GEOTECHNICAL INVESTIGATION REPORT FOR PROPOSED RESIDENTIAL SUBDIVISION, 184 KOUTU LOOP ROAD, WHIRINAKI

Project Reference: 18655
3 December 2020

CONTENTS

1 EXECUTIVE SUMMARY

Based on the investigation and appraisal of the site reported herein, the proposed subdivision development has been assessed as stable and is generally considered to be suitable for conventional construction in accordance with the relevant codes of practice. The foundations should be modified to mitigate against the highly expansive soils encountered at the site. This would either involve deepening shallow-type foundations to a minimum depth of 900mm below cleared ground level, or modifying the stiffness or subgrade of a proprietary raft system.

All other geotechnical hazards at the site have been assessed as either not present or of acceptable risk provided that the various mitigation measures and good practice recommendations made in this report are adopted.

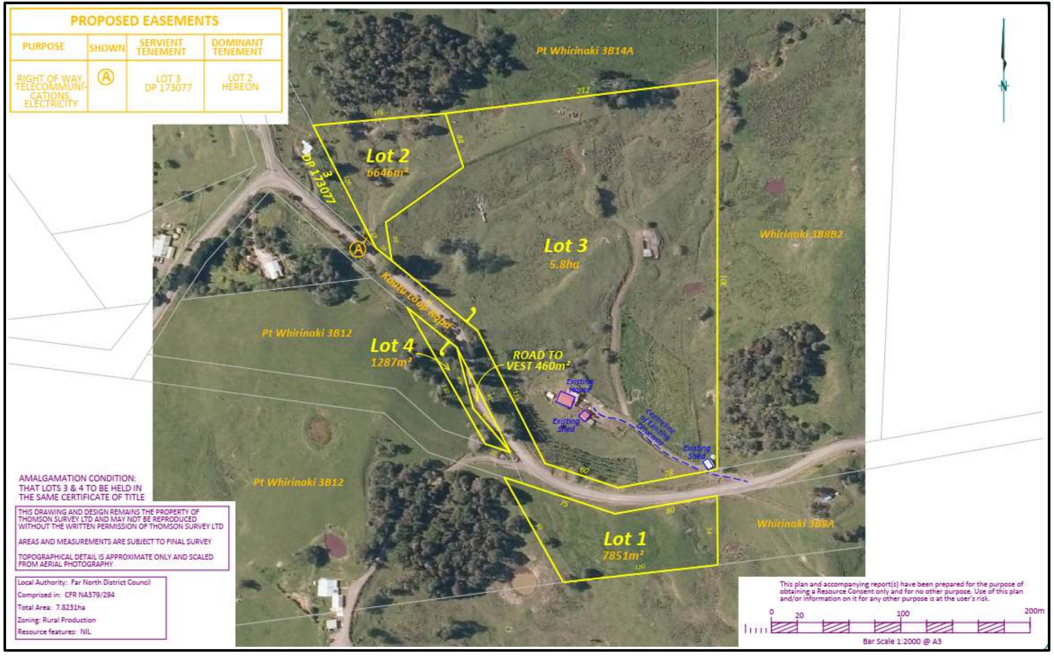
2 INTRODUCTION

LDE Ltd have been engaged by Darius and Pearl Cleaver to undertake a geotechnical investigation of a new subdivision located at 184 Koutu Loop Road, Whirinaki (Figure 1). It is understood that the client is subdividing the existing property into 4 lots, between 1287m^2 – 5.8 ha in area and with some land vested to the Far North District Council (FNDC).

This report has been completed in reference to an “Request For Information” dated 30th September 2020, to confirm a stable building locations on each site, specifically for Lot 2 as the FNDC resource consent engineer identified hummocky ground, and signs of downhill movement on the site.

The purpose of the investigation was to determine the nature of the ground beneath the site, assess the geotechnical hazards posed to the development in accordance with the Resource Management Act, and to provide geotechnical recommendations for the building. This includes the geotechnical suitability of the proposed house sites within the lots and stormwater disposal. Onsite wastewater disposal has been covered by another report dated 17th September 2020, by Kerikeri Drainage Ltd.

