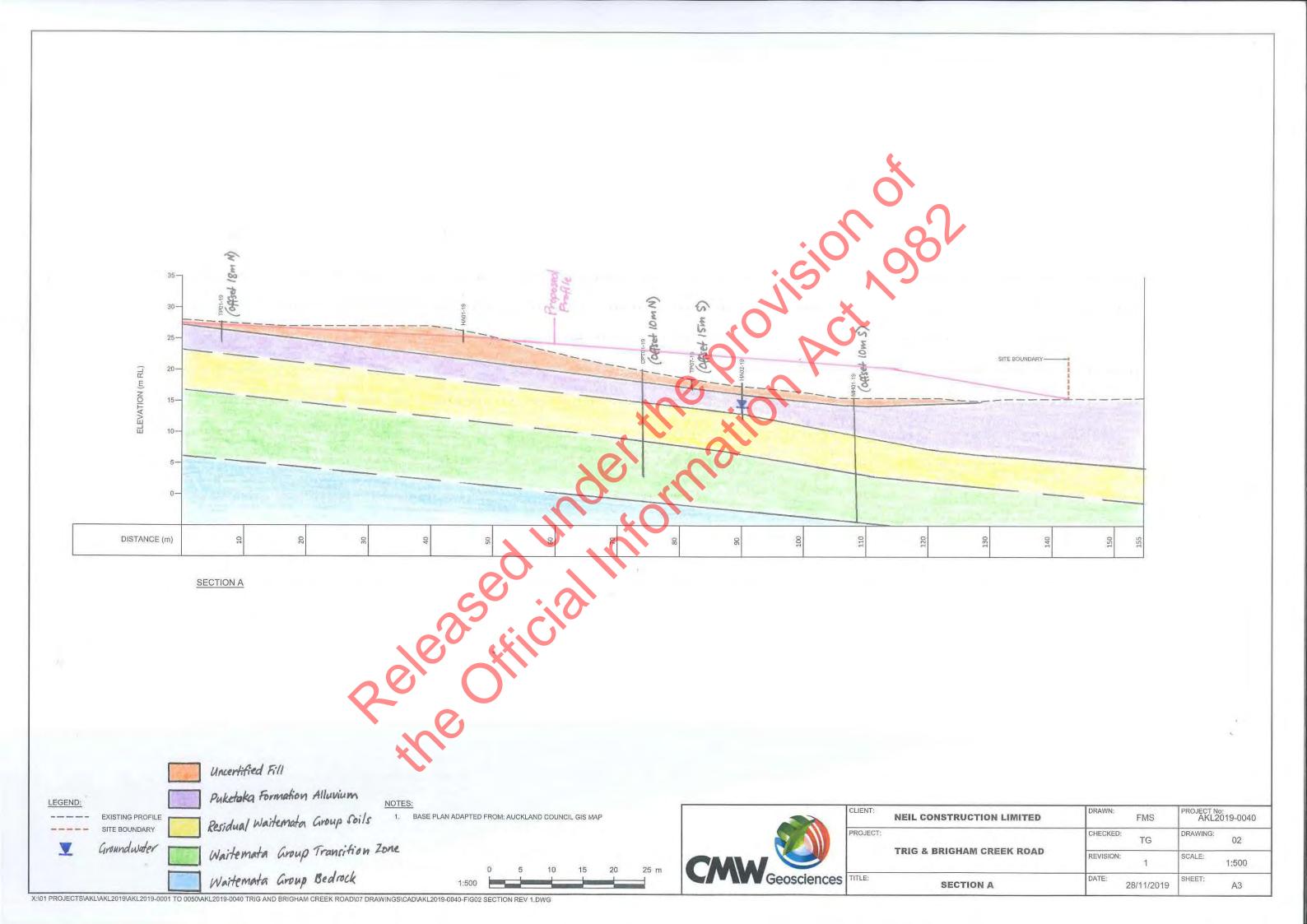
Costly problems can cour when other design professionals develop their plans based on misinterpretations of a geotechnical report. Read all geotechnical documents closely and do not hesitate to ask any questions you may have. To help avoid misinterpretations, retain the assistance of geotechnical professionals familiar with the contents of the geotechnical report to work with other project design professionals who need to take account of the contents of the report. Have the report implications explained to design professionals who need to take account of them, and then have the design plans and specifications produced reviewed by a competent Geotechnical Engineer.

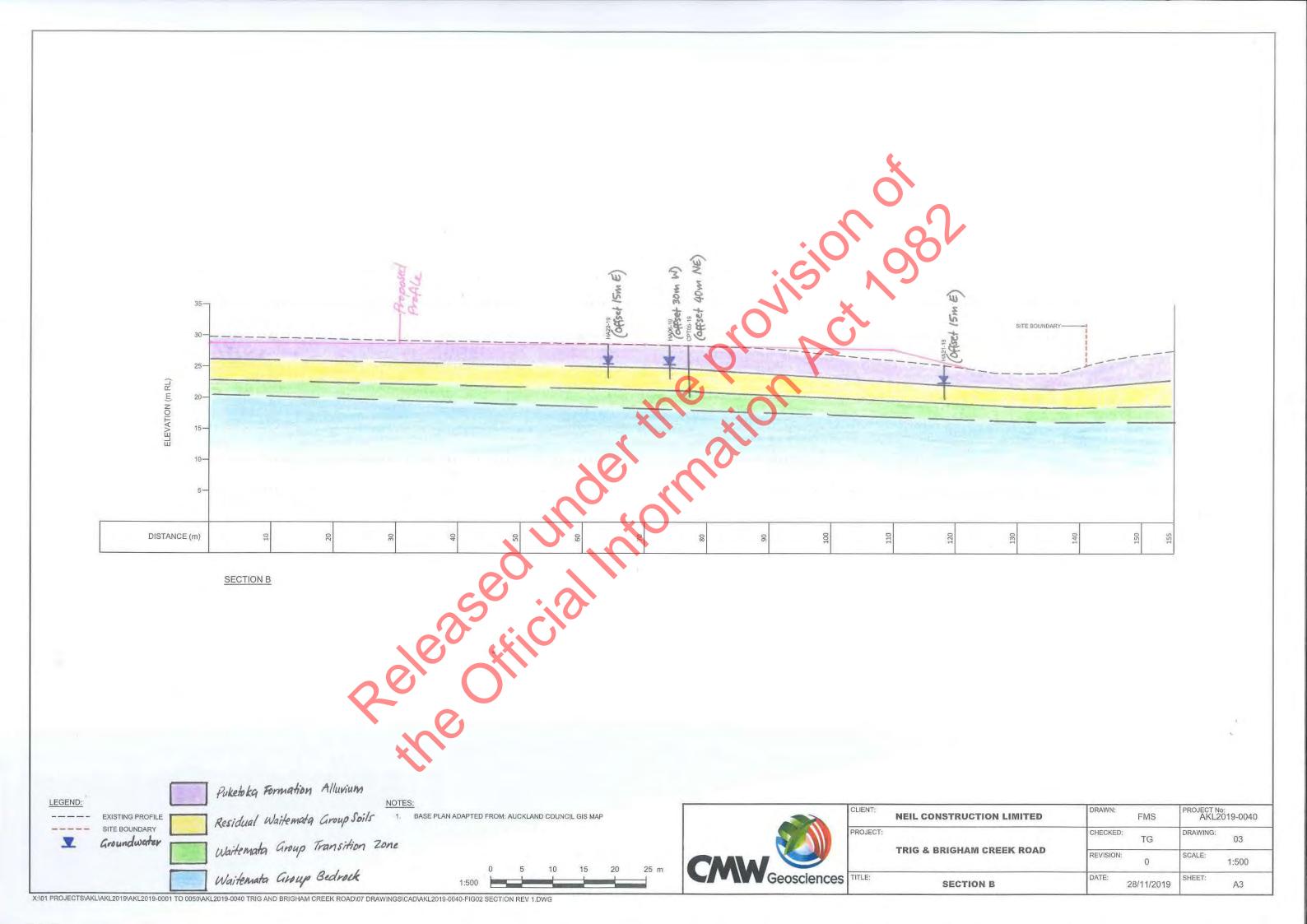
# **CMW Drawings**

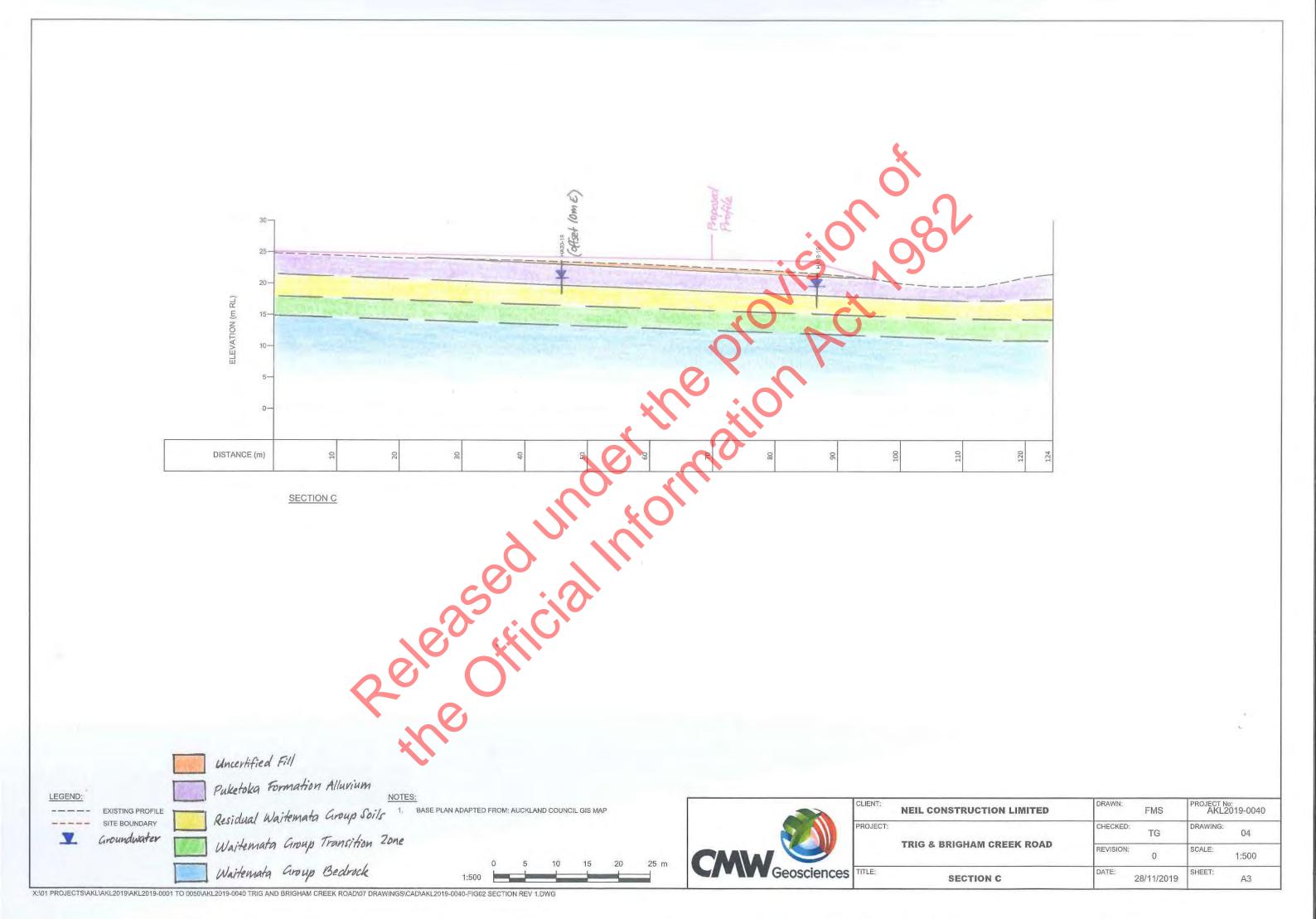
Drawing 01: Site Investigation Plan Drawing 02: Geological Section A-A Drawing 03: Geological Section B-B Drawing 04: Geological Section C-C Geological Section DD Drawing 05: Underfill Drainage Plan Drawing 06:

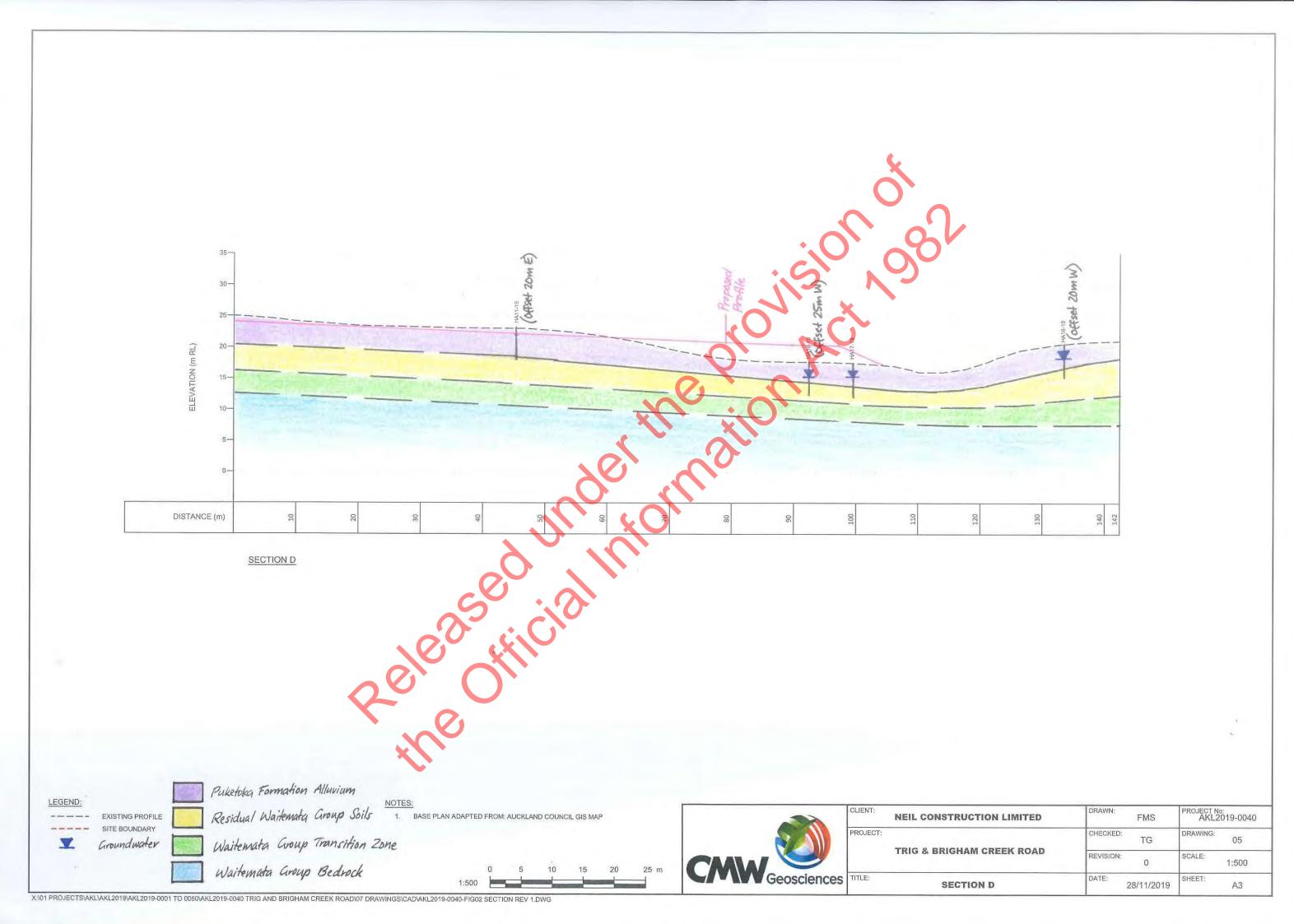
Typical Underfil Dran Detail Drawing 07:

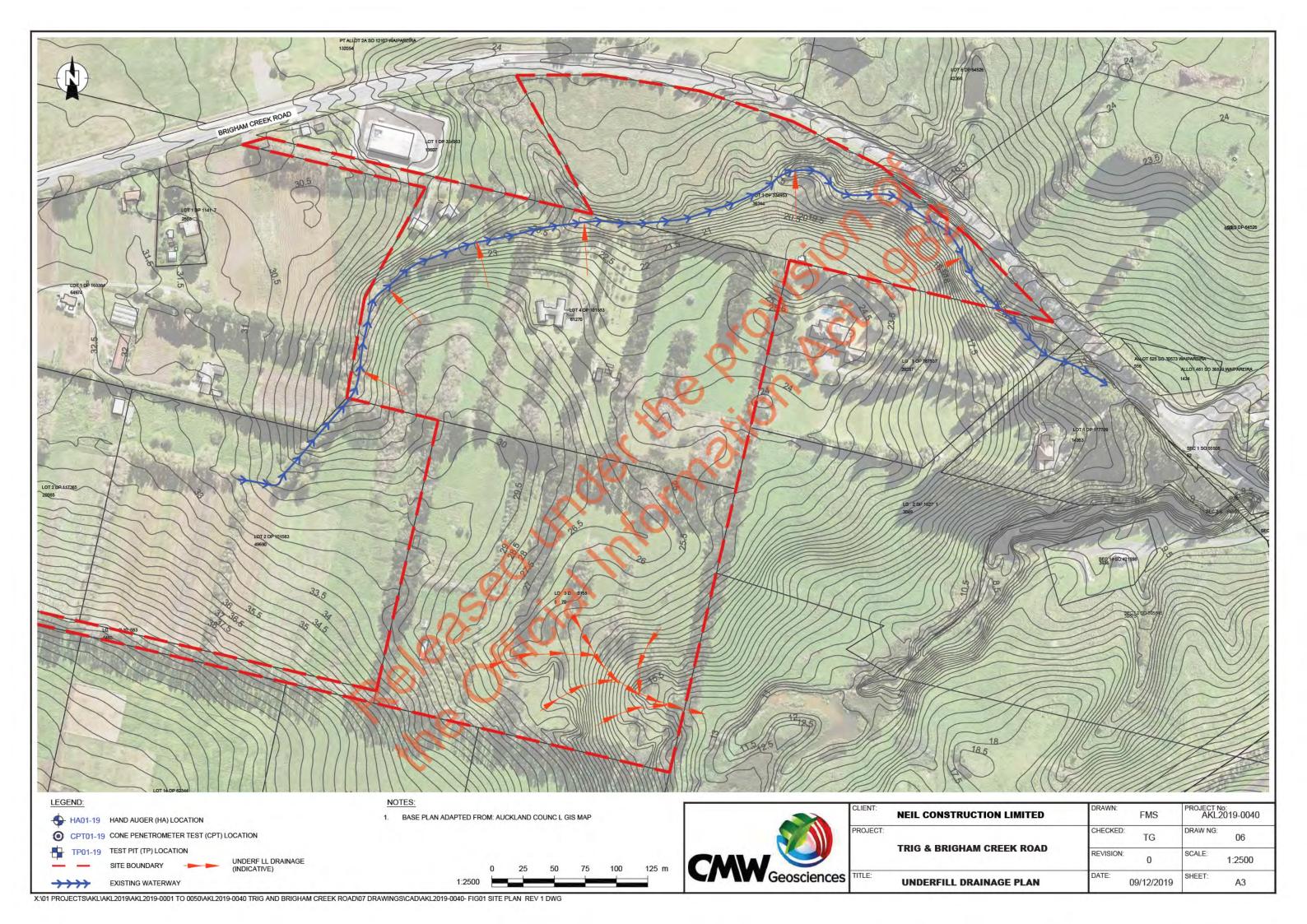


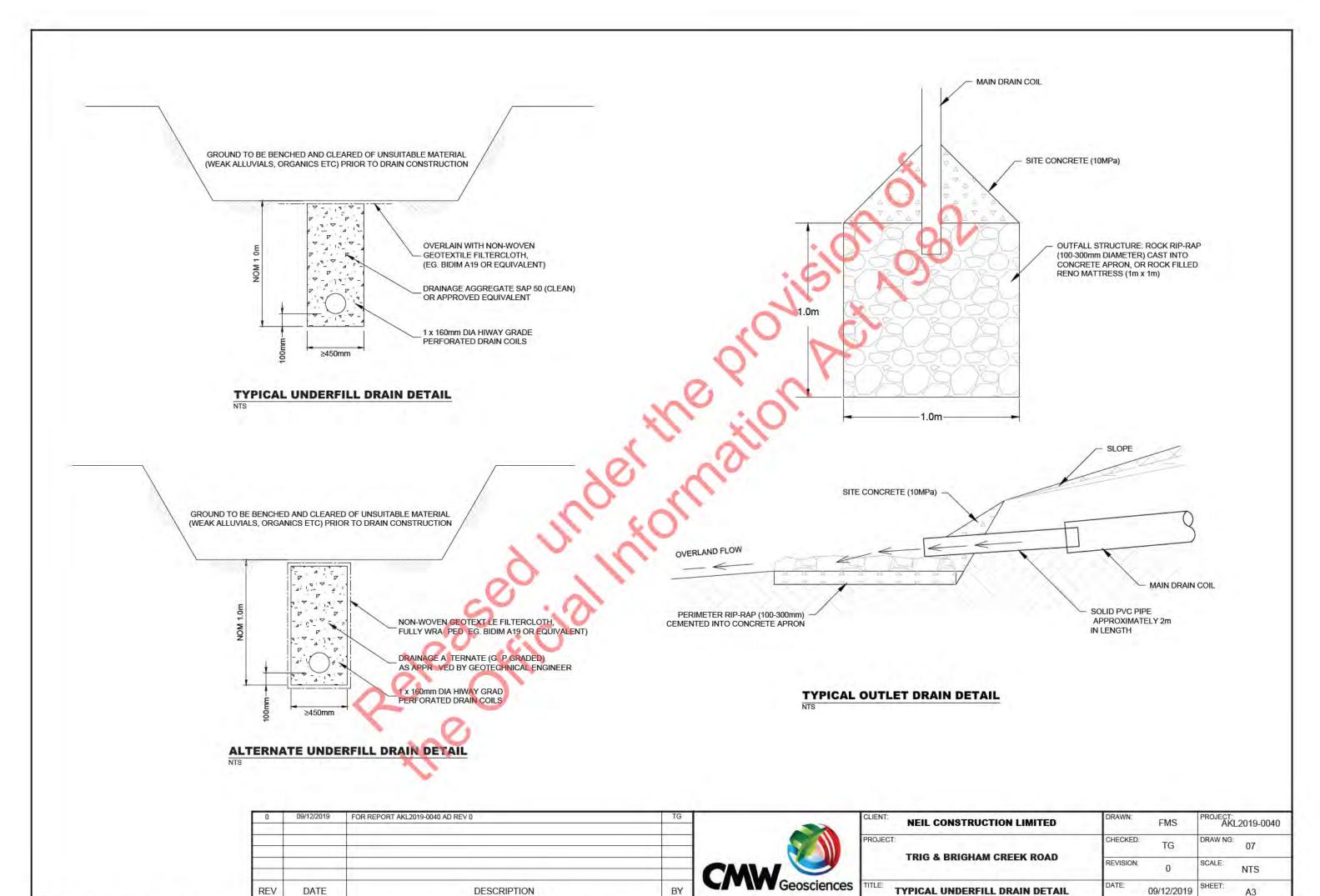












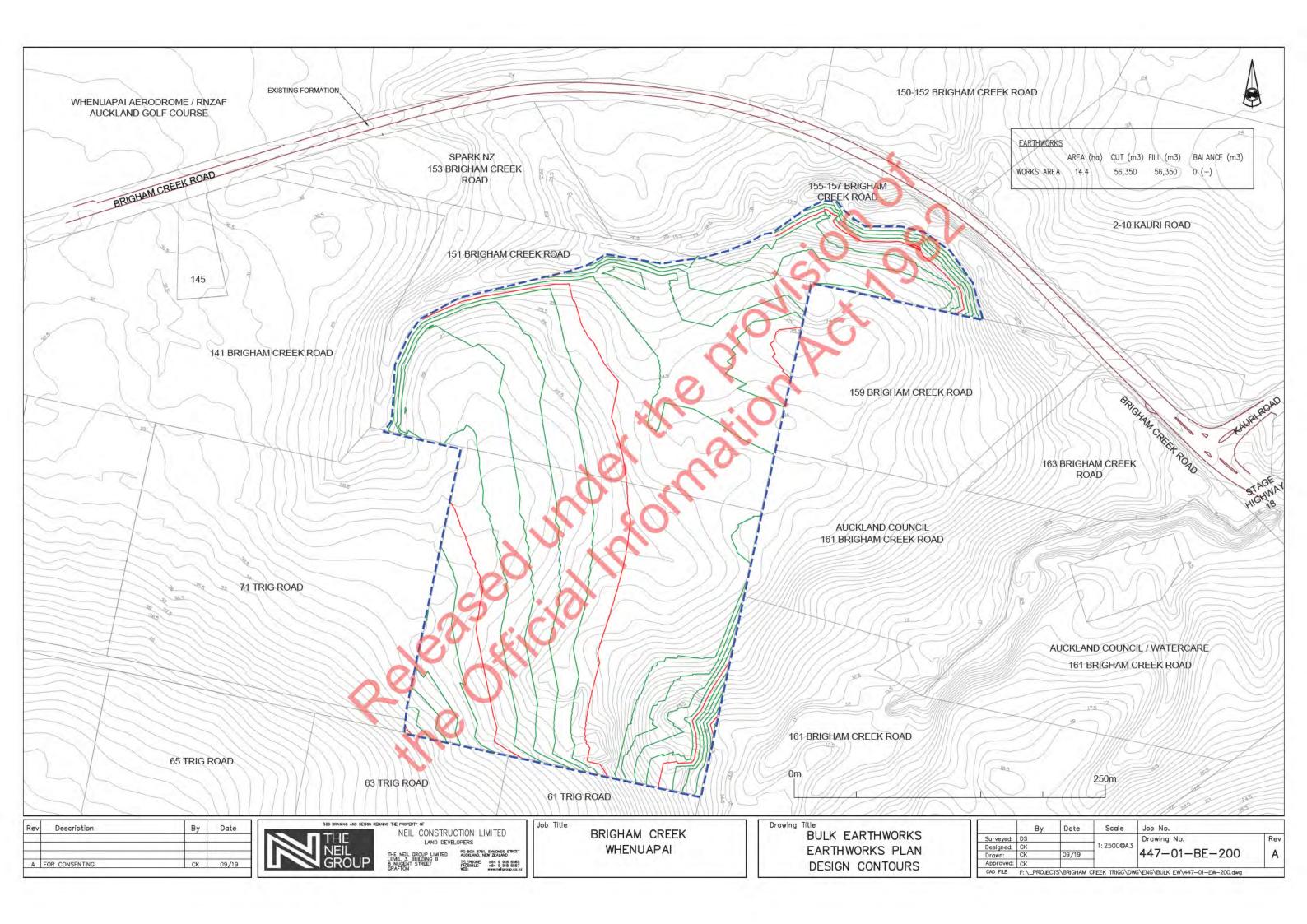
Appendix A: Neil Construction Limited Development Plans

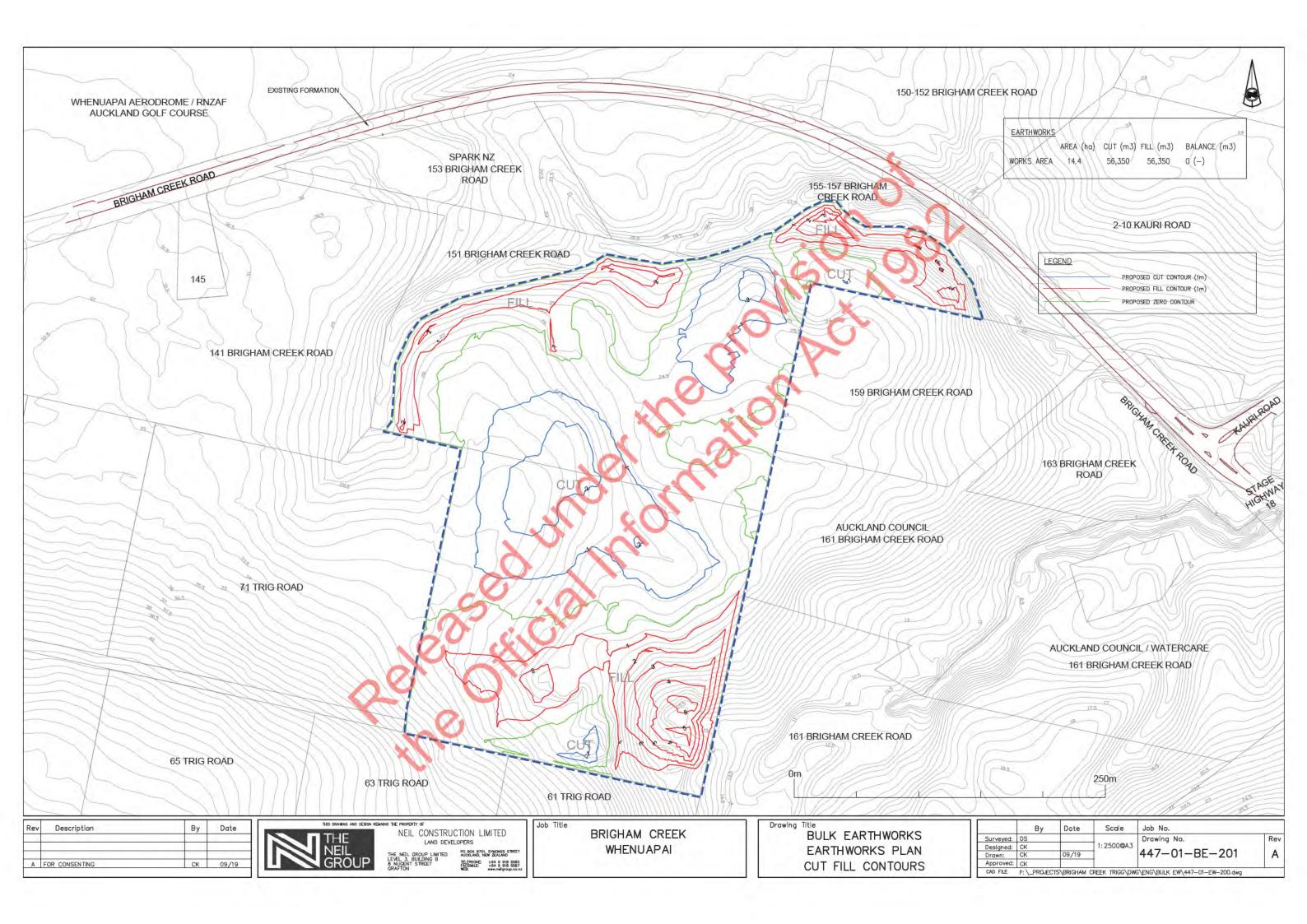


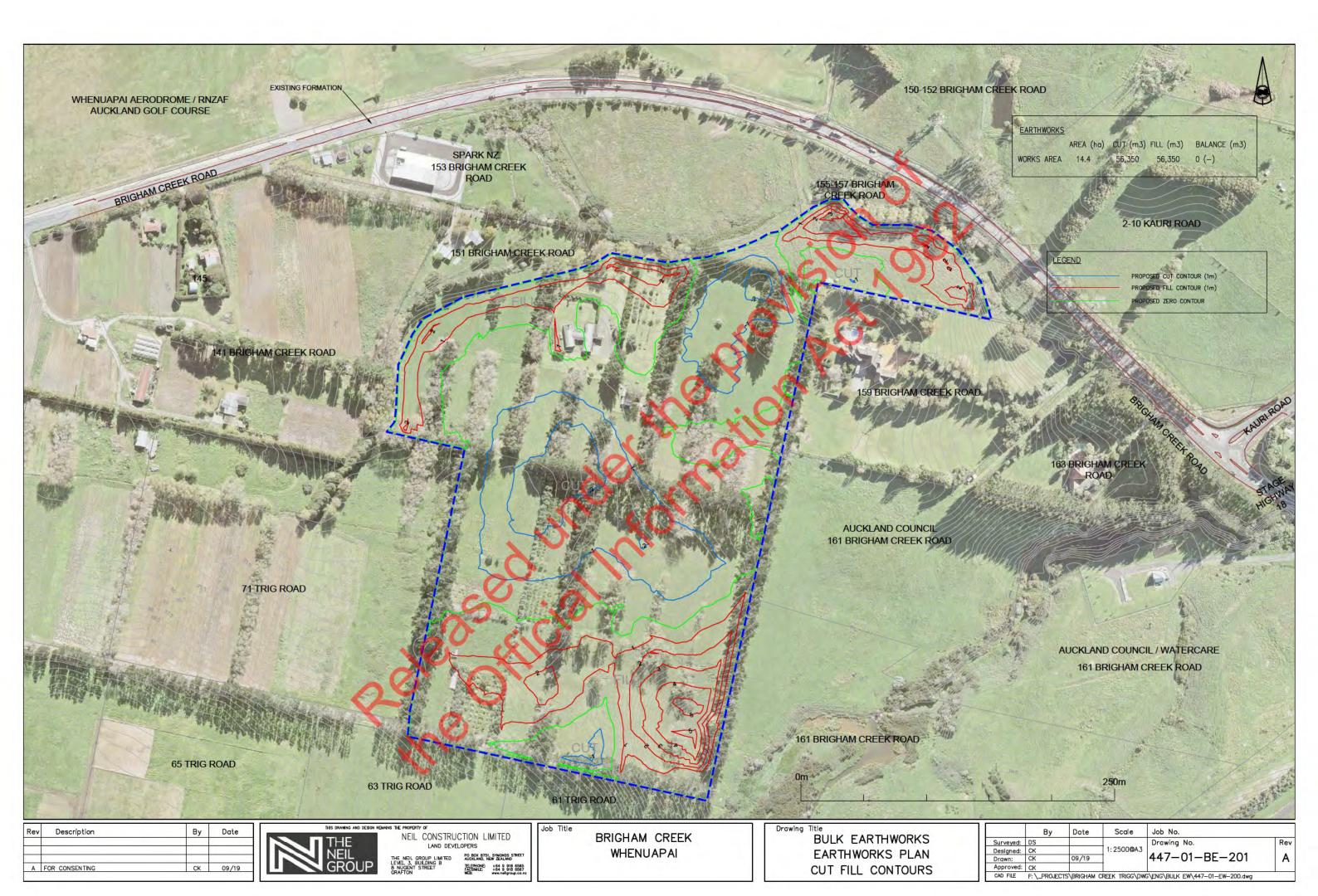
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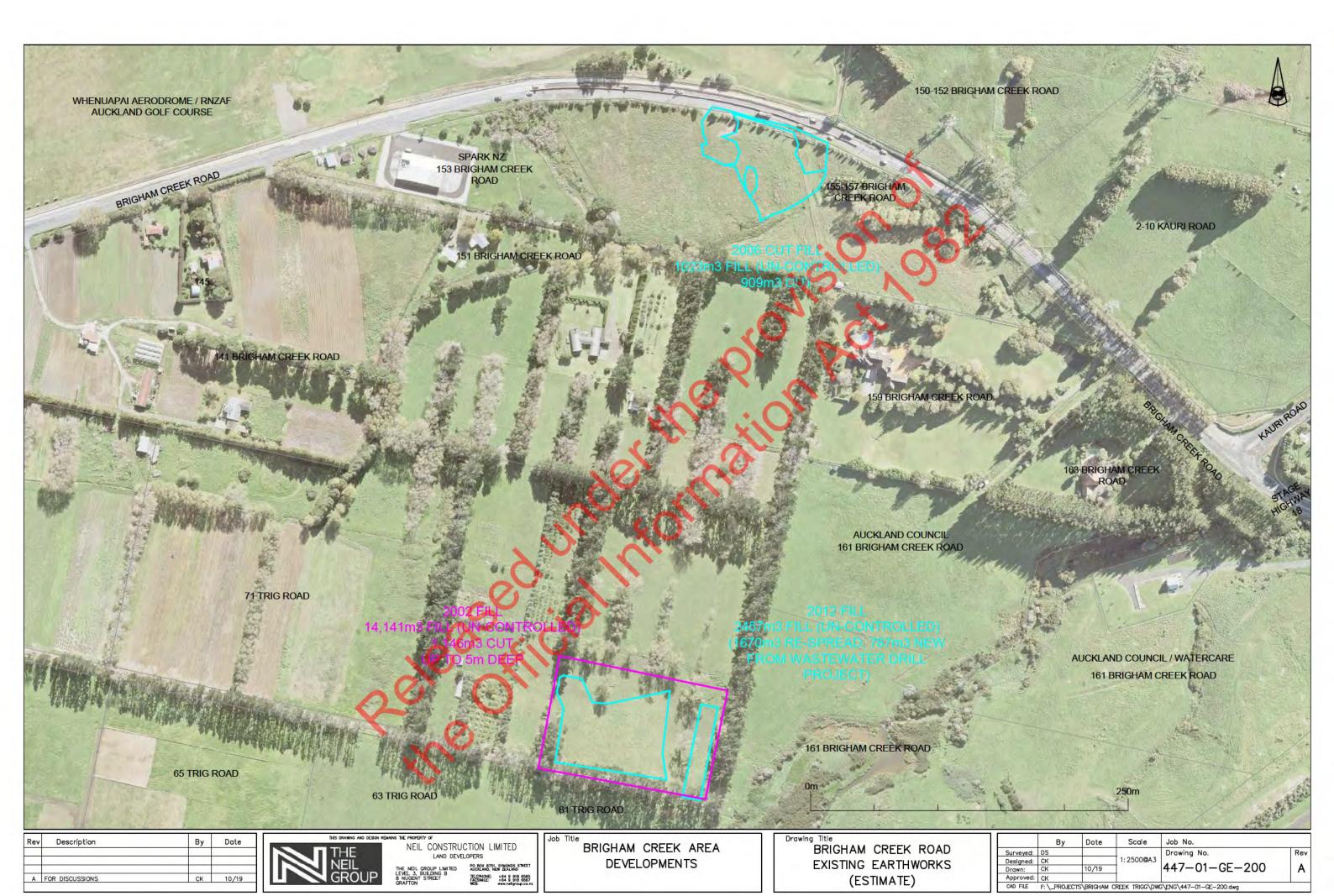
151,155-157 BRIGHAM CREEK RD & 69 TRIG RD WHENUAPAI

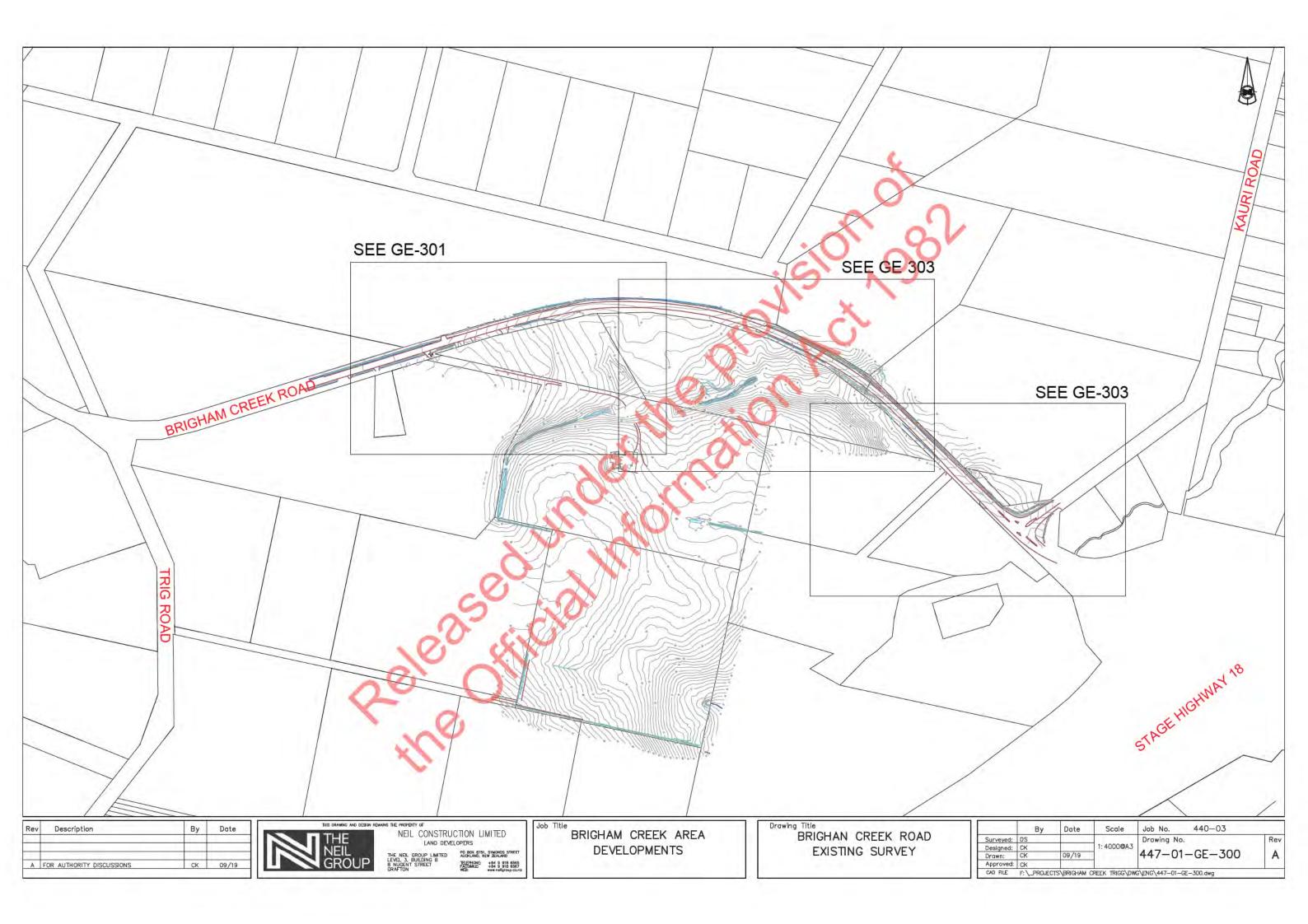
POSSIBLE SUBDIVISION











Appendix B: Investigation Data

## **BOREHOLE LOG - HA01-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745248.4m N.5925965.4m RL 26.00m Flevation: Hole Diameter: 50mm Datum: Angle from horizontal: 90° Checked by: TG Survey Source: NZTM Measured onsite Structe & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Material Description Samples & Insitu Tests Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks (Blows/100mm) Graphic L Well Depth ( Groundy R Type & Results Depth 26.0 OL: TOPSO L CL: Gravelly CLAY: brown and orange. Low plasticity. (Fill) 25.8 0.4 Peak = UTP D to 0.8 Peak = UTP ... at 0.90m, with trace topsoil. 1.2 Peak = 204+kPa 24.6 GC: GRAVEL with some clay: black and g ey ΜĎ 1.6 Peak = UTP Borehole terminated at 1 6 m 2 Termination reason: Unable to Penetrate Further

Remarks: Groundwater not encountered.

#### **BOREHOLE LOG - HA02-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: RD Position: E.1745291.5m N.5925975.4m RI 18 00m Hole Diameter: 50mm Flevation: Checked by: TG Survey Source: Measured onsite Angle from horizontal: 90° Datum: N7TM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Ê (Blows/100mm) Graphic L Well Ground Depth 귐 Depth Type & Results 18 0 OL: TOPSO L 17.7 CL: CLAY with some silt: dark brown, grey mottled 0.4 Peak = 217+kPa orange. Low plasticity. M Peak = 124kPa Residual = 53kPa 0.8 Peak = 56kPa Residual = 35kPa 1.2 16.8 CH: CLAY: grey streaked blackish brown. High plact city. (Puketoka Formation)
... from 1.20m to 1.40m, organic stained with loose sand St at 1.50m. with trace fine sand. Peak = 46kPa 1.6 Residual = 28kPa 16.1 OH: CLAY: blackish grey. High plasticity. With fibrous decomposing wood inclusions. 2.0 Peak = 28kPa 2 Residual = 15kPa (Puketoka Formatio) 15.9 CH: CL Y: gre st eak d blackish brown. High pla ticity (Puketoka Form tion) 2.4 Peak = 40kPa Residual = 28kPa НА W to 2.8 Peak = 62kPa Residual = 15kPa St k = UTP SM Sandy S LT with minor clay: grey. Low plasticity. Sand is fine grained. Waitemata Group) Peak = 124kPa Residual = 54kPa CH: CLAY with minor fine sand: grey. High plasticity. Peak = 96 Residual = 59kPa St W to Peak = 186kPa Residual = 65kPa VSt 4.8 Peak = 112kPa Residual = 50kPa Borehole terminated at 5.0 m

Termination reason:

Target Depth Reached

Remarks: Groundwater encountered at 2.9m.

# **BOREHOLE LOG - HA03-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Position: E.1745316.0m N.5926078.6m Logged by: RD RI 26 00m Hole Diameter: 50mm Flevation: NZTM Angle from horizontal: 90° Checked by: TG Survey Source: Measured onsite Datum: Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ê (Blows/100mm) Graphic L Well Groundy Depth 씸 Depth Type & Results 26.0 OL: TOPSO L 25.7 CH: CLAY with minor silt: light grey streaked orange. High Peak = 77kPa Residual = 23kPa plasticity. (Puketoka Formation) 0.4 St Peak = 155kPa Residual = 65kPa 0.8 CH: CLAY with minor silt trace fine sand: light grey streaked orange. High plasticity. (Puketoka Formation) CL: CLAY with some silt trace fine sand: grey mottled Peak = 170kPa Residual = 77kPa orange. Low plasticity. (Puketoka Formation) 1.2 Peak = 124kPa Residual = 65kPa 1.6 Peak = 103kPa Residual = 62kPa 2.0 2 23.8 CL: Clayey S LT w morange Low p asticity. (Puketo a Formation) minor fine sand: wh tish g ey mottled 2.4 Peak = 93kPa Residual = 59kPa НА 2.8 Peak = 77kPa Residual = 46kPa Peak = 93kPa Resid al 54kF Peak = 77kPa Residual = 62kPa Peak = 77 Residual = 44kPa Peak = 124kPa Residual = 46kPa W to VSt 4.8 Peak = 100kPa Residual = 50kPa Borehole terminated at 5.0 m

Termination reason:

Target Depth Reached

Remarks: Groundwater not encountered.

# **BOREHOLE LOG - HA04-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Remarks: Groundwater not encountered.

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745152.1m N.5926090.1m RL 30.50m Hole Diameter: 50mm Flevation: NZTM Angle from horizontal: 90° Checked by: TG Survey Source: Measured onsite Datum: Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Ê (Blows/100mm) Graphic L Well Groundy Depth 씸 Depth Type & Results 30.5 OL: TOPSO L 30.2 CH: CLAY with minor silt: orange. High plasticity. Peak = 160kPa Residual = 35kPa 0.4 (Puketoka Formation) ... at 0.60m, becoming light grey with orange streaks. 0.8 Peak = 204+kPa CH: Silty CLAY: light grey. High plasticity. (Puketoka Formation) Peak = 175kPa Residual = 88kPa 1.2 Peak = 152kPa Residual = 102kPa 1.6 Peak = 143kPa Residual = 114kPa 2.0 2 at 2.00m, bed 2.4 Peak = 160kPa Residual = 117kPa М НА 2.8 Peak = 140kPa Residual = 93kPa 276 CH: Silty CLAY: ark b ownish grey with pink and orange strea s. High plast ty. (Puketo a Formation) Peak 111kPa Resid al 3kP CH Silt CLAY: light pinkish orange. High plasticity. (Puketoka Formation) Peak = 99kPa Residual = 82kPa at 3.60m, becoming light brown with orange staining. Peak = 85 Residual = 73kPa St Peak = 82kPa Residual = 70kPa 4.8 Peak = 73kPa Residual = 58kPa Borehole terminated at 5.0 m Termination reason: Target Depth Reached

# **BOREHOLE LOG - HA05-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745227.8m N.5926193.3m Hole Diameter: 50mm RI 28 00m Flevation: Checked by: TG Survey Source: Measured onsite Angle from horizontal: 90° Datum: NZTM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ê (Blows/100mm) Graphic L Well Depth ( Groundy 귐 Depth Type & Results 28.0 OL: TOPSO L D to 27.7 CL: CLAY: orange. Low plasticity. 0.4 Peak = UTP (Puketoka Formation) Peak = 190kPa Residual = 120kPa 0.8 Peak = 175kPa Residual = 131kPa 1.2 Peak = 196kPa 1.6 26.4 CH: Silty CLAY: light greyish or nge. High plasticity. Residual = 160kPa (Puketoka Formation) 26.1 ML: Clayey SILT: grey sh white. Low plasticity. No d ata Peak = 143kPa 2.0 2 behavior. Residual = 85kPa (Puketoka Formatio 2.4 Peak = 114kPa Residual = 50kPa НА 2.8 Peak = 117kPa Residual = 44kPa Peak 128kPa Resid al 90kF CH: Ilty CLAY: light whitish orange. (Puketoka Formation) Peak = 67kPa Residual = 44kPa CL: Silty CLAY with trace fine sand: light orange. Low plasticity. Sand is completely weathered siltstone. Peak = 111 Residual = 73kPa (Waitemata Group) Peak = 105kPa Residual = 67kPa St to 4.8 Peak = 99kPa Residual = 67kPa Borehole terminated at 5.0 m

Termination reason:

Target Depth Reached

Remarks: Groundwater not encountered.