Figure 1: Location of the subject site in relation to Kaikohe (source: Google Earth).



PROPOSED EASEMENTS

PURPOSE	SHOWN	SERVIENT TENEMENT	DOMINANT TENEMENT
RIGHT OF WAY TELECOMMUNICATIONS ELECTRICITY	Ⓐ	LOT 3 DP 173077	LOT 2 HEREON

AMALGAMATION CONDITION:
THAT LOTS 3 & 4 TO BE HELD IN
THE SAME CERTIFICATE OF TITLE

THIS DRAWING AND DESIGN REMAINS THE PROPERTY OF THOMSON SURVEY LTD AND MAY NOT BE REPRODUCED WITHOUT THE WRITTEN PERMISSION OF THOMSON SURVEY LTD

AREAS AND MEASUREMENTS ARE SUBJECT TO FINAL SURVEY

TOPOGRAPHICAL DETAIL IS APPROXIMATE ONLY AND SCALED FROM AERIAL PHOTOGRAPHY

Local Authority: Far North District Council
Comprised in: CFR NA379/294
Total Area: 7.8231ha
Zoning: Rural Production
Resource features: NIL

This plan and accompanying report(s) have been prepared for the purpose of obtaining a Resource Consent only and for no other purpose. Use of this plan and/or information on it for any other purpose is at the user's risk.

Figure 2: Proposed subdivision Plan (source: Thomas Survey Ltd's Proposed Subdivision Plan[1]).

3 SITE SETTING

3.1 Desktop Review

A review of the Far North District Council (FNDC) and the Northland Regional Council (NRC) GIS websites was undertaken to determine the presence of mapped hazards for the property.

The following items were encountered during our review:

- The entire site is located in an area which has been modelled as unlikely to experience flooding. However, localised flooding of ponds and/or depressions was not modelled.

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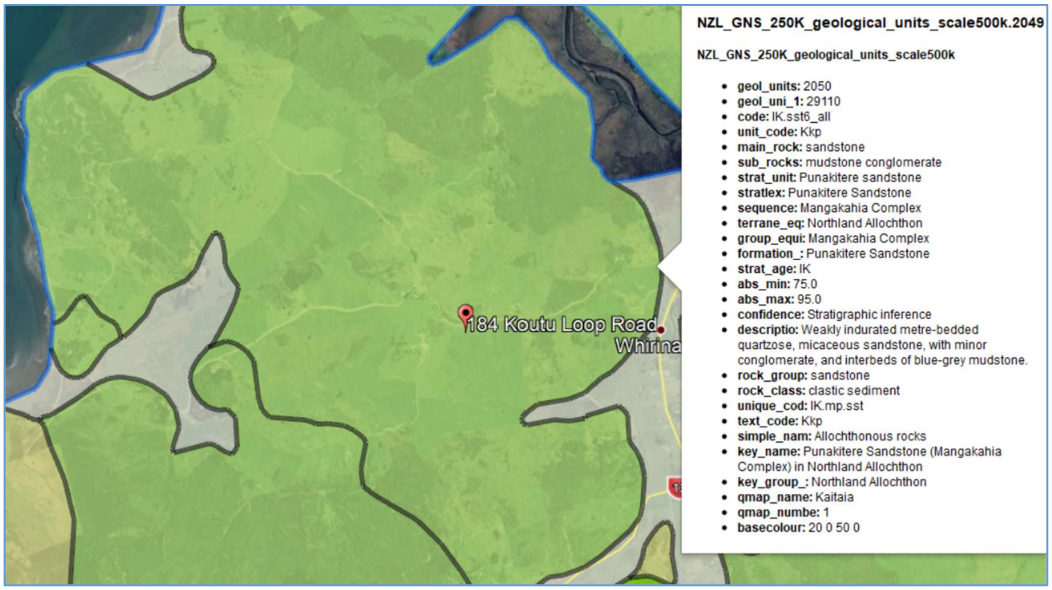
[1] Thomas Survey Ltd's Proposed Subdivision Plan tilted "Proposed Subdivision of PT Whirinaki 3B13 and Easement over Lot 3 DP 173077" 184 Koutu Loop Road, Kaikohe, dated 28th May 2020, Surveyors Ref: 9766.