# **BOREHOLE LOG - HA06-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745097.1m N.5926241.7m RL 27.00m Hole Diameter: 50mm Flevation: Angle from horizontal: 90° NZTM Checked by: TG Survey Source: Measured onsite Datum: Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Material Description Samples & Insitu Tests Moisture Condition Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ê (Blows/100mm) Graphic L Well Depth ( Groundy R Depth Type & Results 27.0 OL: TOPSO L D to M 26.7 CL: CLAY: light brownish grey with orange streaks. Low plasticity. (Puketoka Formation) 0.4 Peak = 204+kPa ... at 0.60m, becoming moist and high plasticity. Peak = 178kPa Residual = 82kPa 0.8 Peak = 117kPa Residual = 82kPa 1.2 Peak = 102kPa Residual = 61kPa 1.6 Peak = 90kPa Residual = 61kPa 2.0 2 24.7 CH: Sil y CLAY dark brown with ora ge str aks. High 2.4 Peak = 88kPa plas city. a Formation) Residual = 47kPa НА St M to 2.8 Peak = 90kPa Residual = 47kPa CH: Ity C AY: dark grey. High plasticity. Waitemata Group) 3.2 Peak = 178kPa Residual = 111kPa Peak = 181k Residual = 111kPa w Peak = 204+kPa 4.8 Peak = 204+kPa Borehole terminated at 5.0 m

Termination reason:

Target Depth Reached

Remarks: Groundwater encountered at 3.1m

# **BOREHOLE LOG - HA07-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019

Borehole Location: Refer to site plan



Sheet 1 of 1 Logged by: RD Position: E.1745366.0m N.5926247.1m Elevation: RL 24.50m Hole Diameter: 50mm Angle from horizontal: 90° Checked by: TG Survey Source: Measured onsite Datum: N7TM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cor Material Description Samples & Insitu Tests Moisture Soil: Soil symbol; soil type; colour, structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geolog Recovery Disco ti ities: Depth; Defect Number; Def ot Type; Dip; Defect Sh pe; R ghne s; Aperture; Infili; eepage Spacing; Block Size; Block Shape; Remarks E /s/100mm) ₩ Groundw Graphic Depth 균 Depth Type & Results 24.5 OL: TOPSO L 24 3 CH: CLAY: orange. High plasticity. (Puketoka Formation) 0.4 Peak = 217+kPa ... at 0.40m, becoming light grey streaked orange. 0.8 Peak = 217+kPa Peak = 217+kPa 23.0 CL: Silty CLAY with minor fine sand: light gr y str aked Peak = UTP 1.6 (Puketoka Formation) 2.0 Peak = >209kPa Residual = 77kPa 22.4 CH: CL Y with mi or s t: orange streaked light grey High plasticity. (Puketoka Fo mation) 2.4 Peak = 87kPa idual = 47kPa HA M to 2.8 Peak = 72kPa Residual = 46kPa H: CLAY ith minor silt and minor fine sand: orange = 77kPa rown. High plasticity St uketoka Formation) CL: CLAY with some fine to medium sand: orange and grey. Low plasticity. (Puketoka Formation) Peak = 66kPa Residual = 43kPa Residual = 38kPa 20.4 ML: Clayey SILT with minor fine sand: grey. Low plasticity. (Puketoka Formation) 20.2 ML: Sandy SILT: grey. Low plasticity. Sand is fine to medium grained Peak = 155kPa Residual = 85kPa (Waitemata Group) VSt Peak = 190kPa Residual = 87kPa 4.8 Borehole terminated at 5.0 m Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 3.0m.

# **BOREHOLE LOG - HA08-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Remarks: Groundwater encountered at 3.6m.

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745232.3m N.5926335.4m RL 22.50m Hole Diameter: 50mm Flevation: NZTM Angle from horizontal: 90° Checked by: TG Survey Source: Measured onsite Datum: Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Material Description Samples & Insitu Tests Moisture Condition Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks (Blows/100mm) Well Graphic Depth ( Groundy R Depth Type & Results 22.5 OL: TOPSO L 22.3 CL: Silty CLAY: light whitish grey with orange streaks. Low plasticity. (Puketoka Formation) 0.4 Peak = 204+kPa 0.8 Peak = 204+kPa Peak = 187kPa Residual = 82kPa 1.2 ... at 1.20m, becoming moist and highly plastic. Peak = 111kPa Residual = 61kPa 1.6 Peak = 111kPa Residual = 44kPa 2.0 2 20.3 CH: Silty C AY: gr y with brown orange tainin High plastic y. (Puketo a Formation) 2.4 Peak = 102kPa М Residual = 41kPa НА VSt 2.8 Peak = 105kPa Residual = 50kPa at 2.80m becoming dark grey with orange streaks. CL: CLAY: dark grey. Low plasticity. (Waitema a Group) Peak = 160kPa Residual = 82kPa ... at 3.60m, becoming wet. w Peak = 204+kPa 4.8 Peak = 204+kPa Borehole terminated at 5.0 m Termination reason: Target Depth Reached

# **BOREHOLE LOG - HA09-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Remarks: Groundwater encountered at 2.8m.

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Logged by: JMJ Position: E.1745237.9m N.5926451.8m RI 23 50m Flevation: Hole Diameter: 50mm Survey Source: Checked by: TG Angle from horizontal: 90° Measured onsite Datum: NZTM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Ê (Blows/100mm) Graphic L Well Ground Depth 귐 Depth Type & Results 23.5 OL: TOPSO L 23.3 CL: CLAY: light orange. Low plasticity. D to Н (Puketoka Formation) 0.4 Peak = 204+kPa 23.0 CH: Silty CLAY: dark brownish grey. High plasticity. (Puketoka Formation) Peak = 117kPa Residual = 44kPa 0.8 Peak = 140kPa Residual = 82kPa 1.2 at 1.30m, becoming with black and orange staining. Peak = 140kPa Residual = 73kPa 1.6 21.7 CH: Silty CLAY: black with brow streaks. High plasticity Organic smell and min fibrous rootlets and wood inclusions Peak = 67kPa Residual = 32kPa 2.0 2 (Puketoka Formation) M to 21.2 CH: Sil y CLAY ight brownish grey High p sticity (Puk toka F mation) 2.4 Peak = 70kPa Residual = 44kPa НΑ 2.8 Peak = 82kPa Residual = 47kPa St Peak = 88kPa Resid al 29kF Peak = 93kPa Residual = 47kPa CL: CLAY with some silt and trace fine sand; dark grev. Low plasticity. Sand is crushed completely weathered siltstone. Peak = 90 (Waitemata Group) Residual = 29kPa Peak = 160kPa Residual = 41kPa VSt 4.8 Peak = UTP Borehole terminated at 5.0 m Termination reason: Target Depth Reached

# **BOREHOLE LOG - HA10-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Position: E.1745346.6m N 5926396.7m Logged by: RD Elevation: RL 21.00m Hole Diameter: 50mm Checked by: TG Survey Source: Measured onsite Angle from horizontal: 90° Datum: N7TM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Con-Penetrometer Material Description Samples & Insitu Tests Soil: Soil symbol; soil type; colour, structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geolog Moisture Recovery Disco ti ities: Depth; Defect Number; Def. ot Type; Dip; Defect Sh. pe; R. ghne s; Aperture; Infili; eepage Spacing; Block Size; Block Shape; Remarks E (s/100mm) ₩ Groundw Graphic Depth 럾 Depth Type & Results 21.0 OL: TOPSO L 20.7 ML: Clayey SILT with trace fine sand: light grey and light Peak = 108kPa Residual = 28kPa 0.4 brown Low plasticity (Puketoka Formation) Peak = 110kPa Residual = 32kPa 0.8 Peak = 121kPa Residual = 41kPa Peak = 109kPa Residual = 46kPa 1.6 19.3 CL: Silty CLAY with trace fin sand grey. Low plasticity (Puketoka Formation) 2.0 Peak = 81kPa 2 Residual = 34kPa at 2 10m, w h ome fine sand. St 2.4 Peak = 155kPa Residual = 49kPa HA 2.8 Peak = 189kPa Residual = 46kPa ML: Sandy SILT ith minor clay: grey. Low plasticity. Sand is fin grained. (Waitemata Group) = 217+kP Peak = 201kPa Residual = 46kPa Peak = UTP 4.8 Peak = 217+kPa Borehole terminated at 5.0 m Termination reason: Target Depth Reached

Remarks: Groundwater not encountered.

# **BOREHOLE LOG - HA11-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 18/03/2019



Borehole Location: Refer to site plan Sheet 1 of 1 Position: E.1745465.3m N.5926340.9m Hole Diameter: 50mm Logged by: RD RI 22 00m Flevation: Checked by: TG Survey Source: Angle from horizontal: 90° Measured onsite Datum: NZTM Struct e & Other Observations Consistency/ Relative Density Drilling Method/ Support Dynamic Cone Penetrometer Samples & Insitu Tests Material Description Moisture Condition Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Recovery Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks (Blows/100mm) Graphic L Well Groundy Depth 씸 Depth Type & Results 22 0 OL: TOPSO L 21.9 ML: SILT: orange. Low plasticity. Friable. (Puketoka Formation) D 0.4 Peak = UTP 21.6 CH: CLAY with minor silt: orange brown. High plasticity. (Puketoka Formation) VSt to 0.8 Peak = 217+kPa CL: Silty CLAY with minor fine sand: light greyish orange. Low plasticity. (Puketoka Formation) Peak = 155kPa Residual = 65kPa 1.2 Peak = 116kPa 1.6 Residual = 46kPa 20.3 ML: Clayey SILT with minor ne sand: light grey streaked orange. Low plasticity. (Puketoka Formation) Peak = 96kPa Residual = 34kPa 2.0 2 St 2.4 Peak = 118kPa Residual = 32kPa НА 2.8 Peak = 143kPa Residual = 32kPa M to W VSt Peak 167kPa Resid al 7kF 17.9 ML: Sandy SILT with minor clay: light grey streaked orange. Low plasticity. Sand in fine grained. (Waitemata Group) Peak = 139kPa Residual = 44kPa W VSt 4.8 Peak = 153kPa Residual = 29kPa Borehole terminated at 5.0 m

Termination reason:

Target Depth Reached

Remarks: Groundwater not encountered.

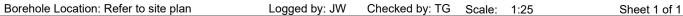
# **HAND AUGER BOREHOLE LOG - HA12-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019



Position: 1745342.0mE; 5926450.0mN Projection: NZTM

		n: 1745342.0 on: 23.50m	)mE;	59	2645	0.0mN Projection: NZTM Datum: AUCKHT 1946 Survey Source: Hand	d Hel	d GF	PS.		
		oles & Insitu Tests		(i	go.			y	D) P	ynamic Co Penetromet	eter
Groundwater	Depth	Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Cons stency/ Relati e D n t	(B)	310ws/100m	
			23.5			ML: SILT with minor clay: brown. Low plasticity. (Uncontrolled Fill)					
			23.3		××	ML: SILT with some clay: orange brown. Low plasticity. Trace limonite streaks throughout. (Puketoka Formation)				7	
	0.4	Peak = 160kPa Residual = 58kPa			X X   X X   X X X X X X X X X X X X X	(i dictora i diffidadi)		VS		1	
		Residual = 50KPa			* × × * × ×	• 6			力		
			22.8		X X X X	CH: CLAY with minor silt: light brown streaked dark orange. High plasticity.	r			<b>'</b>	
	0.8	Peak = 64kPa Residual = 26kPa			+-	(Puketoka Formation)					
				1 -	£_	at 1.00m, becoming grey with trace organic staining and rootlets		St		_	
	1.2	Peak = 160kPa			<u> </u>						
		Residual = 32kPa				O' Y					
			22.0				М				
	1.6	Peak = 128kPa Residual = 45kPa			<u> </u>	CH: Silty CLAY: grey brown. High plasticity. Tra e organ c staining. (Puketoka Formation)		VSt			
			21.8		× ×	CH: Organic stained Silty CLAY: b. ck. High plasticity. Rootlets. (Puketoka Formation)					
					* <u>*</u>						
	2.0	Peak = 83kPa Residual = 58kPa	21.5	2 -		CH: CLAY with minor s i grey ith black streaks. High plasticity. (Puketoka Formation					
					-						
	2.4	Peak = 99kPa									
		Residual = 64kPa			ŧ	11, 50,		0,			
					<u> </u>			St			
<b>Y</b>	2.8	Peak = 86kPa Residual = 32kPa	20.7		X	CH: Silty CLAY wi mino fine to coarse sand: grey. High plasticity. Sand is sub angular to sub rounded. Trace organics.	w				
				3	X	(Puketoka Formation) at 3.00m, saturated				+	
	3.2	Peak = 128kPa	Y		<u> </u>						
		Residual = 35 P	7		X	at 3.20m, w some fine to coarse grained sand					
		~0			×—						
	3.6	Peak 131kPa Resid al = 32kPa	19.9			CH: Sandy CLAY with some silt: grey. Low plasticity. Trace organics.					
						(Puketoka Formation)					
)	V						s				
	4.0	Peak = 147kPa Residual = 38kPa		4 -				VSt			
		W.									
	4.4	Peak = 157kPa									
		Residual = 58kPa									
	4.8	Peak = 176kPa Residual = 70kPa	18.7			CH: Silty CLAY: dark grey. High plasticity. Trace organic staining. (Puketoka Formation)	M to				
				5 -	×	Borehole terminated at 5.0 m	W	<u> </u>		$\perp$	$\perp$
$\vdash$		ion Reason: Tar	J	41-	D	- 4					-

Termination Reason: Target Depth Reached
Shear Vane No: 2081 DCP No:
Remarks: Groundwater encountered at 2.8m.

### **HAND AUGER BOREHOLE LOG - HA13-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019

Borehole Location: Refer to site plan Logged by: JW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745363.0mE; 5926449.0mN Projection: NZTM

Datum: AUCKHT 1946 Elevation: 23.00m Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests **3raphic Log** Groundwater Moisture Condition  $\widehat{\Xi}$ Material Description (Blows/100mm) манана цевскарион
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Depth 귐 Cons 10 Type & Results Depth OL: TOPSO L CL: Silty CLAY with trace gravel: orange, grey, brown and black. Low plasticity. 23.0 23.0 (Uncontrolled Fill) Peak = 147kPa Residual = 64kPa 0.4 OL: Buried TOPSOIL

CH: Silty CLAY with trace fine to coasre sand: grey streaked orange and brown. High plas city (Puketoka Formation) Peak = 83kPa Residual = 35kPa 0.8 ... at 0.80m, 100mm seam of black organic stained CLAY 22.1 CH: CLAY with minor silt and trace rootlets: grey mottled orange. High plastic y. Trace white pumiceous (Puketoka Formation) Peak = 128kPa Residual = 80kPa 1.2 1.6 Peak = 115kPa Residual = 58kPa VSt ... at 1.80m. with trace fine to medium grained sand Peak = 99kPa 2.0 21.0 2 fine o coarse sand: grey. High plasticity. Trace white pumiceous mottles and CH: Silty CLAY with m Residual = 51kPa trace organics (Puketoka Formation St 2.4 Peak = 115kPa Residual = 51kPa 2.8 Peak = 134kPa Residual = 48kPa 20.2 CH: Sandy CLAY ith mor silt: dark grey. High plasticity. Sand is fine to coarse grained. Trace organics. (Puketoka Formation 3.2 Peak = 144kPa Residual = 48 P at 3.20m, w some silt eak 147kPa VSt Peak = 138kPa Residual = 35kPa 4.0 18.8 CH: Silty CLAY: dark grey. High plasticity. (Waitemata Group) Peak = 176kPa Residual = 74kPa W to 4.8 Peak = 224+ kPa Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached
Shear Vane No: 2081 DCP No:
Remarks: Groundwater encountered at 2.9m.

#### **HAND AUGER BOREHOLE LOG - HA14-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019

Checked by: TG Scale: Borehole Location: Refer to site plan Logged by: JW Sheet 1 of 1

Position: 1745395.0mE; 5926441.0mN Projection: NZTM

Datum: AUCKHT 1946 Elevation: 21.20m Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests **3raphic Log** Groundwater Moisture Condition  $\widehat{\Xi}$ Material Description (Blows/100mm) Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Depth 귐 Cons 10 Type & Results Depth 21.2 21.2 OL: TOPSO L CH: Silty CLAY with trace gravel: orange, brown, grey, black. High plasticity. (Uncontrolled Fill) Peak = 166kPa Residual = 70kPa 0.4 20.4 OL: Buried TOPSOIL 20.2 CH: CLAY with minor silt and trace fine to coarse sand: brown str aked orange. High plast city. Trad rootlets. (Puketoka Formation) Peak = 90kPa Residual = 45kPa 1.2 ... at 1.20m, becoming grey streaked orange
CH: Silty CLAY with minor fine to coarse sand: grey brown st aked orange. High plasticity. Trace organic staining and trace rootlets.
(Puketoka Formation) St 1.6 Peak = 67kPa Residual = 19kPa 19.4 CH: Sandy CLAY with minor rootlets: d\_rk grey. High plasticity. r\_ce organic staining. Alternating every 100-150mm with Clayey SILT\_dark grey, low plasticity. (Puketoka Formation) Peak = 173kPa Residual = 45kPa 2.0 2.4 Peak = 144kPa Residual = 80kPa 2.8 Peak = 115kPa Residual = 48kPa CH: Sandy C AY: dark grey. High plasticity. Sand is fine to coarse grained. Inter-bedded with Clayey SILT, dark grey low p asticity. (Waitemata Group 3.2 Peak = 176kPa Residual = 45 P VSt eak 192kPa 4.0 4.8 Peak = UTP Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached Shear Vane No: 2081 DCP No: Remarks: Groundwater encountered at 2.5m.

## **HAND AUGER BOREHOLE LOG - HA15-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019

Checked by: TG Scale: Borehole Location: Refer to site plan Logged by: TK Sheet 1 of 1 Position: 1745378.0mE; 5926419.0mN Projection: NZTM Elevation: 20.20m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests Graphic Log Groundwater Moisture Condition Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)  $\widehat{\Xi}$ (Blows/100mm) Depth 귐 Cons 10 Type & Results Depth 20.2 OL: TOPSO L 0.4 Peak = 178+ kPa 19.8 CI: Silty CLAY: Yellowish brown, mottled grey. Low-high plasticity. Trace fine sand (Uncontrolled Fill) Peak = 135kPa Residual = 61kPa 0.8 Peak = 61kPa Residual = 28kPa 1.2 18.9 OL: Buried TOPSOIL: Contains gravel. 1.6 Peak = 28kPa Residual = 18kPa F to St 18.5 CL: Sitty CLAY with some sand: Br whish grey, mottled brown Low last ity trace organic fragments and roots (<15mm) (Puketoka Formation) W Peak = 74kPa 2.0 Residual = 18kPa V 18.0 MH: Clayey SIL (Waitemata Goup) 2.4 Peak = 178+ kPa 17.6 MH: S ndy SILT: Grey. Low plan (Waitemata Group) 2.8 Peak = 178+ kPa from 3.00m to 5.00m, Becoming moist, loosely packed 3.2 VSt to 4.8 Peak = 178+ kPa

Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No: Remarks: Groundwater encountered at 2.2m

Peak = 178+ kPa

5.0

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

Borehole terminated at 5.0 m

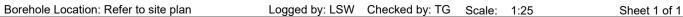
# **HAND AUGER BOREHOLE LOG - HA16-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019



Position: 1745402.0mE; 5926415.0mN Projection: NZTM

	Elevati	on: 20.10m	,			Datum: AUCKHT 1946 Survey Source: Hand	Hel	d GF	PS_		
durotor.	Sam	ples & Insitu Tests	RL (m)	Depth (m)	Graphic Log	Material Description  Soil Soil number cell type release structure; hedding plecticity contitivity additional comments. (origin/goolegical unit)	Moisture Condition	stency/ D n ty	P	ynamic Co Penetrome Blows/100r	eter
rotomballoa	Depth	Type & Results	R	Dept	Graph	Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)  Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Mois	Cons stency/ Relati e D n t	5	10	15
			20.1			OL: TOPSO L:	D				
			19.9			CL: Silty CLAY: Yellow, mottled brown. Low plasticity.				7	
	0.4	Peak = 123kPa				(Uncontrolled Fill)			-	1	
		Residual = 42kPa									
			19.5			ML: Clayey SILT: Brown, mottled yellow and grey. Low plasticity. Friable. (Uncontrolled Fill)					
	0.8	Peak = 120kPa Residual = 60kPa						vst			
				1 -		(0)	M				
					***						
	1.2	Peak = 114kPa Residual = 57kPa				from 1.20m to 1.60m, Becoming yellow, mottled brown, ey, some orange.					
	1.6	Peak = 81kPa	18.5			CH: Silty CLAY: Yellow-orange High, la ficity					
		Residual = 42kPa			*-×	CH: Silty CLAY: Yellow-orange. High la ticity (Puketoka Formation)		0,			
					X-X			St			
3	2.0	Peak = 211+ kPa	18.1	2 -	^-  x_	CH: Silty CLAY: Dark g stre ked orange. High plasticity (Puketoka Formation					
	2.4	Peak = 211+ kPa			X	~O, \'</td <td></td> <td></td> <td></td> <td></td> <td></td>					
					<u> </u>						
					<u> </u>						
	2.8	Peak = 211+ kPa			X_X						
			17	3 -	X	CL: Clavey STT with some sand: Dark grey Low plasticity. Sand is fine to coarse grained				$\perp$	
	0.0	Peak = 211+ kPa	V			CL: Clayey S LT with some sand: Dark grey, Low plasticity. Sand is fine to coarse grained. (Waitemata Group)					
	3.2	Peak = 211+ kPa	)			~~	M to				
								VSt to			
	3.6	Peak = 211+ kPa						Н			
	V										
	4.0	Peak = 211+ kPa		4 -							
	4/4	Peak = UTP									
	4.8	Peak = UTP									
	5.0	Peak = UTP		5 -		Borehole terminated at 5.0 m				$\perp$	
		l tion Reason: Tar		41-	D						

Termination Reason: Target Depth Reached
Shear Vane No: 2082 DCP No:
Remarks: Groundwater encountered at 2.0m



# **HAND AUGER BOREHOLE LOG - HA17-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019

Borehole Location: Refer to site plan Logged by: TK Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745434.0mE; 5926388.0mN Projection: NZTM

Elevation: 17.50m Datum: AUCKHT 1946 Survey Source: Hand Held GPS

Lieva	17.50111				Datum: AUCKHT 1946 Survey Source: Hand	HIE	u Gr	3		
Samples & Insitu Tests  Samples & Results		RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)	Moisture Condition	tency/ D n ty	Pe	namic Cor enetromete ows/100m	ter
Depti	n Type & Results	R	Dept	Graph	Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Mois	Cons stency/ Relati e D n t	5	10 ·	15
		17.5			OL: TOPSO L	D				
		17.2			CI: Silty CLAY with trace sand: Orange mottled grey. Low-High plasticity. Sand is fine to medium	•			7	
0.4	Peak = 178+ kPa		-	-XX	(Puketoka Formation)				Ψ	
				- ×		1			,	
0.8	Peak = 145kPa Residual = 63kPa			1×- - - - -	at 0.90m, Becoming light grey mottled orange		VSt			
			1 -	         	at 0.90m, Decoming light grey motited drange				_	
1.2	Peak = 122kPa Residual = 36kPa			       		М				
				X_    X_						
1.6	Peak = 99kPa Residual = 43kPa									
				×-  ×-  ×-	at 1.80m, Trace organic fragments o <20mm appearing					
2.0	Peak = 56kPa Residual = 23kPa	15.5	2 -	<u>-</u>	CH: CLAY: Brown. High plastic y. Trace organic fragments of <10mm. (Puketoka Formation		St		+	
					(Functional Formation)					
2.4	Peak = 43kPa Residual = 23kPa				at 2.30m, Becoming grey, mottled brown and o ange					
				<u>-</u>	(1), KO,		F			
2.8	Peak = 61kPa Residual = 15kPa				at 2.70m, Trace medium to coarse sand appearing					
			3			W to S			_	
3.2	Peak = 56kPa Residual = 23 P	Y		<u> -</u> -			St			
	0			<u> </u>						
3.6	eak = 41kPa Resid al = 18kPa									
0							F			
4.0	Peak = 137kPa Residual = 36kPa	13.6	4 -	×_×	CI: Silty CLAY with minor sand: Grey. Low to high plasticity. Sand is medium to coarse. (Waitemata Group)			$\vdash$	+	+
	_(?)			- X-   X-						
474	Peak = 152kPa Residual = 56kPa			X X		w	VSt			
	Julia - Juni a		-	X X			,50			
4.8	Peak = 132kPa			X						
5.0	Residual = 48kPa  Peak = 152kPa		5 -	X   X   X   X   X   X   X   X   X   X	Borehole terminated at 5.0 m				$\perp$	
Termin	Residual = 30kPa ation Reason: Tar	get D	epth I	] Reach						

Termination Reason: Target Depth Reached
Shear Vane No: 1620 DCP No:
Remarks: Groundwater encountered at 2.0m

#### HAND AUGER BOREHOLE LOG - HA18-19

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 25/11/2019

Borehole Location: Refer to site plan Logged by: LSW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745409.0mE; 5926375.0mN Projection: NZTM

Datum: AUCKHT 1946 Elevation: 18.60m Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests Graphic Log Groundwater Moisture Condition  $\widehat{\Xi}$ Material Description (Blows/100mm) Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Depth 귐 Cons 10 Type & Results Depth 18 6 OL: TOPSO L: 18.4 MH: Clayey SILT: Grey, mottled brown and orange. Low plasticity, friable. (Uncontrolled Fill) Peak = 172kPa Residual = 60kPa 0.4 Peak = 135kPa Residual = 84kPa 0.8 MH: Clayey SILT: Grey, mottled brown and orange. High plasticity (Uncontrolled Fill) Peak = 135kPa Residual = 63kPa 1.2 1.6 Peak = 105kPa 17.0 CH: Silty CLAY: Yellow, mottled orange and gr y. High plasticity. Residual = 42kPa 16.8 MH: Clayey SILT with minor sand: Gre small orange and brown mottles High plasticity. (Puketoka Formation) Peak = 54kPa 2.0 Residual = 27kPa 16.4 CH: Silty CLAY G ey an accurate rep esentat on. (Puketoka Formation dark brown. High pla ticity Poor recovery after 2.4m, shear strengths are not an 2.4 Peak = 69kPa Residual = 27kPa 2.8 Peak = 57kPa Residual = 30kPa St 3.2 Peak = 66kPa Residual = 48 P eak = 60kPa sid\_al = 45kPa Peak = 105kPa Residual = 81kPa 14.2 Peak ML: Clayey SILT with some sand: Grey. Low plasticity. (Waitemata Group) VSt to 4.8 Peak = 211+ kPa 5.0 Peak = UTP Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached
Shear Vane No: 2082 DCP No:
Remarks: Groundwater encountered at 2.0m



## **HAND AUGER BOREHOLE LOG - HA19-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Borehole Location: Refer to site plan Logged by: LSW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745295.0mE; 5926333.0mN Projection: NZTM

Datum: AUCKHT 1946 Elevation: 21.40m Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests **3raphic** Log Groundwater Moisture Condition  $\widehat{\Xi}$ Material Description (Blows/100mm) Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Depth 귐 Cons 10 Type & Results Depth 21.4 OL: TOPSO L: Peak = 124kPa Residual = 28kPa 0.4 21.0 CL: Silty CLAY: Yellow mottled grey and orange. Low plasticity (Uncontrolled Fill) 20.8 ML: Clayey SILT with minor sand: Dark brown. Low plasticity. Friable. Fine to medium sand. (Puketoka Formation) Peak = 140kPa Residual = 48kPa 0.8 CL: Silty CLAY with minor sand: Grey mottled orange and brown. Low plasticity (Puketoka Formation) Peak = 142kPa Residual = 79kPa 1.2 20.0 ML: Clayey SILT: Light grey and brown. Low plasticit (Puketoka Formation) 1.6 Peak = 58kPa Residual = 25kPa St Peak = 36kPa Residual = 18kPa 2.0 ... from 2.00m to 2.20m Becoming saturated, high plasticity F 19.2 ML: Clayey SIL led orange. Low plasticity (Puketoka Fo mation 2.4 Peak = UTP from 2.60m to 2.80m, Be 2.8 Peak = UTP s from 2.80m to 3 60m, ecoming grey mottled orange 3.2 VSt ML: Clayey SILT with some sand: Dark grey. Low plasticity. (Waitemata Group) 16.9 ML: Clayey SILT with some sand: Dark grey. Low to high plasticity. (Waitemata Group) s 16.7 ML: Clayey SILT with some sand: Dark grey. Low plasticity. (Waitemata Group) 4.8 Peak = UTP W 5.0 Peak = UTP Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached
Shear Vane No: 1620 DCP No:
Remarks: Groundwater encountered at 2.0m

## **HAND AUGER BOREHOLE LOG - HA20-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Borehole Location: Refer to site plan Logged by: LSW Checked by: TG Scale: Sheet 1 of 1

Position: 1745296.0mE; 5926292.0mN Projection: NZTM

Elevation: 23.40m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests Graphic Log Groundwater Moisture Condition Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)  $\widehat{\Xi}$ (Blows/100mm) Depth 귐 Cons Type & Results Depth 23.4 OL: TOPSO L: 23.2 CL: Silty CLAY: Dark brown, mottled orange. Low plasticity. (Uncontrolled Fill) 0.4 Peak = 178+ kPa 23.0 CL: Silty CLAY: Grey, mottled orange. Low plasticity. (Puketoka Formation) Peak = 119kPa Residual = 58kPa 0.8 ... from 1.00m to 1.60m, Orange mottles ending Peak = 160kPa Residual = 109kPa VSt 1.2 1.6 Peak = 142kPa 21.8 ML: Clayey SILT: Light grey, mottled ange. L w plasticity Residual = 79kPa (Puketoka Formation) 21.6 MH: Clayey SILT: Yellow, mottled orange and grey. Low to high **p** sticity (Puketoka Formation) Peak = 114kPa Residual = 76kPa 2.0 2.4 Peak = 99kPa Residual = 43kPa 20.8 St ML: Cayey SILT with trace sand Ora Low to high plasticity (Puketoka Formation) s 2.8 Peak = 178+ kPa 20.6 CL: Silty CLAY: G y. Lo plastic y (Waitemata Group) 3.2 Peak = 168kPa Residual = 76 P ML: Clayey SILT with some sand: Grey. Low plasticity. VSt 4.8 Peak = UTP 5.0 Peak = UTP Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No: Remarks: Groundwater encountered at 2.6m

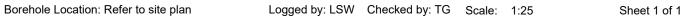
## **HAND AUGER BOREHOLE LOG - HA21-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019



Position: 1745120.0mE; 5926306.0mN Projection: NZTM

Elevation: 25.00m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests **3raphic** Log Groundwater Moisture Condition  $\widehat{\Xi}$ Material Description (Blows/100mm) Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Depth 귐 Cons 10 Type & Results Depth 25.0 OL: TOPSO L: 24.8 CL: Silty CLAY with trace sand: Grey, streaked orange/yellow. Small brown mottles. Low plasticity. Sand is fine to medium (Puketoka Formation) Peak = 168kPa Residual = 56kPa 0.4 Peak = 114kPa Residual = 50kPa 0.8 ML: Clayey SILT with some sand: Light grey, almost white, mottled orange. Low plasticity. Friable. Sand is fine to medium. (Puketoka Formation) Peak = 132kPa Residual = 72kPa 1.2 M 1.6 Peak = 117kPa Residual = 69kPa 2.0 Peak = 112kPa Residual = 63kPa 2.4 Peak = 147kPa 22.6 CL: Sil y CL Y: Grey mottled orange. Low to high plasticity. (Puke ka Formation) Residual = 63kPa VSt 22.4 MH: Cayey SILT: Light grey. Hig plas (Puketoka Formation) 2.8 Peak = 150kPa Residual = 51kPa ML: Clayey SILT with some sand: Dark grey. Low plasticity. (Waitemata Group) 3.2 Peak = UTP 4.8 5.0 Peak = UTP Borehole terminated at 5.0 m

Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No: Remarks: Groundwater encountered at 2.8m

# **HAND AUGER BOREHOLE LOG - HA22-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019 Borehole Location: Refer to site plan Logged by: LSW Checked by: TG Scale: Sheet 1 of 1 Position: 1745145.0mE; 5926258.0mN Projection: NZTM Elevation: 28.60m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Dynamic Cone Penetrometer Samples & Insitu Tests **3raphic** Log Groundwater Moisture Condition Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)  $\widehat{\Xi}$ (Blows/100mm) Depth 귐 Cons Type & Results Depth 28.6 OL: TOPSO L: Peak = 160kPa Residual = 69kPa 0.4 28.2 CL: Silty CLAY: Orange, mottled brown, grey, dark grey. Low plasticity (Puketoka Formation) Peak = 102kPa Residual = 63kPa 0.8 Peak = 155kPa Residual = 69kPa 1.2 1.6 Peak = 124kPa Residual = 53kPa 26.8 CL: Silty CLAY: Orange, mottled grey. ow to high plasticity (Puketoka Formation) Peak = 56kPa 2.0 Residual = 25kPa 2.4 Peak = 99kPa Residual = 63kPa 2.8 Peak = 59kPa Residual = 41kPa St ML: Clayey SILT: Grey, mottled orange. Low to high plasticity. (Puketoka Formation) 3.2 Peak = 61kPa Residual = 51 P eak = 99kPa lesid al = 61kPa ML: Clayey SILT with some sand: Grey. Low plasticity. Peak = 129kPa Residual = 58kPa Peak = 150kPa VSt ... from 4.60m to 5.00m, ecoming interbedded with Silty CLAY Peak = 124kPa 4.8 Residual = 58kPa

Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No: Remarks: Groundwater encountered at 2.6m

Peak = 117kPa

5.0

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

Borehole terminated at 5.0 m

## **BOREHOLE LOG - MH01-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Borehole Location: Refer to site plan Logged by: TK Checked by: TG Scale: 1:50 Sheet 1 of 2

Position: 1745319.0mE; 5925970.0mN Projection: NZTM Angle from horizontal: 90°
Elevation: 15.80m Datum: AUCKHT 1946 Survey Source: Hand Held GPS

E	Eleva	tion: 1	5.80m				Datum: AUCKHT 1946							Survey Sc	ource:	Hand	Held GPS
Well	Groundwater	Sam	oles & Insitu Tests	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	We	atherir	Recovery	RQD	Estimated Strength	Defect Spacing (mm)	Met	Struct e & Other Observations  Disco ti ities: Depth; Defect Number; Def ct Type; Dip; Defect
>	Groun	Depth	Type & Results		Dep	Grap	Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	S S	Cons Relativ	S S	M M M	W. Rec	2	W W W W K K K K K K K K K K K K K K K K	<20 20-60 20-200 200-600 60-200	>2000 >2000 Drilling Su	Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks
		0.5	Peak = 74kPa Residual = 36kPa Peak = 110kPa	15.8 15.7	-		TOPSOIL: brown. CH: Silty CLAY: with trace fine to medium sand; brown mottled light grey. High plasticity. (Uncontrolled Fill)	D to	St			100 60				OB / PQ	8
		1.5 1.5	Peak = 63kPa Peak = 63kPa Residual = 20kPa SPT = (4,4,10) N* = 14	14.6	-	×	CH: Silty CLAY: with trace fine to medium sand; light brownish grey mottled orange. High plasticity. (Puketoka Formation)		VSt			89 100	10			TdS	
		3.0 3.0	Peak = 74kPa Residual = 30kPa SPT = (4,7,10) N* =		3 -	× × × × × × × × × × × × × × × × × × ×	at 2.20m, trace organic fragments <20 mm	M to W	2			100 86				SPT 0B/PQ3	
		4.5	SPT = (3,3,3) N* =		4 -	× × × × × × × × × × × × × × × × × × ×	at 3.70m, becoming bluish grey at 4.00m, becoming b ownish grey, minor fine to medium sand		St			96				OB / PQ3	
		4.5	6			×_×	at 4 50m, becoming grey mottled orange					100				SPT	
		5.0-5.5	Push Tube 1 U63		5 -	× ×	)), KO					91				ne3	
		6.0	SPT = (3,3,3) N*		6	XXX						100				OB / PQ3	-
			6			×						100				SPT	
		7.5	SPT = (5,7 0) N	8.3	7	× – × × × × × × × × × × × × × × × × × ×	at 7.10m, becoming brownish grey mottled dark grey, minor medium to coarse sand.	w				86				OB/PQ3	-
	0		(1,75).1		8 -	(	ML: Sandy SILT: with minor clay; bluish grey. Low plasticity. Medium to coarse sand. (Waitemata Group)					100				SPT	- - - -
	×		SDT = /7.42.47\\\		-	( X X			VSt			100				OB / PQ3	
		9.0	SPT = (7,13,17) N* = 30		9 -	(						100				SPT	
					10 -	× × × × × × × × ×						100				OB / PQ3	-
	ermi	nation	Reason: Tar	get l	Dep	th Re	ached	1	1		11		1	11111		1 1	1

Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No:

Remarks:

#### **BOREHOLE LOG - MH01-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Borehole Location: Refer to site plan Checked by: TG Sheet 2 of 2 Logged by: TK Scale: 1:50

Position: 1745319.0mE; 5925970.0mN Projection: NZTM Angle from horizontal: 90° Datum: AUCKHT 1946 Elevation: 15.80m Survey Source: Hand Held GPS Defect Estimated Samples & Insitu Tests Weathering Spacing



Termination Reason: Target Depth Reached Shear Vane No: 1620 DCP No:

Remarks:



Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/19

Logged by: TK

Checked by: TG

Position: 1745319.0 E, 5925970.0 N Elevation: RL 15 8m

Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig

Geosciences

Sheet No. 1 of 4





MH01-19: 0m to 3.0m



MH01-19: 3.0m to 6.0m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/19

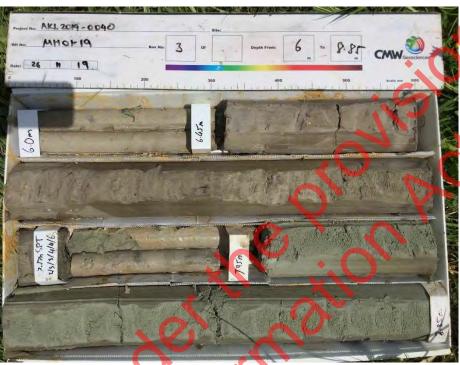
Logged by: TK

Checked by: TG

Position: 1745319.0 E, 5925970.0 N Elevation: RL 15 8m Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig Contractor: Prodrill

Geosciences

Sheet No. 2 of 4



MH01-19: 6.0m to 8.85m



MH01-19: 8.85m to 11.65m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/19

Logged by: TK

Checked by: TG

Position: 1745319.0 E, 5925970.0 N Elevation: RL 15 8m Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig Contractor: Prodrill





MH01-19: 11.65m to 15.0m



MH01-19: 15.0m to 18.9m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/19

Logged by: TK

Checked by: TG

Position: 1745319.0 E, 5925970.0 N Elevation: RL 15 8m

Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig

Geosciences

Sheet No. 4 of 4





MH01-19: 18.9m to 20.0m

## **BOREHOLE LOG - MH02-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 27/11/2019

Borehole Location: Refer to site plan Sheet 1 of 2 Logged by: TK Checked by: TG Scale: 1:50

Position: 1745259.0mE; 5926130.0mN Projection: NZTM Angle from horizontal: 90°

E	Eleva	tion: 2	27.00m				Survey Source: Hand H												
Well	Groundwater	Sam	ples & Insitu Tests	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	W	/eath	ering	Recovery	RQD	Estimated Strength	S	Defect Spacing (mm)	>2000 Drilling Method/ Support	Struct e & Other Observations  Disco ti lities: Depth; Defect Number: Def ct Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size;
	9.	Depth	Type & Results		٥	ğ	Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	20	Relat	RS	8 ₹	₩ % M	2		S × × × ×	ES 420	60-200 200-60 600-20	Drilli	eepage Spacing; Block Size; Block Shape; Remarks
		0.5	Peak = 178+ kPa	27.0 26.8	- - - -	X	TOPSOIL: brown.  CH: Silty CLAY: with trace fine to medium sand; orange mottled grey. High plasticity. (Puketoka Formation) at 0.50m, becoming grey	D to					100 80					OB / PQ	
		1.0	Peak = 152kPa Residual = 58kPa		1 -	^  X 	mottled orange.		_				100		+ C			98	
		1.5 1.5	Peak = 120kPa Residual = 86kPa SPT = (2,6,14) N* = 20		2 —	X X X X X X X X X X X X X X X X X X X							100 1					SPT	-
					- - - - -	× × × × × × × × × × × × × × × × × × ×			VSt				100					OB / PQ3	
		3.0 3.0 3.4-4.0	Peak = 142kPa Residual = 33kPa SPT = (4,4,4) N* = 8 Push Tube 2 U63		3 -	×_×_ × × × × × × ×	×	M o W	S				100					SPT	- - - - - -
				23.0	4 -	X  X  X	CL: Silty CLAY: w min r fine to				7		91					13 N63	= = = = = = = = = = = = = = = = = = = =
		4.5 4.5	Peak = 38kPa Residual = 13kPa	22.5	-	×— ×— ×××	medium sand; grey Low plasticity. (Puketok Forma ion)  ML: Cl yey S T: with minor fine to medium sand; grey. Low plasticity.		5				0 100					т 08/РОЗ	
			SPT = (4,4,7) N* = 11		5 —		(Puk toka mation)  at 5.50m, becoming g v mottled dark grey, ome medium to						67 100					OB / PQ3 SPT	- - - - - - - - - - -
		6.0 6.0	Peak = 28kPa Residual = 10kPa SPT = (3,3,3) N =	3	6	× × × × × × × × × × × × × × × × × × ×	coarse sand.						100					SPT	
		(2)	3	20 0	7		Sandy SILT: with minor clay; grey. Low plasticity, medium to coarse. (Puketoka Formation)		F				86					OB / PQ3	-
	2	7.5 7.5	Peak = 3 Pa Residua = 10kPa SPT = (3,3) N* =		8 —	× × × • × × × • × × × • × × ×		W					100					SPT	
	×	C	8		- - - - -	(							71					OB / PQ3	-
		9.0 .0	Peak = 25kPa Residual = 3kPa SPT = (2,4,4) N* = 8		9 —	X X X X X X X X							100					SPT	
					10 -	× × × × × × × × ×	from 9.80m to 9.85m, with trace organic fragments.						100					OB / PQ3	-
T	ermi	nation	Reason: Re	fusa	l me	et .		1		П	П	II				17			-

Shear Vane No: 1620 DCP No:

Remarks:

#### **BOREHOLE LOG - MH02-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 27/11/2019

Borehole Location: Refer to site plan Logged by: TK Checked by: TG Scale: 1:50 Sheet 2 of 2

Position: 1745259.0mE; 5926130.0mN Projection: NZTM Angle from horizontal: 90° Datum: AUCKHT 1946 Elevation: 27.00m Survey Source: Hand Held GPS Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Structe & Other Observations Defect Consistency/ Relative Density Drilling Method/ Support Estimated Samples & Insitu Tests Weathering Spacing Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Recovery  $\widehat{\mathbf{E}}$ Graphic L RQD Well Groundw Depth 귐 Depth Type & Results 16.7 ML: Sandy SILT: dark grey Peak = 58kPa Residual = 15kPa SPT = (4,6,9) N\* = 15 interbedded with clay layers. Low (Waitemata Group) 8 St to VSt PQ3 9 15.5 Grey mottled dark grey, 0B/ SANDSTONE. Weathered to Silty SAND fine to medium sand. (Waitemata Group) SPT = (14,30,20/75mm) N\* 12 12.0 SPT = 50+ Peak = UTP 14.5 Grey SILTSTONE. Weathered to a PQ3 Sandy SILT, grey, medium to 8 14.2 coarse. 8 (Waitemata Group)
Grey mottled dark grey,
SANDSTONE. Weathered to Silty 13 13.2 (32,50/95mm) Nc = SAND fine to medium sand. SPT 50+ (Waitemata Group) Grey, SANDSTONE. 13.8-14.0m:DI. 13.2 È (Waitemata Group)
... from 14.00m to 14.3 m, Core
loss due to cor bou d. 14 HQ3 14.7-14.9m:5,DI,5°,UN,R,CL, 53 È 15.0m:1,B,ST,R,GA,IF,(Z), 15.0m:1,B,5°,PL,S,CL, 11.9 G ey, SILTSTONE. (Wa emata Group) rey, SANDSTONE. Waitemata Group) Borehole terminated a 15.50 m 15.2-15.4m:4,B,5°,UN,R,CL,C 11.7 15.5 SPT = (50/115mm) Nc = 50+ 18 19 20

Remarks:

Termination Reason: Refusal met

DCP No:

Shear Vane No: 1620

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 27/11/19

Logged by: TK

Checked by: TG

Position: 1745259.0 E, 5926130.0 N Elevation: RL 27.0m Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig Contractor: Prodrill



Sheet No. 1 of 3



MH02-19: 0m to 2.86m



MH02-19: 2.86m to 7.2m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

#### **BOREHOLE CORE PHOTOGRAPHS: MH02-19**

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 27/11/19

Logged by: TK Position: 1745259.0 E, 5926130.0 N Checked by: TG Elevation: RL 27.0m Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig Contractor: Prodrill



Elevation: RL 27.0m

Angle from Horizontal: 90°

Contractor: Prodrill

Research Angle from Horizontal: 90°

Contractor: Prodrill

Research Angle from Horizontal: 90°

Contractor: Prodrill

Research Angle from Horizontal: 90°

Contractor: Prodrill

MH02-19: 7.2m to 10.32m



MH02-19: 10.32m to 13.2m

#### **BOREHOLE CORE PHOTOGRAPHS: MH02-19**

Client: Neil Group Ltd

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 27/11/19

Logged by: TK

Checked by: TG

Position: 1745259.0 E, 5926130.0 N Elevation: RL 27.0m Hole Diameter: 100mm Angle from Horizontal: 90° Plant: Tractor Rig Contractor: Prodrill



Sheet No. 3 of 3



MH02-19: 13 2m to 15.5m

#### **TEST PIT LOG - TP01-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

2081

Remarks: Groundwater not encountered.

No:

DCP No:

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: Sheet 1 of 1

Position: 1745206.0mE; 5925974.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.0m Elevation: Elevation: 27.00m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 10 15 20 27.0 OL: TOPSO L 26.8 ML: Clayey SILT: brown, orange, grey and black. Low plasticity. Trace gravel, concrete and old drain pipe (Uncontrolled Fill) 0.5 Peak = UTP Peak = >200kPa Residual = 48kPa 1.0 26.0 CH: CLAY with some silt: light grey streaked orange. High plastici (Puketoka Formation) Peak = 224+ kPa 1.5 2.0 Peak = 192kPa Residual = 112kPa 2.5 Peak = 163kPa Residual = 74kPa 24.4 MH: C ayey SILT: light grey mott ed o High plasticity. (Puketoka Formation) 3.0 Peak = 144kPa Residual = 51kPa Test pit terminated at 3.00 m Termination Reason: Target depth reached Shear Vane

# **TEST PIT PHOTOGRAPHS: TP01-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

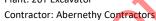
Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Logged by: JW Position: E: 1745206 N: 5925974
Checked by: TG Elevation: 27.0m

Position: E: 1745206 N: 5925974 Dimensions: 3.0m x 2.0m Elevation: 27.0m Termination Depth: 3.0m

: 3.0m x 2.0m Plant: 20T Excavator



Sheet No. 1 of 1



TP01-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP02-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745227.0mE; 5926000.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.5m Elevation: Elevation: 25.50m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 25.5 OL: TOPSO L 25.3 CH: Silty CLAY with minor topsoil: brown streaked orange and grey. Rootlets. Trace organics. Very loosely compacted. (Uncontrolled Fill) Peak = 48kPa Residual = 13kPa 0.5 Peak = 77kPa Residual = 29kPa 1.0 ... at 1.00m, perched groundwater and trace organics 1.5 Peak = 51kPa Residual = 19kPa 24.0 CH: Organic stained Silty CLAY with some organics: da k grey streaked black. Highly plasticity. (Puketoka Formation) 2 0m: yellow nova coil at the -base of test pit Peak = 83kPa 2.0 terminated at 2.00 m Residual = 29kPa

Termination Reason: Terminated early due to nova coil encountered. Shear Vane

No: 2081 DCP No: Remarks: Perched groundwater at 1.0m.

# **TEST PIT PHOTOGRAPHS: TP02-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Logged by: JW Position: E: 1745227 N: 5926000 Checked by: TG

Elevation: 25.50m

Dimensions: 3.0m x 2.5m

Termination Depth: 2.0m

Plant: 20T Excavator Contractor: Abernethy Contractors





TP02-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP03-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

2081

Remarks: No groundwater encountered.