- The site is not located overlying or near an existing aquifer.

3.2 Published Geology

The 1:250,000 geological map of the region[2] as shown in Figure 3 below, shows the site as being underlain by Punakitere Sandstone (Mangakahia Complex) of Northern Allochthon which consists of *'Weakly indurated metre-bedded quartzose, micaceous sandstone with minor conglomerate, and interbeds of blue-grey mudstone.'*



NZL_GNS_250K_geological_units_scale500k.2049

NZL_GNS_250K_geological_units_scale500k

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- **stratlex:** Punakitere Sandstone
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- **abs_min:** 75.0
- **abs_max:** 95.0
- **confidence:** Stratigraphic inference
- **descriptio:** Weakly indurated metre-bedded quartzose, micaceous sandstone, with minor conglomerate, and interbeds of blue-grey mudstone.
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- **rock_class:** clastic sediment
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- **text_code:** Kkp
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- **qmap_numbe:** 1
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Figure 3. Extract of GNS Geology Map

3.3 Site Characteristics

The existing property at 184 Koutu Loop Road, Whirinaki is legally described as PT Whirinaki 3B13 and is approximately 7.82 hectares in area. It is understood that the property is to be subdivided into four lots.

Lot 1 is located on the southern side of Koutu Loop Road, and is approximately 7851m^2 in area, with a cut / fill building platform has been constructed on the eastern side of the lot. An old duck/irrigation pond sits in the south eastern corner of the site, which is to be drained and backfilled.

Lot 2 is located in the north-western corner of the property to the east of Koutu Loop Road, and is approximately 6,646m^2 in area. This lot will also have a small easement on Lot 3 DP 173077 (neighbouring property to the west), for right of way, telecommunications, and electricity access. An old quarry is located at the northern end of the site, indicating that the underlying rock is likely to be shallow underneath the site.

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[2] Isaac, M.J. (compiler) 1996: Geology of the Kaitaia area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences 1:250,000 geological map 1. 44 p. + 1 folded map

Lot 3 is located on the eastern side of Koutu Loop Road, and is the largest lot, being approximately 5.8 ha in area. The lot comprises of the existing dwellings and sheds, and surrounding paddocks.

Lot 4 is located on the western side of Koutu Loop Road, and is the smallest lot at approximately 1287m^2 in area. It is understood that this small piece of land shall be held on the same Certificate of Title as Lot 3. A small part of this lot (460m^2) shall be vested to the Far North District Council as Koutu Loop Road is located in this section of land.

4 GROUND CONDITIONS

4.1 Subsurface Investigations

Our investigation of the site included the following ground investigation work:

- Two 50mm hand augered boreholes put down to a target depth of 3.0m or refusal on Lot 2. Measurements of the undrained shear strength were taken at 200mm intervals within cohesive soils encountered down through the boreholes using a calibrated shear vane.

The locations of the subsurface investigations are shown on the Geotechnical Investigation Plan in Appendix A. Geotechnical investigation logs of the boreholes and penetrometer tests are presented in Appendix B. The field work was completed in spring.

4.2 Subsurface Conditions

In summary, our investigations generally encountered residual soils consistent with the weathering of the bedrock shown on the published geology for the site.

On Lot 2, specifically Topsoil overlying Silty Clay to the termination depth of 1.0 – 1.8m depth, refusing on either underlying boulders or bedrock.

4.3 Soil Moisture Profile and Groundwater Conditions

The soils beneath the building site were moist to the termination depth of 1.0 – 1.8m

The moisture content of the near surface soils is expected to be higher during the winter months or extended periods of wet weather resulting in their saturation at times. The extent of the wetting front will be dependent on the duration of the period of rainfall, but may extend down some 1m to 2m from the surface. Similarly, the groundwater table is expected to rise some 1m to 2m during extended periods of wet weather. In our opinion complete saturation of the ground is possible, but is a low probability occurrence.

4.4 Seismic Subsoil Category

We consider that the site is a Class C shallow soil site as defined by NZS 1170.5 (2004) "Structural Design Actions: Part 5: Earthquake actions – New Zealand".