No:

DCP No:

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: Sheet 1 of 1

Position: 1745219.0mE; 5926036.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.0m Elevation: Elevation: 25.40m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 25.4 OL: TOPSO L 25.2 CH: Silty CLAY with trace organics: orange, brown, grey and black. High plasticity. Trace pipe, trace concrete. Loosely compacted. (Uncontrolled Fill) at 0.30m, large block of concrete, 0.4m x 0.4m Peak = 72kPa Residual = 29kPa 0.5 Peak = 80kPa Residual = 32kPa 1.0 CH: CLAY with minor silt: grey streaked orange. High pla city. Tr ce rootlets and trace organics.
(Puketoka Formation) 1.5 Peak = 128kPa Residual = 61kPa at 1.90m, moist to wet М. Peak = 131kPa Residual = 64kPa 2.0 st pit terminated at 2.00 m Termination Reason: Target depth reached Shear Vane

### **TEST PIT PHOTOGRAPHS: TP03-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Logged by: JW Position: E: 1745219 N: 5926036

Checked by: TG Elevation: 25.40m

CMWGeosciences

Sheet No. 1 of 1

Plant: 20T Excavator

Contractor: Abernethy Contractors



Dimensions: 3.0m x 2.0m

Termination Depth: 2.0m

TP03-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP04-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745272.0mE; 5926032.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.0m Datum: AUCKHT 1946 Elevation: Elevation: 23.00m Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def. et Type; Dip; Defect Sh pe; R. ghne s; Aperture; Infili; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 10 15 20 23.0 OL: TOPSO L 22.8 ML: Clayey SILT with organics: dark brown. Low plasticity. (Puketoka Formation)
CH: Silty CLAY: grey mottled orange. High plasticity. Organic staining. 22.7 (Puketoka Formation) Peak = 147kPa Residual = 35kPa 0.5 Peak = 160kPa Residual = 83kPa 1.0 Peak = 176kPa Residual = 80kPa 1.2 Test pit terminated at 1.20 m 2

Termination Reason: Target depth reached Shear Vane 2081 DCP No:

Remarks: Groundwater seepage observed at 1.2m.

## **TEST PIT PHOTOGRAPHS: TP04-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Logged by: JW Position: E: 1745272 N: 5926032

Checked by: TG Elevation: 23.0m

Geosciences
Sheet No. 1 of 1

Plant: 20T Excavator

Contractor: Abernethy Contractors



Dimensions: 3.0m x 2.0m

Termination Depth: 1.2m

TP04-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP05-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

2081

No:

DCP No:

Remarks: Groundwater seepage observed at 2.6m in the topsoil.

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Checked by: TG Scale: Sheet 1 of 1 Logged by: JW

Position: 1745271.0mE; 5925996.0mN Projection: NZTM Pit Dimensions: 3.5m by 2.0m Elevation: Elevation: 21.40m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Groundwate Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 10 15 20 21.4 OL: TOPSO L 21.2 CH: Silty CLAY: orange, brown, grey and black. High plasticity. Trace pipe, concrete, gravel, cobbles, cloth and plastic. (Uncontrolled Fill) Peak = 147kPa Residual = 35kPa 0.5 Peak = >200kPa Residual = 51kPa 1.0 ... at 1.00m, well compacted ... at 1.20m, trace concrete Peak = 157kPa 1.5 at 1.50m, moist to wet with trace organics Residual = 45kPa 19.6 CH: CLAY with some silt: grey, black, o ange and brown. High p asticity. (Uncontrolled Fill) Peak = 125kPa Residual = 51kPa 2.0 2 M to W 2.5 Peak = 64kPa Residual = 42kPa 18.8 OL: B ied TOPSOIL 18.7 CH Sity CLAY with organics grey mottled orange. High plasticity. Organic St to VSt staining throughout. (Puketoka Formatio 3.0 Peak = 131kPa Residual = 48kPa Test pit terminated at 3.00 m Termination Reason: Target depth reached Shear Vane

## **TEST PIT PHOTOGRAPHS: TP05-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Position: E: 1745271 N: 5925996 Logged by: JW Checked by: TG

Elevation: 21.40m

Sheet No. 1 of 1

Plant: 20T Excavator

Contractor: Abernethy Contractors



Dimensions: 3.5m x 2.0m

Termination Depth: 3.0m

TP05-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP06-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

2081

Remarks: Groundwater not encountered.

No:

DCP No:

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: Sheet 1 of 1

Position: 1745331.0mE; 5926017.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.0m Datum: AUCKHT 1946 Elevation: Elevation: 20.00m Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 20.0 OL: TOPSO L 19.8 ML: Clayey SILT: brown. Low plasticity. With large roots (Puketoka Formation) 19.6 CH: Silty CLAY: grey mottled orange. High plasticity. (Puketoka Formation) Peak = >200kPa Residual = 51kPa 0.5 Peak = 147kPa Residual = 48kPa 1.0 19.0 CH: CLAY with minor silt: grey mottled orange. High plasticity. (Puketoka Formation) 1.5 Peak = 83kPa Residual = 32kPa Test pit terminated at 1 50 m Termination Reason: Target depth reached Shear Vane

# **TEST PIT PHOTOGRAPHS: TP06-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Position: E: 1745331 N: 5926017 Logged by: JW

Checked by: TG Elevation: 20.0m Sheet No. 1 of 1

Plant: 20T Excavator

Contractor: Abernethy Contractors



Dimensions: 3.0m x 2.0m

TP06-19 - TEST PIT EXCAVATION

#### **TEST PIT LOG - TP07-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Site Location: Whenuapai Project No.: AKL2019-0040

Date: 26/11/2019

No:

Remarks: Groundwater no encountered.

Test Pit Location: Refer to site plan Logged by: JW Checked by: TG Scale: 1:25 Sheet 1 of 1

Position: 1745289.0mE; 5925956.0mN Projection: NZTM Pit Dimensions: 3.0m by 2.5m Elevation: 18.50m Datum: AUCKHT 1946 Survey Source: Hand Held GPS Structe & Other Observations Consistency/ Relative Density Dynamic Cone Penetrometer Samples & Insitu Tests Groundwater Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/deological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit) Moisture Condition Disco ti ities: Depth; Defect Number; Def et Type; Dip; Defect Sh pe; R ghne s; Aperture; Infill; eepage Spacing; Block Size; Block Shape; Remarks Ξ (Blows/100mm) Depth 귐 Type & Results Depth 18.5 OL: TOPSO L 18.4 CH: Silty CLAY: orange, brown, grey and black. High plasticity. Trace rootlets, trace gravel, trace concrete and loosely compacted. (Uncontrolled Fill) Peak = 141kPa Residual = 19kPa 0.5 1.0 Peak = 192kPa Residual = 96kPa 17.4 OL: Buried TOPSOIL CH: CLAY with some silt: grey streaked orange. High pla t city. Tr ce rootlets, trace limonite staining. Trace organic staining. (Puketoka Formation) 1.5 Peak = 147kPa Residual = 64kPa Test pit terminated at 1 50 m Termination Reason: Target depth reached Shear Vane 2081 DCP No:

# **TEST PIT PHOTOGRAPHS: TP07-19**

Client: Neil Group Limited

Project: Trig & Brigham Creek Road

Location: Whenuapai Project No: AKL2019-0040

Date: 26/11/2019

Position: E: 1745289 N: 5925956 Logged by: JW

Checked by: TG Elevation: 18.50m Sheet No. 1 of 1

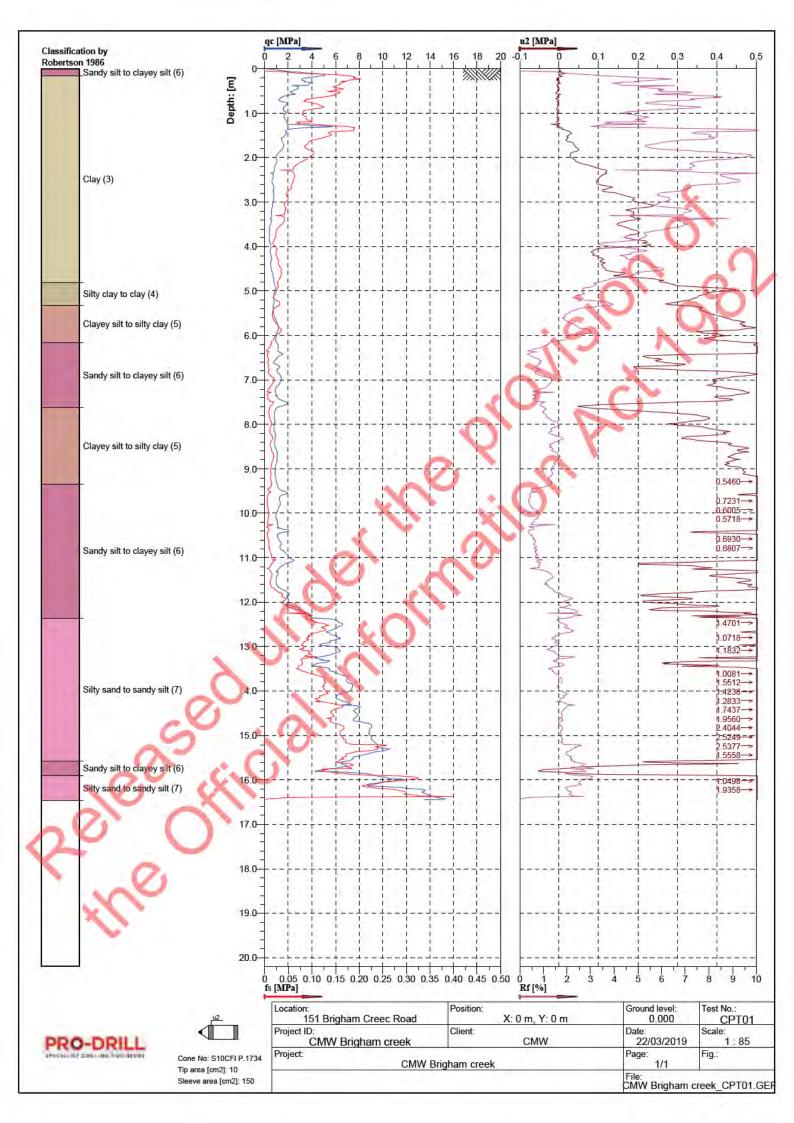
Plant: 20T Excavator

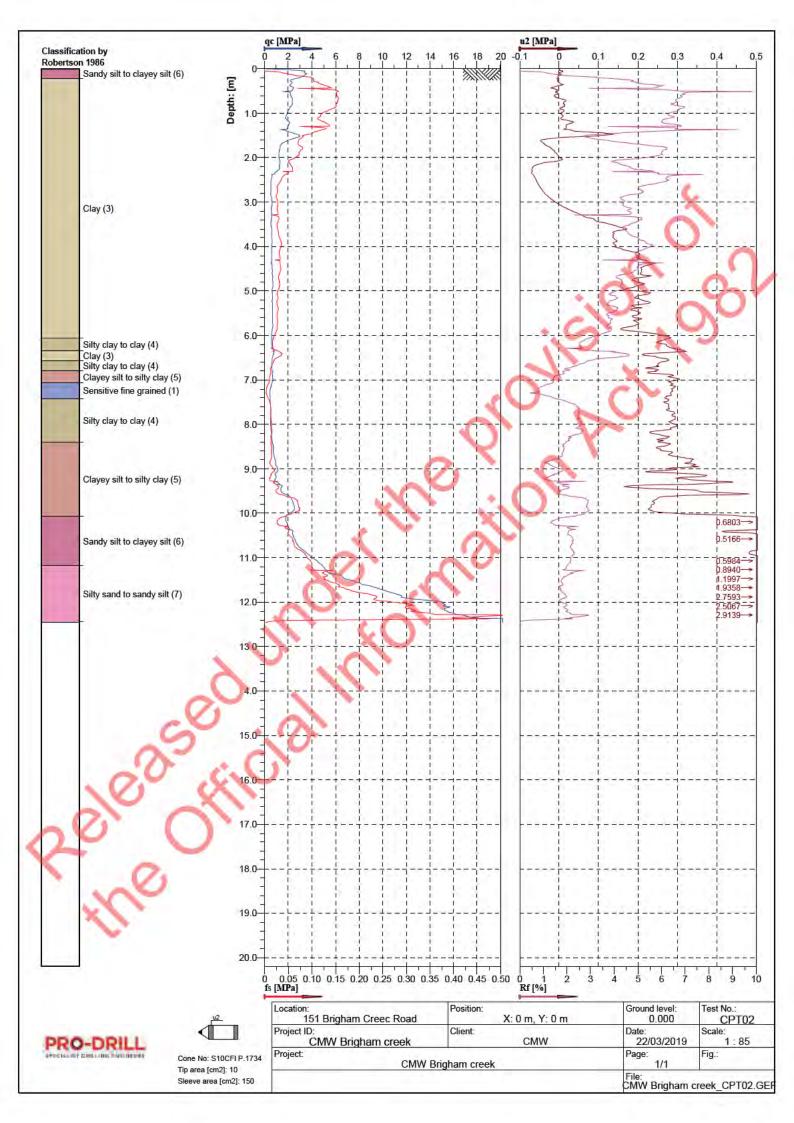
Contractor: Abernethy Contractors

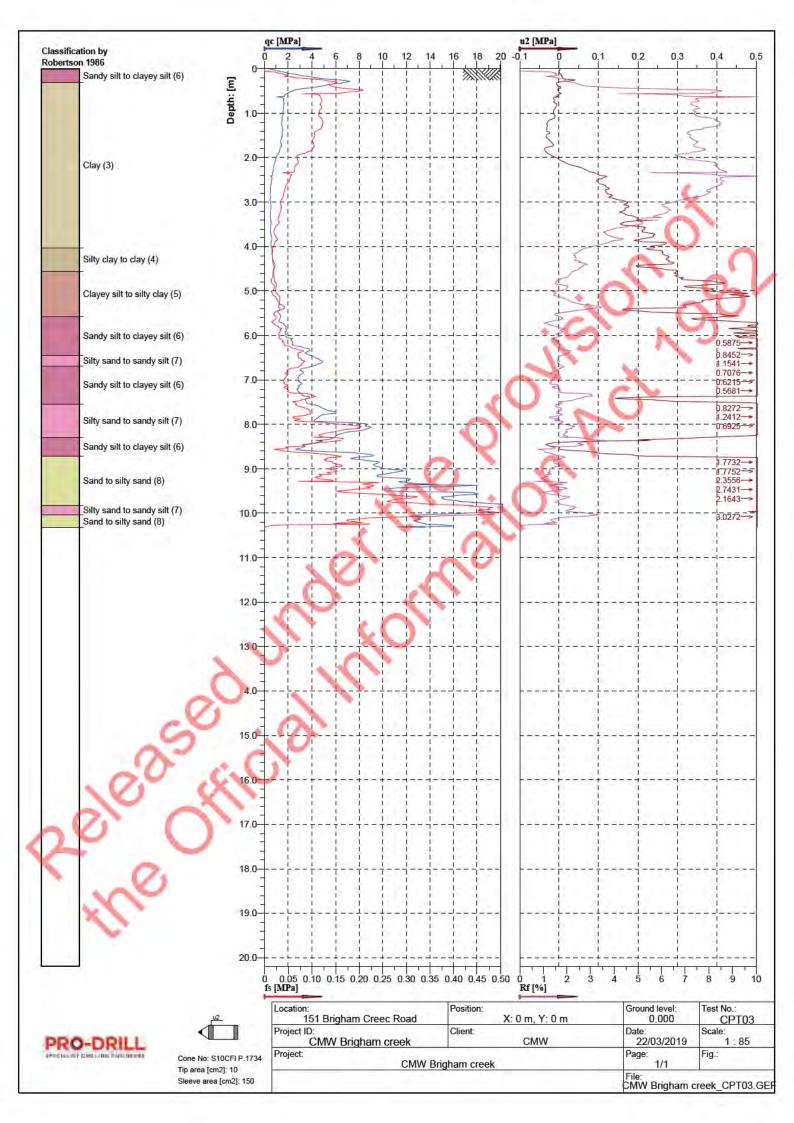


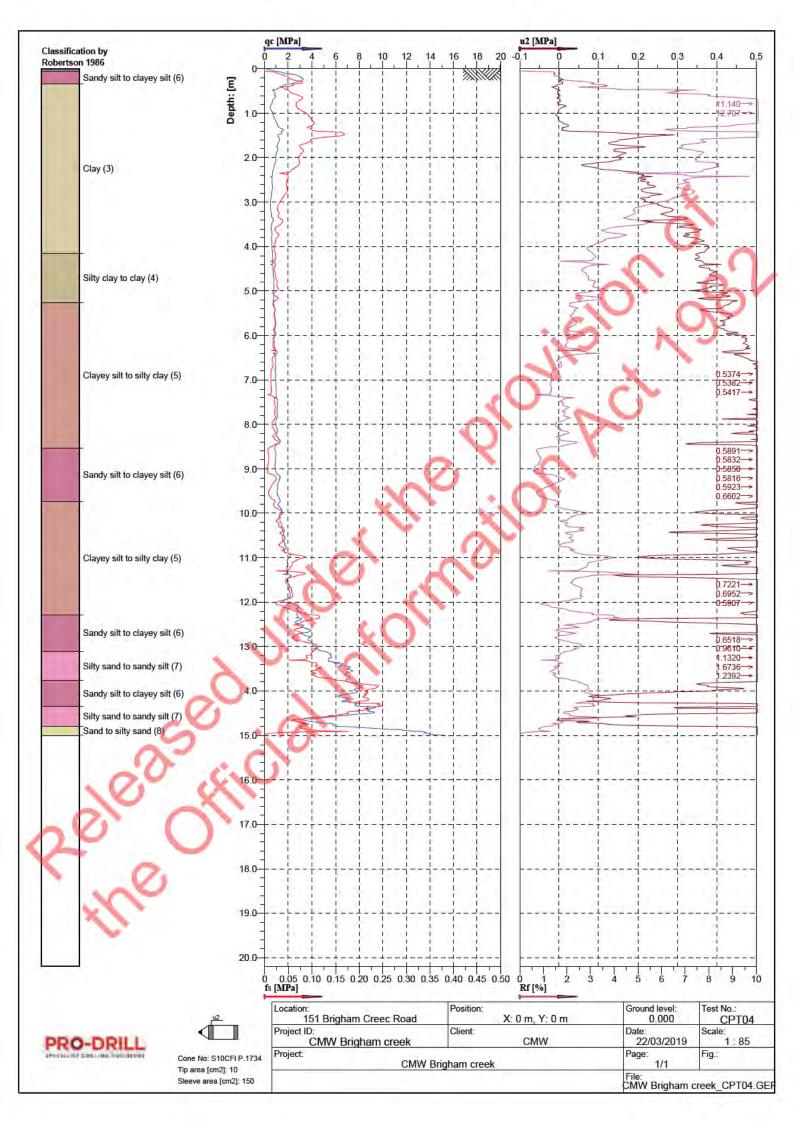
Dimensions: 3.0m x 2.0m

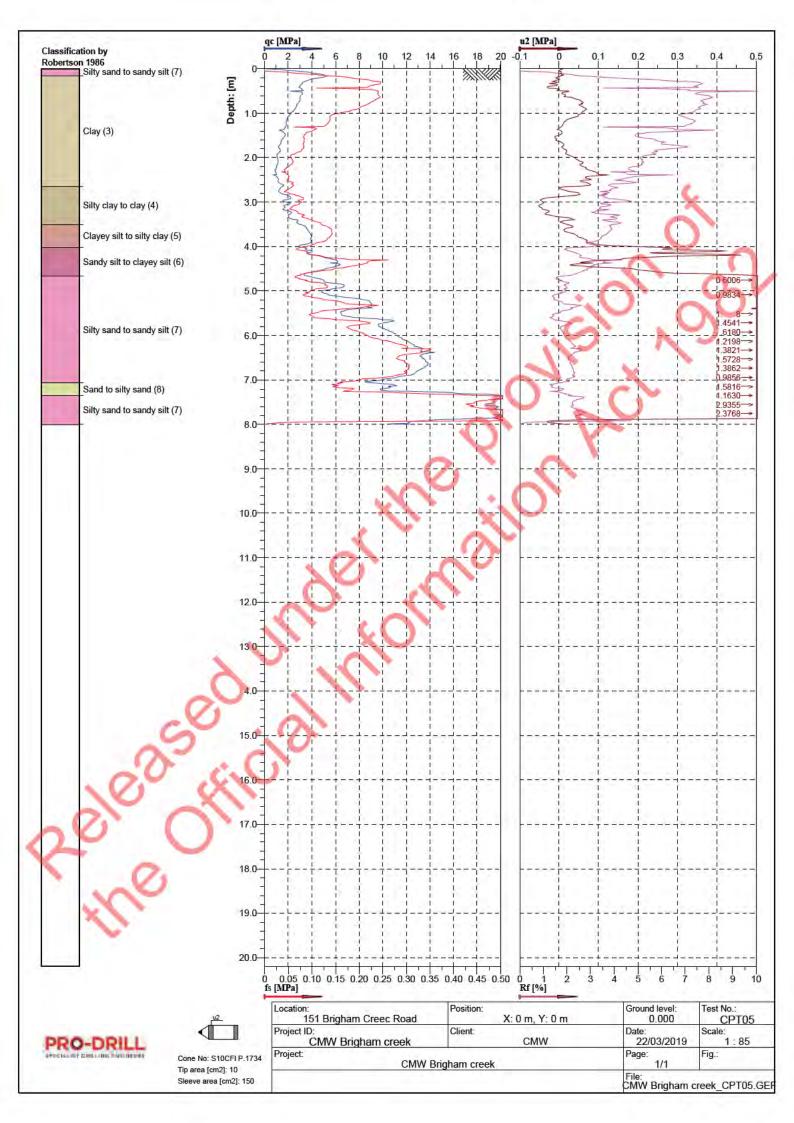
TP07-19 - TEST PIT EXCAVATION

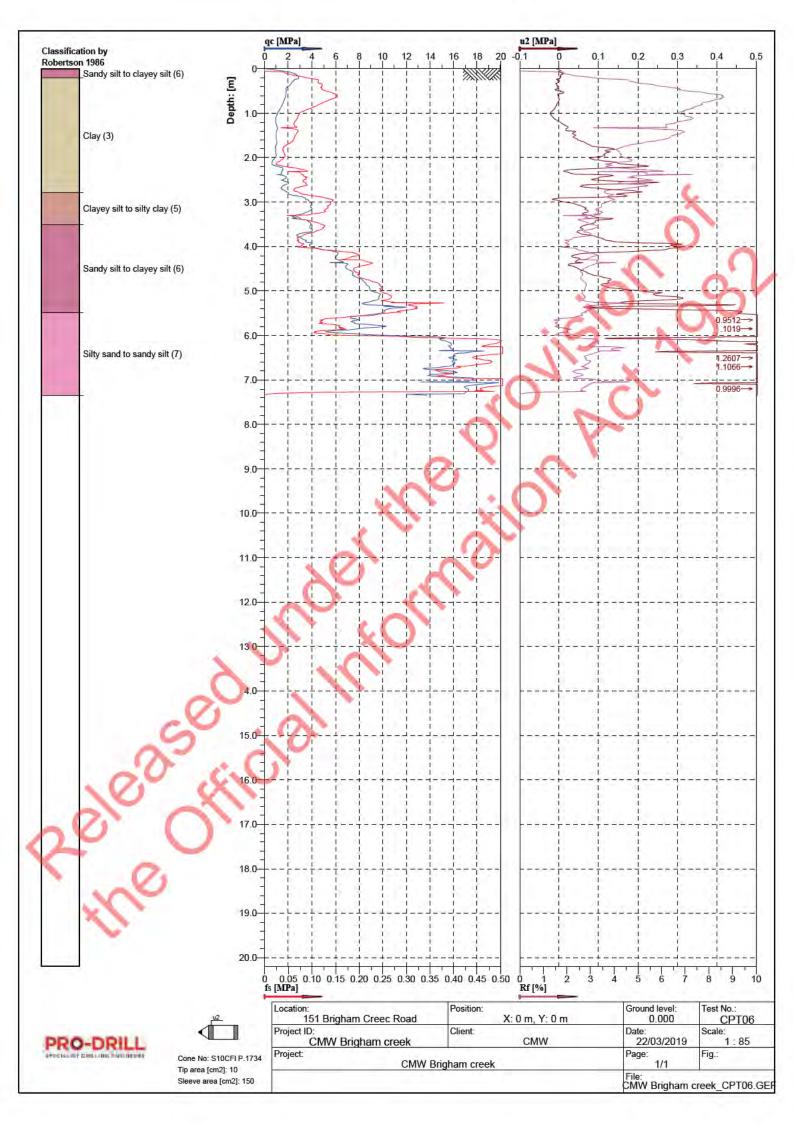


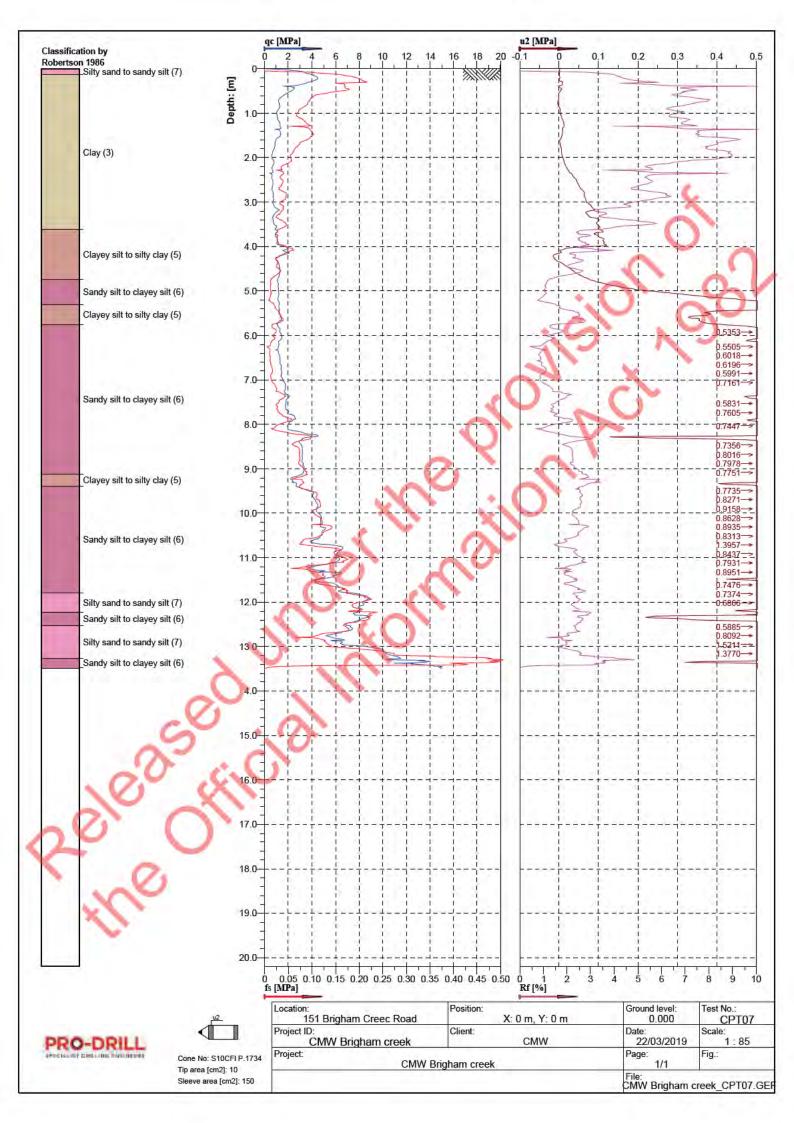












**Appendix C: Laboratory Test Results** 



# DETERMINATION OF THE WATER CONTENT, LIQUID LIMIT, PLASTIC LIMIT, PLASTICITY INDEX & LINEAR SHRINKAGE TEST METHOD NZS 4402 : 1986 TEST 2.1, 2.2, 2.3, 2.4 & 2.6