5 NATURAL HAZARDS AND GROUND DEFORMATION POTENTIAL

5.1 General

This section summarises our assessment of the natural hazards within the property as generally defined in Section 106 of the Resource Management Act (1991 and subsequent amendments) and Section 71 of the Building Act (2004), and the potential risk that these present to the proposed building in terms of vertical and lateral ground deformation.

This section also includes our assessment of ground beneath the building site which is outside the definition of "Good Ground" as defined by the Compliance Document for the NZ Building Code, NZS3604 (2011) "Timber Framed Buildings" and NZS4229 (2013) "Concrete Masonry Buildings Not Requiring Specific Engineering Design". This is any ground which could foreseeably experience movement of 25mm or greater for any reason including one or a combination of compressible ground, land instability, ground creep, subsidence, seasonal swelling and shrinking, frost heave, changing groundwater level, erosion, dissolution of soil in water, and the effect of tree roots.

5.2 Slope Instability

5.3 Slope Instability – Global Stability through Development

Due to the hummocky ground observed on site and the area being mapped within notoriously unstable geology of the Mangakahia Complex of the Northland Allochthon, a slope stability analysis has been undertaken to assess the effects of the development on stability of the overall slope.

5.3.1 Assessment Methodology

The stability of the site has been assessed based on the geomorphology of the surrounding slopes and assessment of a cross section developed of the underlying engineering geology in the Rocscience computer programme Slide 2.

Soil parameters for the analyses were determined based on conservative values from published data of the each of the geological units present at the site and our previous experience of these soils.

The design cases reviewed for the purpose of this report are the long-term groundwater condition (expected normal winter groundwater condition), and extreme groundwater condition (combination of long-term groundwater condition coupled with a wetting front due to a high intensity rain event).

The location of the cross section is shown on the investigation plan in Figure 4 below and printouts of the stability analyses are attached to this report in Appendix C.

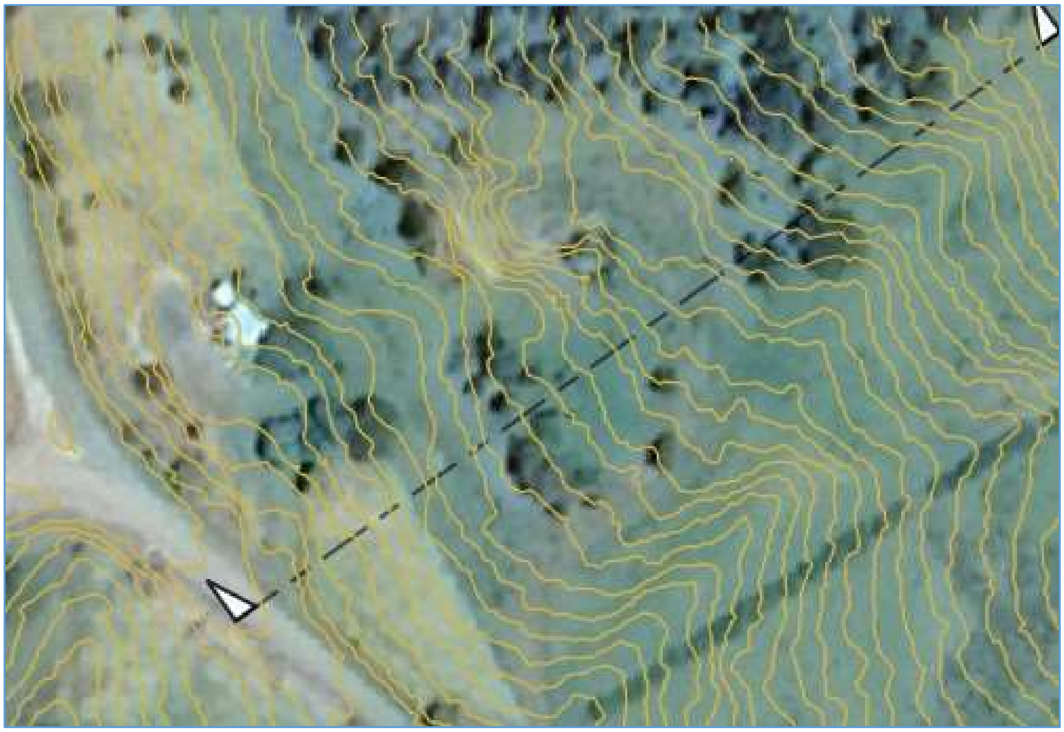

Figure 4. Cross section for stability analysis through Lot 2.