Project Name: Trig & Brigham Creek

 Project No :
 19 0382 00

 Client :
 CMW Geosciences
 Page :
 1 of 1

 Address :
 PO Box 300206
 Date of Order :
 28.11.19

Albany, Auckland 0754

Attention: Tessa Sample Method: Hand Auge
Sample Date: 26.11.19

Sampled By: CMW Geoscienc's Ltd

**Test Details:** 

Test performed on: Whole Sample

History: Natural

			Liquid	Plastic	Plastici y	Linear	Natural
Commis	Laastian	Danth	Liquid				
Sample	Location	Depth	Limit	Limit	Index	Shrinkage	Water Content
No.		(m)	LL)	(PL)	(PI)	(LS)	(%)
				×			
366J	MH01-19	2.5 to 3.0	95	28	67	-	51.8
		76					
		<b>70</b> ,					
			X X				
	X	7					
	S						
	0 81						
70							
	C.						

Commen s:

Tested By: CK Date : 29.11.19 to 06.12.19

Calculated By: CK Date: 09.12.19

Checked By: ZH Date: 09.12.19



Babbage Geotechnical Laboratory

Level 4

 68 Beach Road
 P O Box 2027

 Auckland 1010
 New Zealand

 Telephone
 64-9-367 4954

 E-mail
 wec@babbage.co.nz

Please reply to: W.E. Campton	Page 1 of 4
TESSA GALBRAITH	

# ONE DIMENSIONAL CONSOLIDATION TESTING

	ore	be.
Re: TRIG & BRIGHAM CI Report Number: 63186#L/Con	REEK ROAD (your reference nsol MH01 19 5.00 - 5.50m	AKL2019-0040)
Borehole No: MH01-19	Sample No: TUBE	<b>Depth:</b> 5.00 – 5.50m
		······································
		•••
Water Content: One Dimensiona Cor	nsolidation:	
	······································	



Job Number: 63186#L 12<sup>th</sup> December 2019 Page 2 of 4

Sample Description •not part of BGL IANZ Accreditation MH01-19 / TUBE / 5.00 - 5.50m: \*\*\* \*\* REDITED LABORATORY Signatory (Labo atory Manager) Babbage Geotechnical Laboratory **ACCREDITATION Nº: 126** 

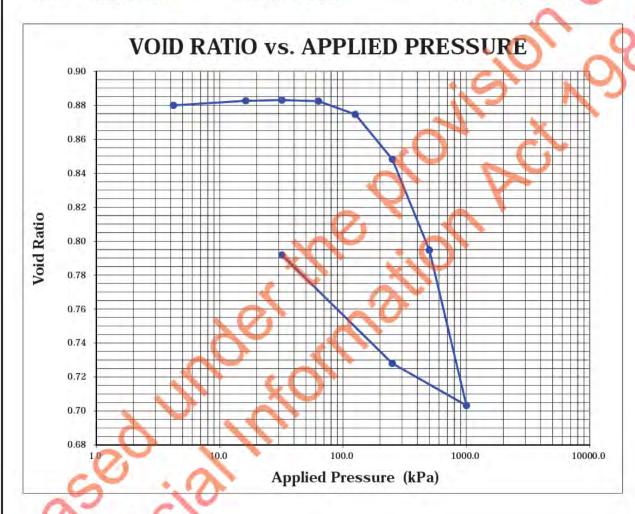


Job No:	Reg. No:	Sheet	of	Version No:	8
63186#L	2752	3	4	Issue Date:	October 2017
PROJECT:				Auth. By:	WEC

# TRIG & BRIGHAM CREEK ROAD

ONE DIMENSIONAL CONSOLIDATION	Tested By:	TH	December 2019
Test Method: NZS4402:1986:Test 2.1 - Water Content	Compiled By:	TH	11-Dec-19
Test Method: NZS4402:1986:Test 7.1 - Consolidation	Checked By:	JF	12-Dec-19

Borehole No: MH01-19 Sample No: TUBE Depth: 5.00 - 5.50m



#### SPECIMEN HISTORY

undisturbed / disturbed / remoulded / compacted / other:

Specimen from 60mm diameter push-tube

Compacted with NZ Standard Compaction effort / other compaction:

#### SPECIMEN PREPARATION

Extruded from 60mm diameter tube straight into consol ring in small increments & trimmed into consol ring. Both sides of ring then trimmed flat with a scalpel & straight edge.

#### **TEST DETAILS**

Consol machine number: 1 Surface area of top of sample: 1960  $mm^2$ Consol ring number: 1A Solid density of soil particles
Sample diameter: 49.95 mm (assumed / measured): 2.65  $t/m^3$ 



Job No:	Reg. No:	Sheet	of	Version No:	8
63186#L	2752	4	4	Issue Date:	October 2017
PROJECT:				Auth. By:	WEC

# **TRIG & BRIGHAM CREEK ROAD**

#### **ONE DIMENSIONAL CONSOLIDATION**

Test Method: NZS4402:1986:Test 2.1 - Water Content Test Method: NZS4402:1986:Test 7.1 - Consolidation

Tested By:	TH	December 2019
Compiled By:	TH	11-Dec-19
Checked By:	JF	12-Dec 19

Borehole No: MH01-19 Sample No: TUBE Depth: 5.00 - 5.50m

Applied Pressure	Incremental Deflection	Specimen Thickness	Compression Ratio	Height of Voids	Void Ratio	Coefficient of Volume Compressibility	Consolic	cien of lation - c <sub>v</sub>
kPa	mm	mm		mm	e	m <sub>v</sub>	(log time) m <sup>2</sup> /year	(sqrt time) m²/year
4.2	0.000	21.150	1.000	9.899	0.880	*,(		N.
16.3	-0.030	21.180	1.001	9.929	0.883		sample swelle	d
32.0	-0.005	21.185	1.002	9.934	0.883		sample swelle	d
63.2	0.007	21.178	1.001	9.927	0.882	0.011	13	21
125.8	0.088	21.090	0.997	9.840	0.875	0.066	6.9	12
250.9	0.297	20.794	0.983	9.543	0.848	0.11	61	7.9
501.1	0.602	20.191	0.955	8.941	0 795	0.12	4.3	5.9
1001.6	1.029	19.163	0.906	7.912	0.703	0.10	3.2	3.7
250.9	-0.278	19.441	0.919	8.190	0.728		BACKLOAD 1	I
32.0	-0.718	20.159	0.953	8.908	0.792		BACKLOAD 2	2
			_ <		\displaystart \text{\tint{\text{\tint{\text{\tint{\text{\text{\tint{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\tint{\text{\text{\text{\text{\text{\tin}\text{\text{\text{\text{\text{\text{\text{\text{\text{\tin}\text{\tin}\tin}\\\ \ti}}\\tinttet{\text{\text{\text{\text{\text{\text{\text{\tin}\tint{\text{\text{\text{\text{\text{\text{\text{\text{\text{\tin}\tint{\text{\text{\texi}\text{\text{\text{\text{\text{\texi}\tint{\text{\text{\texi}\tint{\texi}\tint{\text{\texi}\tint{\tex{\texi}\tinz}\text{\texititt{\text{\tin}\tint{\tiin}\tint{\tiin}\			

Coefficient of Second	lary Compress n - C c
Applied Pressure	C <sub>sec</sub>
sample	e swelled
sample	e swelled
63.2	0.001
125.8	0.001
250.9	0.002
501.1	0.005
1001 6	0.008
5	1.1/

Coefficient of	Permeability - k
Applied Pressure	k (m/s)
63.2	4.3E-11
125.8	1.4E-10
250.9	2.1E-10
501.1	1.6E-10
1001.6	1.0E-10

Mass of d y sp cimen (g)

Thic ness of specimen (mm)

Water Content (%)

Dry Density (t/m³)

Height of soil particles (mm)

**Void Ratio** 

Degree of saturation (%)

INITIAL	FINAL
58.42	58.42
21.150	19.163 (after consolidation)
21.130	20.159 (after rebound)
33.2	31.2
1.41	1.56
11.251	11.251
0.880	0.703 (after consolidation)
0.000	0.792 (after rebound)
100.0	-



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Page 1 of 4

Please reply to: W.E. Campton

TESSA GALBRAITH

# ONE DIMENSIONAL CONSOLIDATION TESTING

	·O.	
	CREEK ROAD (your reference Consol MH02 19 3.45 - 3.95m	e AKL2019-0040)
Borehole No: MH02-19	0	187
	20	
Water Content:		
20 00	onsolidation:	
	······································	
	· · · · · · · · · · · · · · · · · · ·	
		NO. 10. 10. 10. 10. 10. 10. 10. 10. 10. 10



Job Number: 63186#L 12<sup>th</sup> December 2019 Page 2 of 4

	O.
	01 12
	O Y
Sample Description •not part of BGL IANZ Accreditation	ion
**	
MH02-19 / TUBE / 3.45 – 3.95m: *** * * * * * * * * * * * * * * * * *	
	1 1/0
A CONTRACTOR AND A CONTRACTOR AND ADDRESS OF THE AD	
7 111.	
00 1	
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DU CO	
V	ACCREDITED LABORATORY
Signatory (Laboratory Manager)	ACCREDITATION №: 126
Babbage Geotechnical Laboratory	

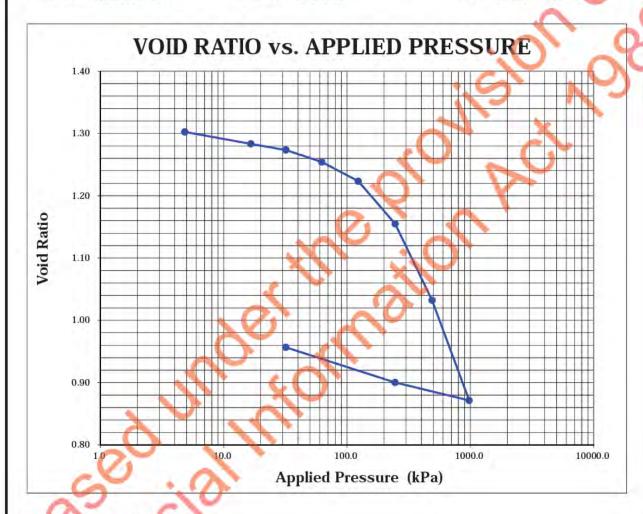


Job No:	Reg. No:	Sheet	of	Version No:	8
63186#L	2752	3	4	Issue Date:	October 2017
PROJECT:				Auth. By:	WEC

# TRIG & BRIGHAM CREEK ROAD

ONE DIMENSIONAL CONSOLIDATION	Tested By:	TH	Dec 2019
Test Method: NZS4402:1986:Test 2.1 - Water Content	Compiled By:	TH	9-Dec-19
Test Method: NZS4402:1986:Test 7.1 - Consolidation	Checked By:	JF	12-Dec-19

Borehole No: MH02-19 Sample No: TUBE Depth: 3.45 - 3.95m



#### SPECIMEN HISTORY

undisturbed / disturbed / remoulded / compacted / other:

Specimen from 60mm diameter push-tube

Compacted with NZ Standard Compaction effort / other compaction:

#### SPECIMEN PREPARATION

Extruded from 60mm diameter tube in small increments & trimmed into consol ring. Both sides of ring then trimmed flat with a scalpel & straight edge.

#### **TEST DETAILS**

Consol machine number: 2 Surface area of top of sample: 2009 mm $^2$ Consol ring number: 2B Solid density of soil particles
Sample diameter: 50.58 mm (assumed / measured):  $t/m^3$ 



Job No:	Reg. No:	Sheet	of	Version No:	8
63186#L	2752	4	4	Issue Date:	October 2017
PROJECT:				Auth. By:	WEC

# TRIG & BRIGHAM CREEK ROAD

#### ONE DIMENSIONAL CONSOLIDATION

Test Method: NZS4402:1986:Test 2.1 - Water Content
Test Method: NZS4402:1986:Test 7.1 - Consolidation

l ested By:	IH	Dec 2019
Compiled By:	TH	9-Dec-19
Checked By:	JF	12 Dec-19

Borehole No: MH02-19 Sample No: TUBE Depth: 3.45 - 3.95m

Applied Pressure	Incremental Deflection	Specimen Thickness	Compression Ratio	Height of Voids	Void Ratio	Coefficient of Volume Compressibilit		cient of dation c <sub>v</sub>
						m <sub>v</sub>	(I g time)	(sqrt time)
kPa	mm	mm		mm	е	m²/MN	m²/year	m²/year
4.8	0.000	19.890	1.000	11.252	1.303			
16.6	0.166	19.724	0.992	11.086	1.283		seating cycle	9
31.9	0.086	19.638	0.987	11.000	1.273	0.28	24	22
62.4	0.165	19.473	0.979	10.835	1 254	0.28	25	30
123.4	0.267	19.206	0.966	10.568	.223	0.22	29	29
245.4	0.590	18.616	0.936	9.978	1.155	0.25	26	28
489.5	1.061	17.555	0.883	8.917	1.032	0 23	24	27
977.5	1.388	16.167	0.813	7.529	0.872	0.16	16	24
245.4	-0.249	16.416	0.825	7.777	0.900		BACKLOAD	1
31.9	-0.487	16.903	0.850	8.265	0 957		BACKLOAD	2

Coefficient of Secondary Compression - C <sub>sec</sub>				
Applied Pressure	C <sub>sec</sub>			
of the Coefficient of Secon	s did not allow determination ndary Compression (Csec nese cyc es.			
123.4	0.001			
245.4	0.002			
489.5	0.004			
977.5	0 003			

Coefficient of Permeability - k				
Applied Pressure	k (m/s)			
31.9	2.1E-09			
62.4	2.2E-09			
123.4	2.0E-09			
245.4	2.0E-09			
489.5	1.7E-09			
977.5	8.1E-10			

Mass of dry specimen (g)
Thickne s of specimen (mm)
Water Content (%)
Dry Density (t/m³)

Dry Density (t/m³)
Height of soil particles (mm)
Void Ratio
Degree of saturation (%)

FINAL
46.00
16.167 (after consolidation)
16.903 (after rebound)
37.6
1.42
8.638
0.872 (after consolidation)
0.957 (after rebound)
-

**Appendix D: Natural Hazards Risk Assessment** 



# NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION AT TRIG & BRIGHAM CREEK ROAD

#### A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land, other land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference AKL2019-0040AD Rev.0 sets out the criteria fir and presents the results of an assessment of the geotechnical-related natural hazards associated with this proposed subdivision development. The remaining hazards, i.e. tsunami, wind, drought, fire and flooding hazards are not covered by this assessment.

#### **B. BASIS OF ASSESSMENT**

#### **B1. Risk Classification**

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1

Table B1: Natural Hazard Risk Classification									
11, 60									
	7	Consequence							
	-6	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5			
Likelihood	Almost Certain 5	Med um 5	High 10	Very high 15	Extreme 20	Extreme 25			
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20			
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15			
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10			
2	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5			

#### **B2.** Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions						
1	Rare	The natural hazard is not expected to occur during the design life of the project				
2	Unlikely	The natural hazard is unlikely, but may occur during the design life				
3	Moderate	The natural hazard will probably occur at some time during the life of the project				
4	Likely	The natural hazard is expected to occur during the design life of the project				
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project				

#### **B3.** Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions					
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic ef ect to landowners			
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance n p ople at risk, very minor economic effect.			
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.			
4	Major	Significant damage to land requiring immediate repair, damage to build ngs beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.			
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect or possible site abandonment.			

#### **B4. Risk Acceptance**

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

CMW Geosciences Ref. AKL2019-0040AE Rev.0 Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

## C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development and adjacent, potentially affected land have been assessed with respect to the criteria outlined above.

Assessment is based on proposed post development ground conditions with and without any geotechnical controls. The latent risk was first assessed with the site in its proposed developed stat to consider the risks to the development and surrounding land, including assessment of land modifications from the pre-existing natural state, without any implemented geo ech ical controls. The specific geotechnical mitigation measures and engineering design solutions, utlined in the table below and CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed controls have been implemented.

Results of this assessment are presented in Table C1 below

	Table C	1: Nat	tural H	azard Risk	Assessment Results			
RMA S2 Hazard	Description	Proposed Site Latent Risk of Damage to Land / Structures		Risk of to Land /	Commen s and Geotechnical Control	Proposed Site Residual Risk of Damage to Land / Structures OR Acceleration/ Worsening of Hazard with Geotechnical Controls Implemented		
00	S.C.C.	Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	1	4	Low 4	Low proximity to active faults	1	4	Low 4
Ne	Liquefaction Induced Flooding and/ or Subsidence	2	4	Medium 8	Depth of cover / mainly clay soils based on existing information	2	4	Medium 8
	Lateral Spread	2	4	Medium 8	Depth of cover / mainly clay soils based on existing information	2	4	Medium 8

Volcanic Activity	Ash & Pyroclastic Falls	1	5	Medium 5	Low proximity to active volcanoes	1	5	Medium 5
	Lava flows & Lahars	1	5	Medium 5	Low proximity to active volcanoes	1	5	Medium 5
Geothermal Activity	Formation of geysers, hot springs, fumaroles, mud pools	1	5	Medium 5	Low proximity to active geothermal areas	1	5	Medium 5
Erosion	Cut Batters	4	3	High 12	Max 1:3 gradient / surface water control / benches	2	3	Medium 6
	Fill Batters	4	3	High 12	Max 1:3 gradient / surfa e water control / bench s	2	3	Medium 6
Landslip	Global Slope Instability	4	4	Very High 16	Slope gradient / drainage / ret ining walls	2	4	Medium 8
	Soil Creep	3	(2)	High 12	Foundation design / footing depth / slope regrading	2	4	Medium 8
	Bearing Capacity Failure	2	4	Medium 8	Undercut and replace / fill embankment gradient	2	4	Medium 8
C	Cut & Fill Bat er Instability	2	4	Medium 8	Surface water controls, regrading	1	4	Low 4
Subsid nce	Expansive soils	5	4	Extreme 20	Foundation design for highly expansive soils	5	1	Medium 5
3, (	Sinkholes	1	4	Low 4	Unlikely in existing geology	1	4	Low 4
No	Soft Soils	2	4	Medium 8	Undercut and remove / pre-load / ground improvement / pile	1	4	Low 4
Sedimentation	Rockfall, debris inundation	2	4	Medium 8	Regrade slope / earthworks	1	4	Low 4

# Notes:

- Assessments include the impact of the proposed subdivision works on adjacent properties.
- The following reference(s) contain information on the hazards contained in this assessment and the non-geotechnical hazards that have not been included:
  - Auckland
     https://aucklandcouncil.maps.arcgis.com/apps/MapSeries/index.html?appid=81aa3de1

     3b114be9b529018ee3c649c8

CMW Geosciences Ref. AKL2019-0040AE Rev.0 **Appendix E: Stability Analyses Results** 

Project Trig & Brigham Creek Road

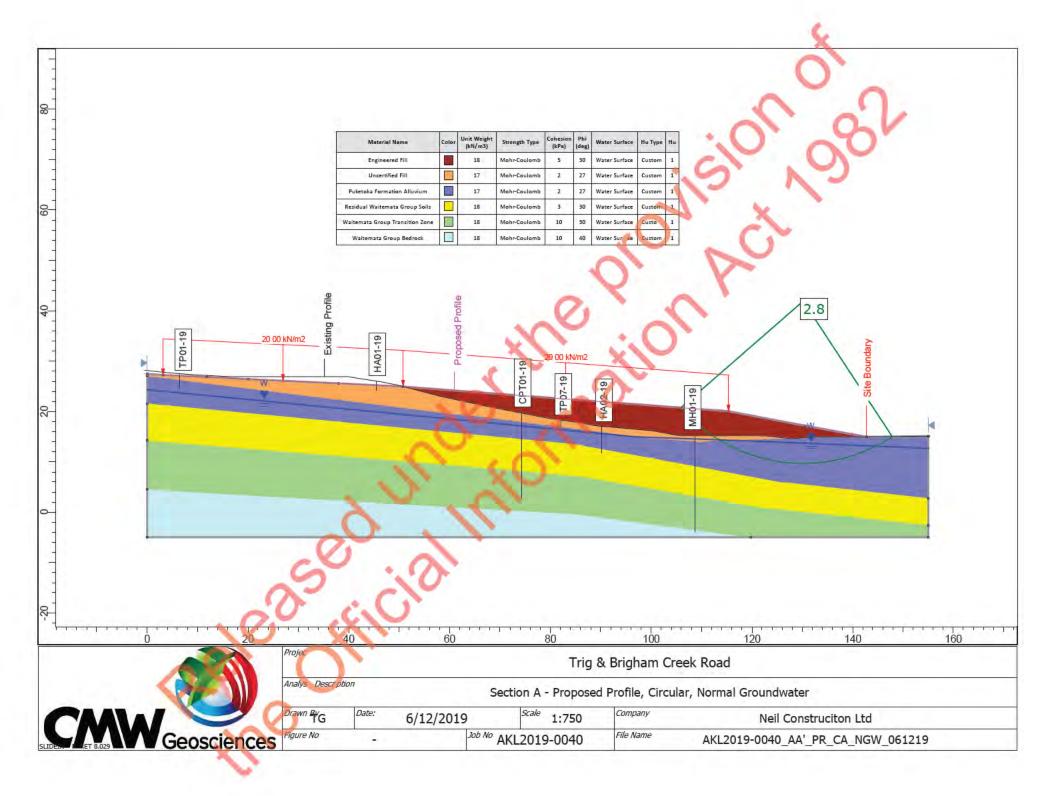
 Job No.
 AKL2019-0040

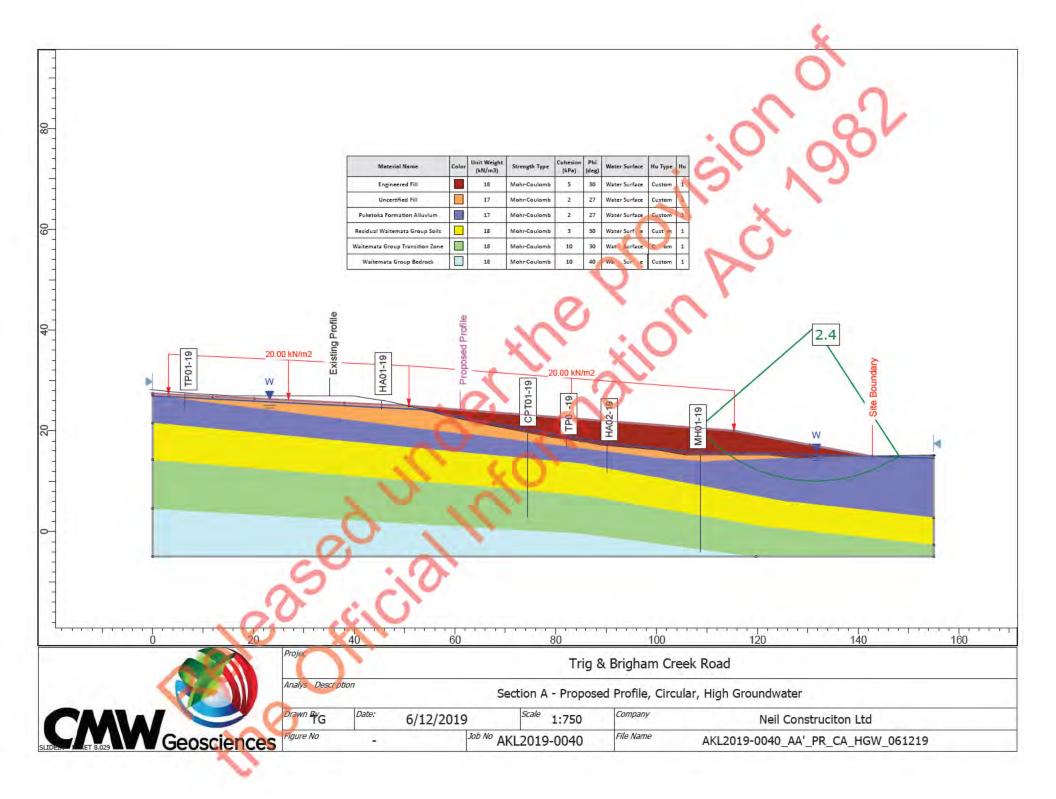
 Date
 6/12/2019

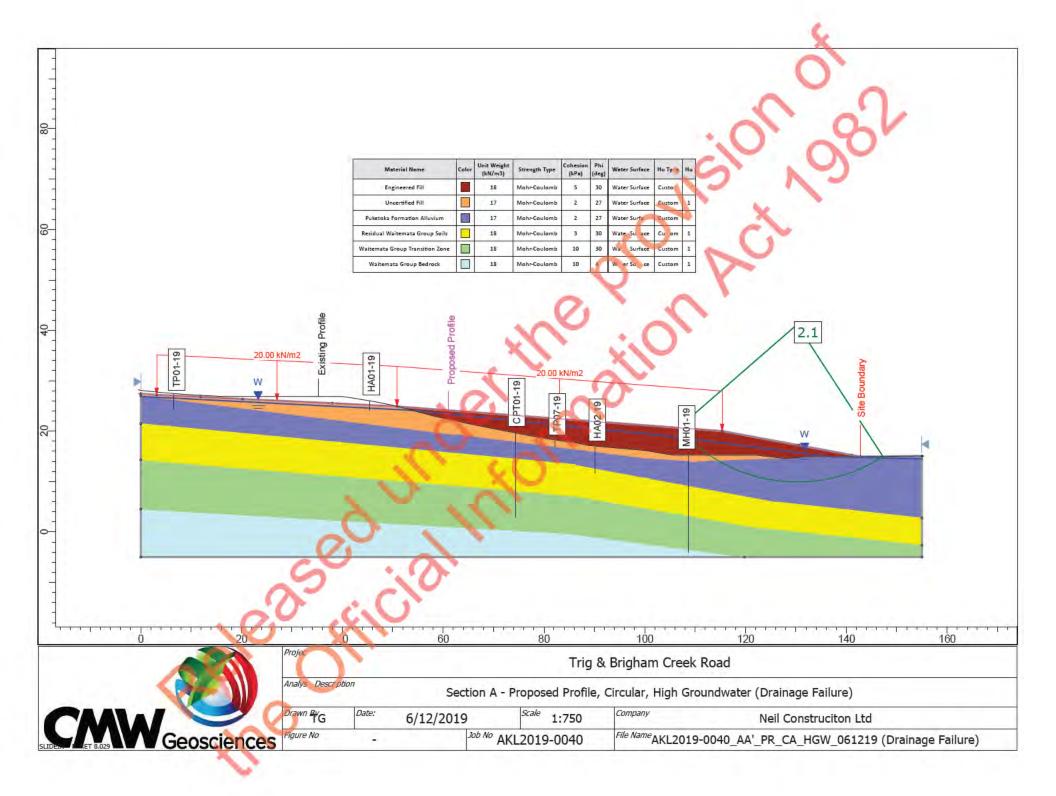
 By
 TG

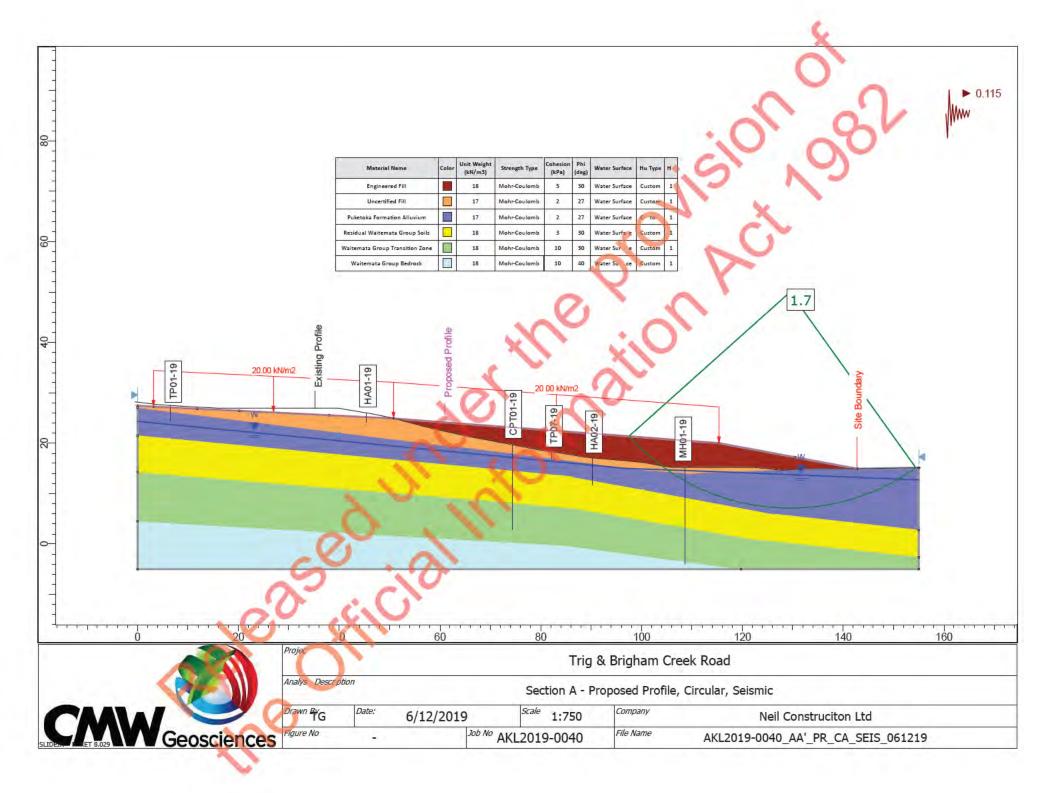
\* seismic peak ground acceleration at 0.115g

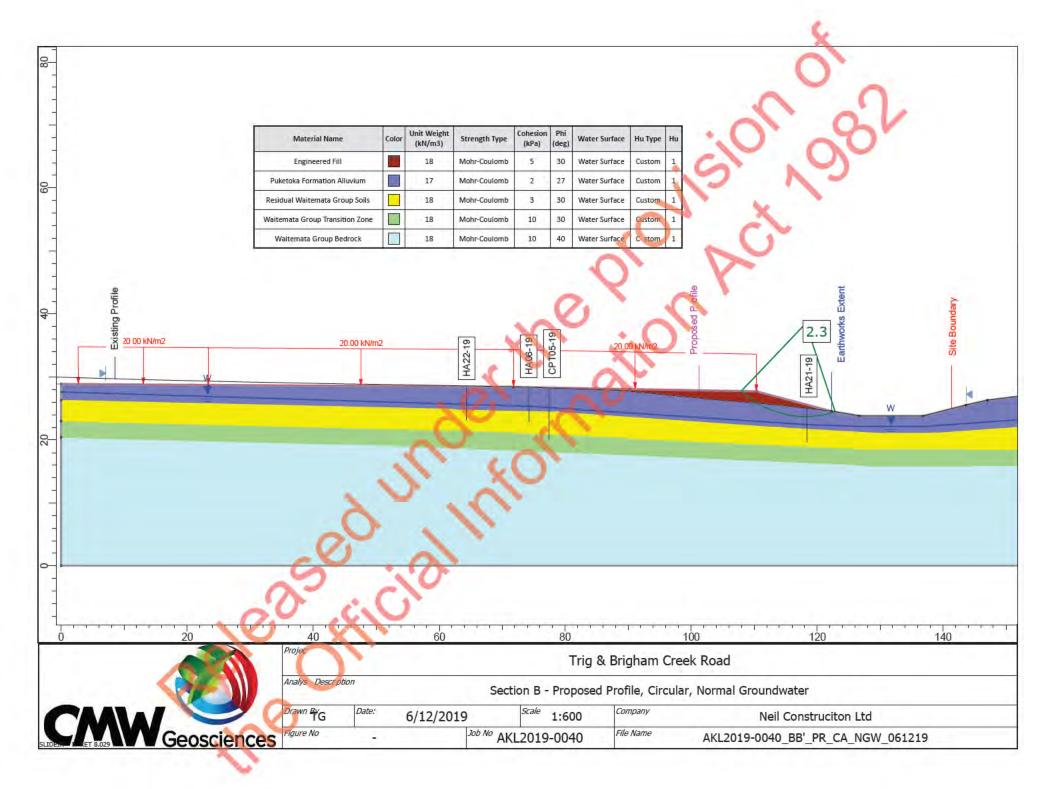
Section	Case	Failure Mode	Min. FS	Acceptance Comments
A	Existing Contour - Normal ground water table	Circular	2.6	у
	Existing Contour - Highly saturated (GW @ 0.5m)	Circular	1.5	y
	Existing Contour - Seismic, Normal GWT	Circular	1.7	y
	Proposed Contour - Normal ground water table	Circular	2.8	v
	,	Circular		У
	Proposed Contour - Highly saturated	Circular	2.4	У
	Proposed Contour - Highly saturated (Drainage Failure)	Circular	2.1	У
	Proposed Contour - Seismic, Normal GWT	Circular	1.7	У
В	Existing Contour - Normal ground water table	Circular	5.0	У
	Existing Contour - Highly saturated (GW @ 0.5m)	Circular	3.0	у
	Existing Contour - Seismic, Normal GWT	Circular	2.4	У
	Proposed Contour - Normal ground water table	Circular	2.3	+ 60
	Proposed Contour - Highly saturated	Circular	1.6	
	Proposed Contour - Highly saturated (Drainage Failure)	Circular	1.4	y
	Proposed Contour - Seismic, Normal GWT	Circular	1.7	V
С	Existing Contour - Normal ground water table	Circular	4.8	У
	Existing Contour - Highly saturated (GW @ 0.5m)	Circular	3	У
	Existing Contour - Seismic, Normal GWT	Circular	2.3	y
	Proposed Contour - Normal ground water table	Circular	2.3	У
	Proposed Contour - Highly saturated	Circular	1.7	y
	Proposed Contour - Highly saturated (Drainage Failure)	Circular	1.5	
	Proposed Contour - Seismic, Normal GWT	Circular	1.6	у
D	Existing Contour - Normal ground water table	Circular	.1	У
	Existing Contour - Highly saturated (GW @ 0.5m)	Circula	1.9	У
	Existing Contour - Seismic, Normal GWT	Circular	2.0	У
	Proposed Contour - Normal ground water table	Circular	1.8	у
	Proposed Contour - Highly saturated	Circular	1.4	У
	Proposed Contour - Highly saturated (Drainage Failure)	Circular	1.3	У
	Proposed Contour - Seismic, Normal GWT	Circular	1.4	У
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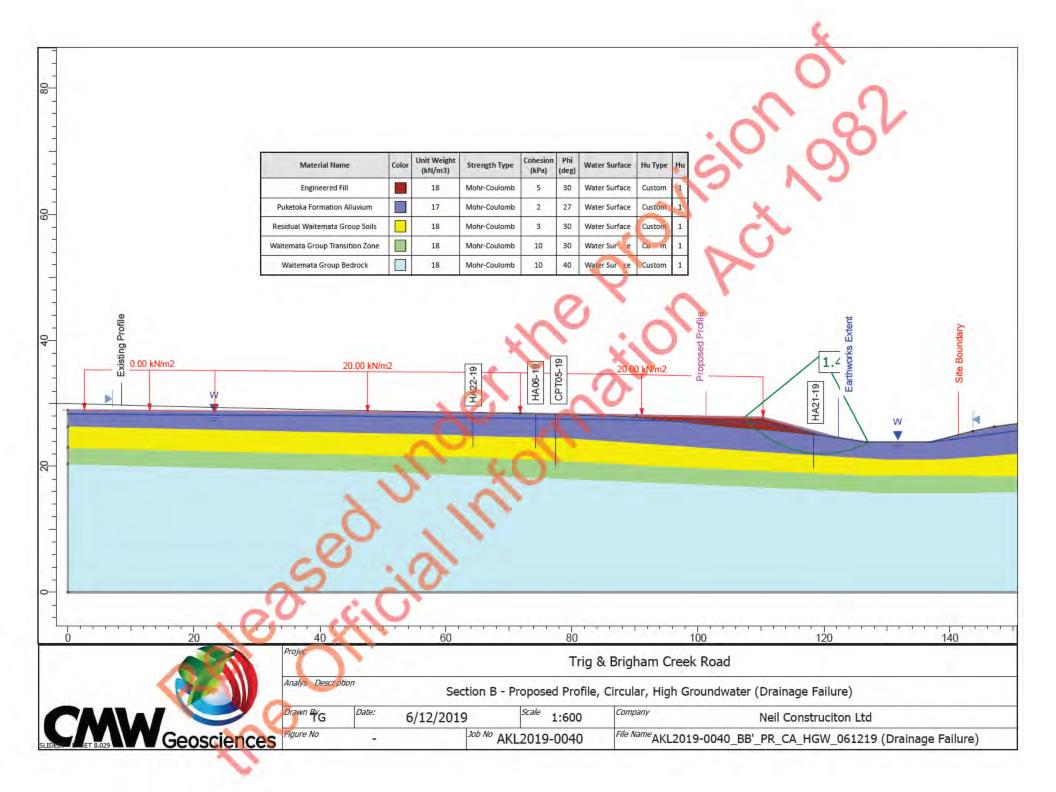


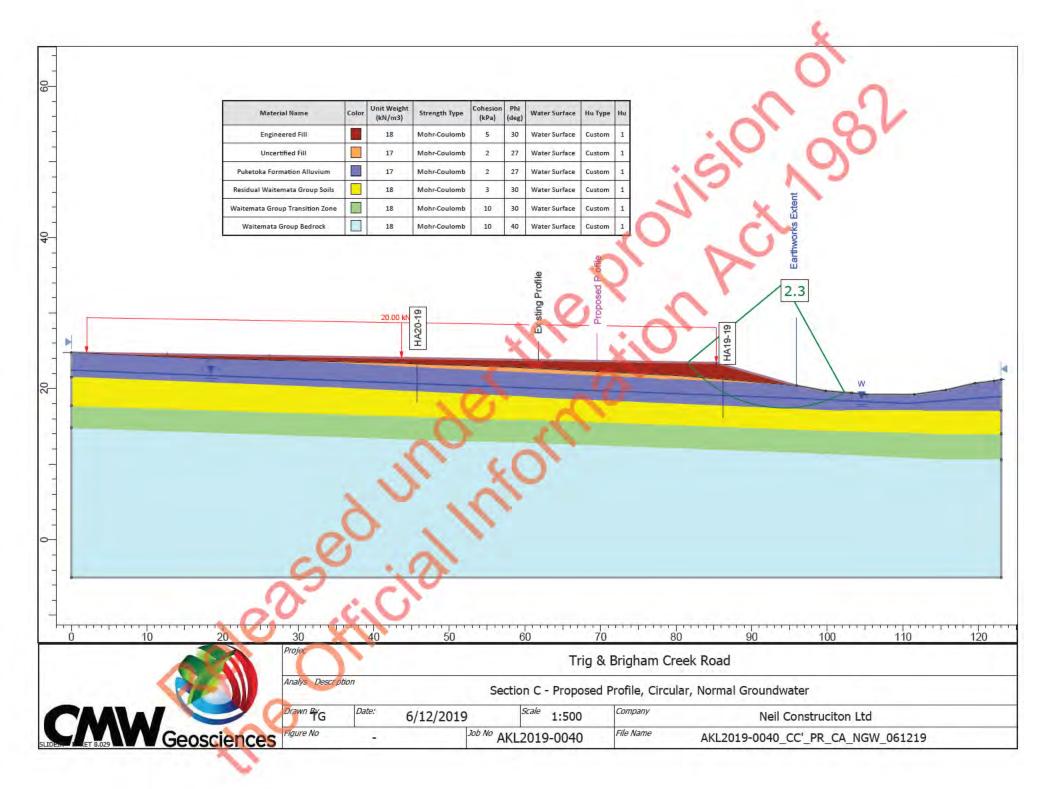


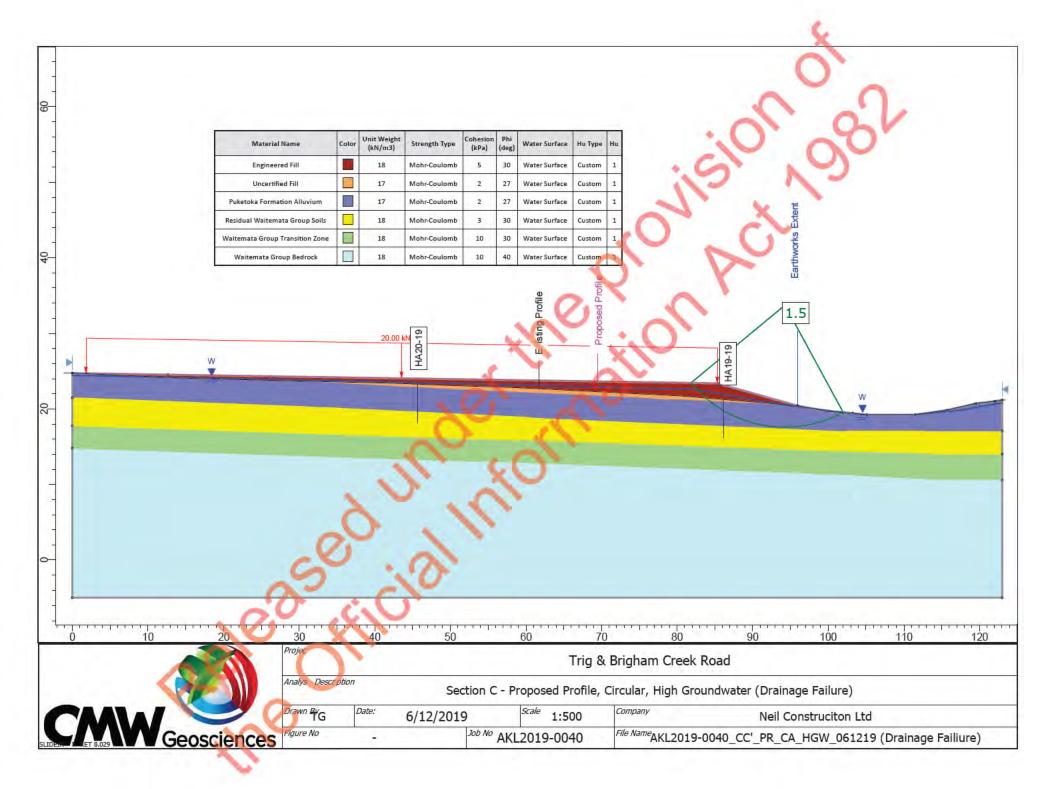


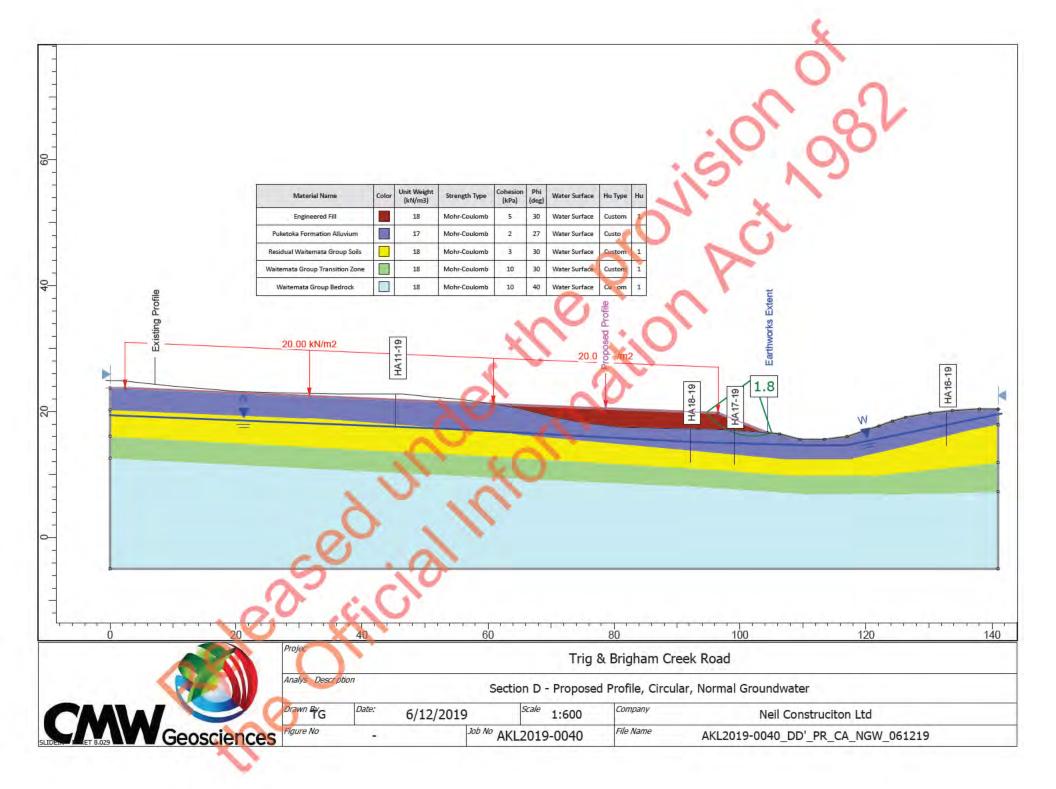


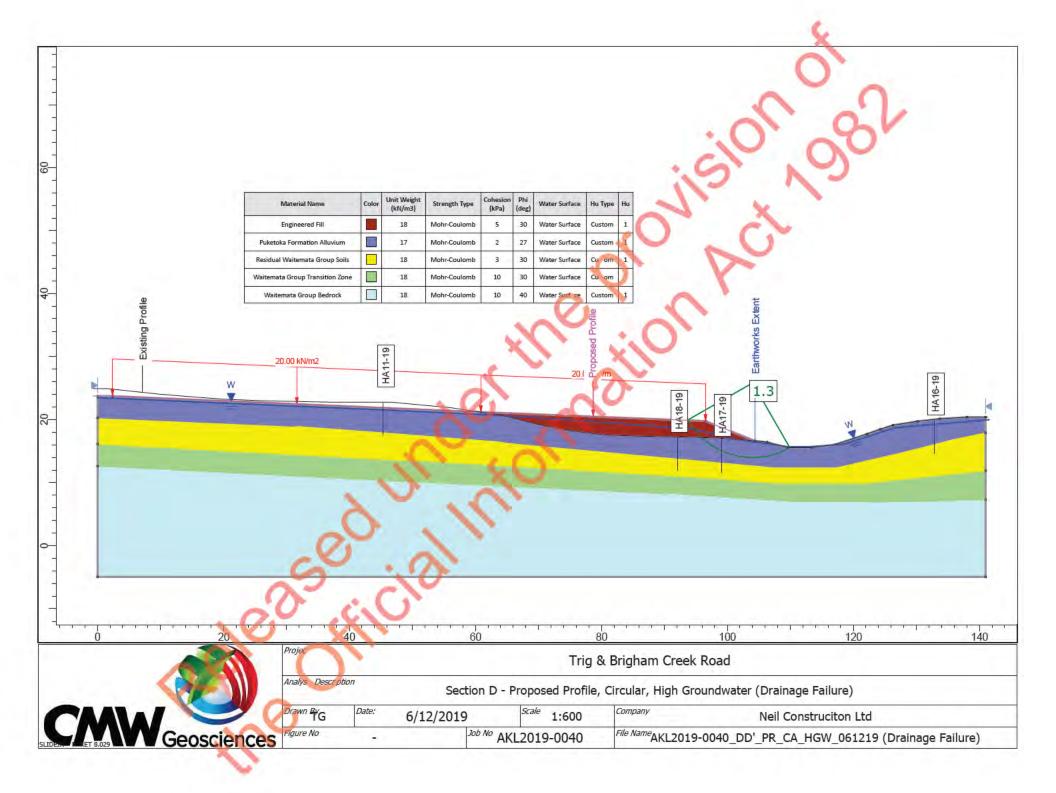












**Appendix F: Geotechnical Works Specification** 



15 January 2020

Document Ref: AKL2019-0040AF Rev 0

# Land Development Geotechnical Works Specification For: Trig & Brigham Creek Road

## 1 INTRODUCTION AND SCOPE

This specification covers the geotechnical remediation works a d associated earthworks outlined in the CMW Investigation Report (GIR), referenced AKL2019-0040AD Rev.0. It suppleme to the information provided on the design drawings and GIR. It provides detail on the required specification for:

- Site clearance and preparation including topsoil stripping and stockping;
- Subsoil drainage installation;
- Cut to fill earthworks operations;
- Fill materials and testing requirements;
- · Earthworks finishing and respread of topsoil; and,
- As-built records.

Excluded from the scope are geotextile reinforc d slopes with a face steeper than 30 degrees or retaining structures covered by a building consent. Such works will be carried out in accordance with an independent structure specific specification.

Unless varied onsite by the Geotechnical E gineer, the following specification requirements must be met in order for CMW Ge sciences (CMW) to provide a Geotechnical Completion Report for the works.

# 2 RELEVANT DOCUMENTS

# 2.1 Standards, Guidelines and Consents

The works shall comply with the relevant sections of the following standards, guidelines and consents:

- 1 Health and Safety at Work Act 2015 and Regulations 2016;
- 2. All Project Resource Consent Conditions and Engineering Works Approvals;
- 3. The applicable Council Infrastructure Design Standard;
- 4. The Auckland Council, Erosion and Sediment Control Guidelines Guidance document 2016/005;
- 5. NZS 4431:1989 Code of Practice for Earth Fill for Residential Development;
- 6. NZS 4402: 1986 Methods of Testing Soils for Civil Engineering Purposes; and,

7. NZS 4404: 2010 Code of Practice for Urban Land Subdivision.

# 2.2 Geotechnical Investigation and Design Report

Details of the geotechnical investigation, soil and rock conditions encountered, and the design of the geotechnical remedial works are contained in the CMW report AKL2019-0040AD Rev.0. The contractor should be aware of the contents and recommendations contained in that report.

The works shall comply with the recommendations contained in that report.

# 2.3 Construction Drawings

The works shall comply with the Neil Construction Limited plans referenced Brigham Creek Whenuap i, drawings 447-01-BE-200, 447-01-BE-201, 447-01-GE-200 and 447-01-GE-300

# 2.4 Conflicting Information

Where there is any conflict or discrepancy in the requirements of this specification and the documents listed above the matter shall be referred to the Geotechnical Engineer (CMW) for carification.

# 3 GEOTECHNICAL OBSERVATION REQUIREMENTS

The following items form hold points in the construction works that require observation, testing and approval by the Geotechnical Engineer (CMW):

- 1. Foundations for filling once topsoil and unsuitable materials, or existing uncertified fills, have been stripped prior to fill placement;
- 2. Shear key excavations and undercuts to confirm depth and extents prior to backfilling;
- 3. Subsoil drain excavations prior to placement of aggregate;
- 4. Any imported soil fill materials pr or to placement on site;
- 5. Drainage aggregate quality prior to placement;
- 6. Geotextile layers once in place and prio to ackfilling;
- 7. Filling placed at r gular intervals to comply with the fill test frequency requirements below;
- 8. Compaction f ba kfilling in critical service trenches;
- 9. Flushing of the subsoil drainage system at the completion of earthworks;
- 10. Any unforeseen ground conditions that may impact on the construction works or future land use; and,
- 11. nstallation of any ettlement monitoring plates or points, application of pre-load and approval prior to its removal.

It is the contractor's responsibility to ensure that the Geotechnical Engineer is given reasonable notice and opportunity to observe the above works and that the works do not proceed until approval has been gained from the Geotechnical Engineer.

24 hours is considered reasonable notice.

# 4 CONSTRUCTION SPECIFICATION

# 4.1 Site Preparation

The Contractor shall remove all vegetation from the site of the earthworks except for trees indicated for preservation either by marking on the site or noted on the drawings, and clear the remainder of the site.

Clearing shall mean the felling of all trees, except those indicated, removal of all growth other than grass and weeds, extraction of tree stumps, demolition of fences and other minor items remaining in the way of site stripping, and the complete disposal of all items. Stumping shall mean the removal of all roots greater than 25mm in diameter.

Cleared areas shall be stripped to remove all turf and organic topsoil to depths designated by the Engineer ahead of or during the stripping operations. Stripping shall also cover picking up any old topsoil stockpiles and any buried topsoil detected during the course of the works. The depth shall be sufficient to remove all materials considered unsuitable as fill or unsuitable to remain beneath fill but will not necessarily extend to the full limit of organic penetration.

## 4.2 Erosion and Sediment Control

The works shall be carried out in accordance with the project Erosion and Sediment Control Management Plan and associated drawings.

The contractor shall ensure good control of surface water runoff at all t mes by shaping of the surface in cut and fill areas to prevent ponding during rainfall events.

The location of temporary Sediment Retention Ponds (SRP) on sloping ground shall be decided upon with input from the Geotechnical Engineer. Where comment of SRP stability is sought by Council then all fill materials used to form batters, must be placed as enginee ed fill and tested accordingly unless advised otherwise by the Geotechnical Engineer.

When decommissioning temporary sediment pones, all water softened material in the bases and sides of the ponds shall be removed and undercut to the satisfaction of the Geotechnical Engineer. Backfilling of temporary ponds shall be to the compaction standard for general filling unless otherwise specified.

# 4.3 Stockpiles

Topsoil stockpiles can add significant driving force for slope instability when placed at or near the crest of a slope. The location of all temporary stockpiles me stable approved by the Geotechnical Engineer prior to placement. Where stockpiles cannot be avoided above sloping ground they should be placed over a wide area with the height restricted under the direction of the Geotechnical Engineer.

# 4.4 Fill Foundations and Benching of Slopes

The foundation on which filling is to be placed must be observed by the Geotechnical Engineer following clearing and prior to the placement of any filling to confirm the strength of the underlying soils is sufficient.

Where it is found, after clearing and stripping operations as specified, that the foundation on which filling is to be placed is unstable, or in cuttings if it is found after the excavation has been cut down to the levels shown in the drawing that unstable ground is encountered, then the Engineer may direct that the soft, yielding or unstable mat rials causing such instability shall be removed to such depth as directed.

B inching of slopes prior to the placement and compaction of filling should be carried out in accordance with the normal requirements of NZS 4431 and related documents as mentioned above, especially on the steeper areas of the site, to ensure that the filling placed is keyed into the underlying natural ground. This would involve the cutting of benches approximately the width of a bulldozer, with a slight reverse gradient back into the slope. The optimum depth of each bench is best confirmed by careful Engineering inspections during construction.

# 4.5 Temporary Batters and Excavation Stability

The temporary stability of the works is the responsibility of the main contractor.

Slope instability during construction is a significant risk where earthworks may cause changes to slope geometry or groundwater conditions.

The causes of instability during earthworks may include:

- Removal of toe support due to excavation;
- · Over steepening of slope angles in temporary batters;
- Geological defects in the soil or rock mass, particularly where these are exposed in excavation aces;
- Elevated groundwater levels following rainfall, perched groundwater or rapid recharge due to the reduced distance to an impermeable layer (i.e. undisturbed rock) due to cut operations; and,
- Additional loading upslope of excavations. ie. construction equipment or stockpiles.

To help mitigate these risks the contractor should consider:

- Staging excavations which reduce support to slopes or create temporarily over steepened slopes, to
  ensure large areas are not left unsupported. The allowable length of excavation to have open at any
  one time will vary and is dependent on a number of factors such as, local ground conditions,
  groundwater, length of time the excavation will be open, weather depth of excavation, geological
  defects present and the earthworks equipment and methodology used;
- Ceasing works in excavations during rainfall and assessing stability of excavations following rainfall events prior to resuming work;
- · Benching or battering back of excavation faces;
- Ensuring good control of surface water runoff above excavations and batters;
- Covering steep batters with impermeable covers where they may be left without support for any significant period of time;
- Avoiding loading the crests of slopes and excavations (including loading with working plant);
- Putting in place comprehensive risk identification and management procedures and work methodologies for temporary excavat on stability;
- Carrying out regular inspections of the areas upslope of excavations and the excavation slope to look for signs of instability such as ground displacement and the development or propagation of cracks; and,
- Seeking advice from t e Geotechnica Engineer where there is doubt as to the stability of a slope or excavation.

# 4.6 Fill Materials and Conditioning

# 4.6.1 Soil Fill, Rock Fill or Soil and Rock Mixed Fill

Site won materials used as engineered filling shall be free of topsoil, organic matter, rubbish and other unsuitable materials. The maximum particle size for soil and rock blended fill shall be 200mm and mixing and/or crushing shall be carried out in a manner that ensures that significant voids are not present in the filling between rock fragments.

For rock fill without soil blending, crushing is to occur to comply with the requirements for blended fills and needs to ensure that uniform compaction can occur without significant voids between particles in the absence of the soil fill.

#### 4.62 Blending of Unsuitables

The blending of 'unsuitables' into structural fills may be undertaken only at the discretion of the Geotechnical Engineer following a request by the contractor and with sufficient time for appropriate consideration. Approval for any such blending must be sought from and provided by the Geotechnical Engineer in writing prior to the commencement of any blending.

In consideration of any such requests, the Geotechnical Engineer will need to be able to assess, et. al., the composition of the materials requested to be blended, the location on the site for the proposed fills, the fill depths and the elevation of the blended materials within the fills and any environmental constraints.

As a minimum, it is expected that any blended fills will be directed to comply with the following conditions

- All significant, solid inorganics (such as roots and stumps) to be removed prior to blending; and
- All inclusions of suitable man-made materials (e.g. concrete) and any excavated rock must comply
  with the normal compaction requirements specified herein in terms of size and ability for appropriate
  compaction to be achieved in close vicinity to the inclusions.
- All blended materials must be appropriately mixed/ blended normal fill materials to the specified ratio.
   Un-mixed interlayering of normal engineered filling with unsuitables will not be accept d.
- As a preliminary indication, it is expected that the ratio of unsuitables to suitable fill will not exceed 1 in 10 by volume.

It is expected that the Geotechnical Engineer will also need to apply limits to the location/ depth of blended fills within any specified fill area.

#### 4.6.3 Hardfill

Hardfill used as structural filling shall be a graded, unweahered, durable, crushed rock product approved by the Geotechnical Engineer, with a grading suitable for compaction.

## 4.6.4 Material Conditioning

The cut materials on site may require some drying prior to c mpaction to achieve the required specification. This may be done by harrowing (such as with discs) and air drying when conditions permit or by the addition of hydrated lime.

The addition of lime and/or cement to engineered filling in concentrations greater than 3% requires the approval of the Geotechnical Engine r.

All additives such as lime or cement proposed for use in backfill materials for Reinforced Earth Slopes or other materials in contact with geosynthetics must be approved and monitored by the Geotechnical Engineer.

# 4.7 Fill Placement, Compaction and Testing Requirements

#### 4.7.1 Soil Fill

Soil placed in fills shall be conditioned and compacted until the following conditions are satisfied. Alternative methods based on specified compaction techniques may be selected by the Geotechnical Engineer if the method below is considered inappropriate due to the granular nature of the materials.

It hould be noted that the surface of the fill area prior to placement of subsequent fill lifts should be in a state so as no to create a break in the consistency of the fill material between lifts. For example if surfaces are left to dry out, or rolled to seal them from rainfall infiltration then the surface must be broken up and scarified with rippers or by other means to ensure a good bond between fill lifts.

The maximum lift of filling placed before compaction is dependent on the size and nature of the compaction equipment. Typically, 300mm loose depth is considered the maximum for a Cat 815/820 type compactor. In any event the contractor must ensure that the fill is placed and compacted to achieve even and adequate compaction throughout each layer/lift.

The test criteria and frequency for cohesive materials (Clays & Silts) are set out in Table 1 and 2 below. If non cohesive soils (i.e. Sands) are to be placed as engineered fill the matter should be referred to the Geotechnical Engineer to define the testing requirements.

Table 1 – Cohesive Materials (soil fill and soil/ rock blended fill) Compaction Test Criteria for Engineered Filling:

	Air Voids (1)		Vane Shea	r Strength <sup>(2)</sup>	Moisture Content (3)	Dry Density (3)	
	Average	Maximum Single Value	Average	Minimum Single Value	Maximum	Minimum	
General Fill	10%	12%	140 kPa	110 kPa	40%	1.25 t/m <sup>3</sup>	
High Strength Fill	8%	10%	150 kPa	120 kPa	40%	1.3 t/m <sup>3</sup>	
Landscape Fill		TBC by Ge	otechnical Er	gineer of case	by case basis	1	

<sup>(1)</sup> Air Voids Percentage (as defined in NZS 4402:1986)

<sup>(2)</sup> Undrained Shear Strength (Measured by hand shear vane - calibrated using NZGS 2001 method)

<sup>(3)</sup> Moisture content and minimum dry density non-compliance may be accepted on site by the Geotechnical Engineer on a case by case basis depending on the nature of the material and the other criteria results.

Table 2 – Cohesive Materials (soil fill and soil/ rock blended fill) Compaction Testing Frequencies for Engineered Filling:

	Field Density & Air Voids %	Vane Shear Strength	Solid Density	Compaction Curve
General Fill	1 test per 1500m <sup>3</sup> of fill placed with not less than 1 test per 500mm lift of filling for each area.	1 set of tests (4 readings within 1 metre of each other) per 500m³ of filling placed with not less than 1 test per 500mm lift of filling for each fill area.	1 test per material type per 50,000m³ or at least 1 test every 8 weeks.	1 test per material type per 30 000m³ or at least 1 test every 5 weeks.
High Strength Fill	1 test per 1000m³ of fill placed with not less than 1 test per 500mm lift of filling and for each 50m length of shear key excavation.	1 set of tests (4 readings within 1 metre of each other) per 500m³ of filling placed with not less than 1 test per 500mm lift o filling per 25m of shear key excavation.	1 test per ma erial type pe 50,000m³ or at least 1 test every 8 weeks	1 test per material type per 30,000m³ or at least 1 test very 5 weeks.
Landscape Filling	TBC by Geotechnic	cal Engineer of case by c	ase basis	

The test criteria and/or frequency may be relaxed at the discretion of the Geotechnical Engineer (CMW) for the project or in a discrete fill area subject to the consistency of the results achieved being acceptable over a specified period of time.

## 4.7.2 Compaction Testing Reporting Requirements

- All test location coordinates to be recorded by hand held GPS with reference to the NZTM projection. Test location coordinates, with date and test number reference are to be provided to the Geotechnical Engineer in electronic (excel) formation a weekly basis. Alternatively, the Geotechnical Engineer may approve the use of site plans to mark the location of tests in lieu of GPS location.
- The volume of filling placed for each progress claim month (typically ending 20<sup>th</sup> of the month) including all filling placed (undercut and cut to fill) to be provided to the Geotechnical Engineer monthly by the contractor or Engineer to the Contract to allow assessment of test frequency adequacy.
- Interim fil test summaries are to be provided to the Geotechnical Engineer for review on a regular basis

# 4.7.3 Hardfill

A plateau compaction test shall be carried out on site under the supervision of the Geotechnical Engineer, for each type of hardfill placed to determine the achievable maximum dry density (MDD) with no more than 20% total voids unless a laboratory derived MDD can be provided. The Geotechnical Engineer shall be given the opportunity to approve the size and type of compaction equipment to be used prior to any plateau testing.

Hardfill shall be placed and compacted to 95% of the MDD determined from the plateau test or laboratory MDD. If these conditions are not able to be met then appropriate adjustment of the moisture content or compaction equipment will be required.

In all cases, the dry density of the compacted fill at any one test site shall be not more than 5% below the minimum and the average of the dry densities of any ten consecutive test sites shall not be less than the specified minimum.

The Geotechnical Engineer, may at their discretion, alter the compaction specification of a method compaction specification based on the plateau test result for materials with a maximum particle size greater than 65mm.

The test frequency shall be 1 test per 500m³ of hardfill placed with not less than 1 test per 500mm lift of filling for each fill area.

The test frequency may be relaxed at the discretion of the Geotechnical Engineer (CMW) for the project or in a discrete fill area subject to the consistency of the results achieved being acceptable over a specified period of time.

# 4.8 Subsurface Drainage

#### 4.8.1 General

Drainage for shear keys, fill drainage keys, buttress fills, underfill gully drains and counterfort drains shall be constructed in accordance with the design drawings and standard details.

#### 4.8.2 Materials

## 4.8.2.1 Pipes

Drainage pipes used in subsoil drainage shall be 160mm diameter highway grade drain coil. Drain coil walls shall be perforated or sold as detailed in the design drawings or directed by the Geotechnical Engineer on site. Drain coils shall not have a geo abric filter sock unless requested by the Geotechnical Engineer on site.

# 4.8.2.2 Aggregate

Auckland Council now generally require that subsoil drainage has a 100 year design life and is essentially maintenance fre unless there is an entity such as body corporate or residents association that maintenance responsibility can be transferred to. Maintenance by individual owners is not practical as the subsoil drainage systems usually cross over, and generally benefit, multiple lots.

This requires a high quality drainage aggregate with the following properties:

- Self-filters against the soils present on site preventing loss of permeability over time; or, able to be plactically wrapped in a suitable geofabric filter;
- High permeability, which translates to a low fines content; and
- Stable and not subject to crushing, weathering, internal erosion or piping, or significant loss of volume (settlement) over time.

Ideally the drainage aggregate should be a well graded self-filtering material such as a clean (free of significant cohesive fines) scoria SAP50 product or Transit F/2 specification filter media.

Alternatively, for shear key drainage, blanket drains, underfill drainage and all applications where full encapsulation with a geofabric filter cloth can be relatively simply and safely achieved, an open graded product, preferably 27/7 Scoria may be used. Care will need to be taken to ensure that the cloth fully encapsulates the aggregate. Observation of the cloth wrap should form an inspection hold point prior to backfilling over the drain. Drain coils in this instance do not require a filter sock.

For counterfort trench drains and applications where a full filter cloth wrap is not practical to construct, and the performance of the drain is not critical to maintaining slope stability then a SAP20 or SAP50 may be used without a filter cloth wrap. Drains which fall into this category must be defined and confirmed as such by the Geotechnical Engineer. Additionally, where such materials are used, regular visual inspections and approval of the aggregate quality and laboratory grading curves is required. This is to comprise visual inspection of each site stockpile prior to material being placed in the trench. One wet sieve grading curve from each site stockpile per week is required while material is being imported to site to monitor the fines content. Drain coils in this instance do not require a filter sock.

For counterfort trench drains and applications where a full filter cloth wrap is not practical to construct, and the performance of the drain is critical to maintaining slope stability then a TNZ/F2 or (approved) modified F2 aggregate must be used. In conjunction with this an approved high specification drainage pipe with filter cloth surround such as the Megaflo products may be specified.

Light compaction (i.e. tamping with back of excavator bucket) only is to be applied to drainag aggregates.

#### 4.8.2.3 Filter Cloth

Any filter cloth surround specified on the drawings shall meet the requirements of Transit Specification TNZ/F7, Filtration Class 2 and Strength Class B unless otherwis specified on the drawings.

## 4.8.2.4 Trench Backfill in Service Trenches

It is important on all sloping land that service trenches running paralle to contours are avoided where possible as they can permit the ingress of surfac water and/or lateral movement of trench sides that could lead to progressive land slippage, help develop tension cracks and possibly lead to slope and building instability.

Backfilling of all trenches should be to the general fill stand or above unless specifically varied in writing by the Geotechnical Engineer and where possible the pip—bedding in all trenches on steep ground should contain a 50mm diameter perforat—d drain coil that is connected into each manhole on the line. This is to help prevent instability arising fr m the ingress of surface water and/or lateral movement of trench sides that could lead to progressive land slippage—ind is especially important where the lines are in close proximity to buildings

The subdivision drain laying contractor must be made aware of these requirements and of the need to contact us when trench backfilling is to take place.

## 4.8.3 Depth and Extent

The locatio extent and depth of the drainage shown on the design drawings may be varied on site by the Geotechnical Engineer in response to the ground conditions encountered.

# 4.8.4 Drainage Outlets and Inspection Points

Outlets for subsurface drainage shall be provided at regular intervals shown on the drawings or as determined on site by the Geotechnical Engineer. Pipe outlets shall be specifically formed structures with adequate protection such as a headwall and/or rock rip rap. The position of all outlets shall be recorded on the asbuilt drawings.

Where possible it is good practice to include additional inspection and/or flushing points in the subsoil drainage system in the event that their performance needs to be confirmed in the future.

In any event, at least one temporary flush point is required for each subsoil drainage system to enable flushing of the system once the earthworks are substantially complete.

The flushing of the subsoil drainage system must be witnessed by the Geotechnical Engineer.

# 4.9 Finishing Works and Topsoil Respread

#### 4.9.1 Overcut

All areas cut to below finished level should be reinstated with engineered filling to the satisfaction of the Geotechnical Engineer.

### 4.9.2 Topsoil Depth

Topsoil respread depth should be between 100mm and 300mm, or as directed by the Engineer to the contract. On ground steeper than 1V:3H the surface should be roughened under the supervision of the Geotechnical Engineer prior to topsoil placement.

#### 4.9.3 Unsuitable Materials

At the conclusion of earthworks all surplus unsuitable materials should be removed from site or placed in designated permanent stockpiles. The size and location of such sto kpiles must be approved by the Geotechnical Engineer and recorded on the asbuilt drawings.

## 4.9.4 Road Subgrades

Testing and formation of road subgrades will be carried out a part of the subdivision civil works package.

#### 5 MONITORING

#### 5.1 Settlement

Where filling is placed over materials suspected to be of a compressible nature or where a significant depth of filling is to be placed, then ettlement monitoring points should be installed on the stripped surface prior to filling and on finished surface of the filling and monitored during and post construction to ensure ongoing settlement rates are within acceptable guidelines for residential building development.

The number and position of monitoring points and the frequency of post construction settlement monitoring is to be agreed with the Geotechnical Engineer during construction.

It is the contractor's responsibility to ensure the integrity of the monitoring points is maintained during the works.

# 6 ASBUILT INFORMATION REQUIREMENTS

In order to provide a Geotechnical Completion Report (GCR) certain as-built information must be provided to CMW. t is the contractor's responsibility to ensure that all of the following items are surveyed prior to placing filing. The survey of these items should therefore form a hold point in the construction sequence.

- The location and invert of all sub surface drainage; and,
- 2. The depth of filling placed including all benching, undercuts, shear or fill drainage keys and temporary ponds which have been backfilled.

CMW require the following as-built information to be provided for the GCR:

- Cut and fill depth plan (including undercuts and shear keys);
- 2. Final contour plan;
- 3. Drainage locations and inverts (surface and subsurface);
- 4. Drainage outlet locations (surface and subsurface);
- 5. Details of any defined overland flow paths;

- 6. Location and heights of any retaining walls;
- Material data for imported products used such as draincoils, aggregates and geofabrics as well as confirmation that products installed comply with the requirements of the project drawings and his specification; and,
- 8. Any settlement Monitoring Data.