5.3.2 Stability Assessment

The property is located on a north-easterly facing slope with an average gradient of 12°, with a fairly consistent gradient down the slope.

The assessed cross section was developed perpendicular to the contour through the proposed building platform. The elevation profile for the cross section was developed based on Lidar data. The analysis assumes a 10kPa vertical surcharge from the weight of the proposed building.

Table 1 below outline the soil parameters used for the analyses.

Table 1: Soil parameters for Slide analysis

Layer/Lithology	Unit Weight kN/m^3	Cohesion (kPa)	Phi (°)
Residual Clay	18	3	26
Weathered Allochthon	18	5	32
Unweathered Allochthon	20	10	40
Bedrock (infinite strength)	20	-	-

It is generally considered appropriate for residential construction to achieve the below Factors of Safety for each of the above scenarios.

Table 2: Generally accepted Factor of Safety for analyses types

Analyses	Minimum Factor of Safety required	Actual FoS results
Long-term Groundwater	1.5	1.74
Extreme Groundwater	1.3	1.68

Both analyses met the minimum FoS values outlined above in Table 2. The shallow soft rock of the unweathered Allochthon, observed within the old quarry and the cut platform at Lot 1 indicate high strength material at a shallow depth along the ridgeline. This shallow rock provides fundamental stability to the slopes near the top of the ridgeline. Although the ground surface was observed to be hummocky, this is likely due to shallow creep of the surface soils, and manmade disturbance of the natural ground, from the access to, and extraction of material from the quarry.

It should be noted that the analysis has been limited a global assessment based on ground investigation data from the proposed building platform only. Further analysis of the slope will be required at building consent stage once the building platform location/access/parking has been confirmed, the foundation type is known, and the cut and fill areas of the proposed development are known. Specifically designed retaining walls may be necessary to achieve the required FoS.

5.4 Compressible Ground and Consolidation Settlement

Other than the moderately organic topsoil, there does not appear to be any compressible ground beneath the locations of the likely building locations of Lots 1 and 2 as defined by NZS3604:2011.

This topsoil layer will need to be removed within the extents of the building sites where shallow foundations are used to reduce potential for settlement to occur that may adversely affect future buildings.

5.5 Ground Shrinkage and Swelling Potential

Plastic soils can be subject to shrinkage and swelling due to soil moisture content variations which can result in apparent heaving and settlement of buildings, particularly between seasons.

Based on a visual assessment and knowledge of soils in the area they are considered to be moderately to highly plastic and therefore is likely to be highly reactive to shrinkage and swelling during the year, therefore we recommend that any foundations and retaining structures take this into consideration.

We consider that shallow foundations can be used provided that these extend down to the minimum depth recommended below where excessive changes in soil volume are not expected to occur.

5.6 Tree Root Deformation

Trees within close proximity to buildings can result in potentially significant building damage due to heaving as a result of tree root growth, and also settlement due to soil shrinkage from the moisture uptake of the roots.

There are presently no trees within 5m of the building footprints which would have the potential to result in soil settlement due to the uptake of water from the tree roots or ground heave from tree root growth.

5.7 Flooding Inundation

Localised ponding of water is not considered to be an issue on the site, however it is possible that the low points of the site may experience ponding. Based on our observations, the proposed building platforms are located near the ridgeline, and the immediate ground surface around slopes away, therefore flood inundation is unlikely to occur.

5.8 Conclusions

From our assessment of the natural hazard and ground deformation risks presented to the proposed development we consider that a building can be safely located on the site, provided that the recommendations given in Section 6 are adhered to.

6 ENGINEERING RECOMMENDATIONS

6.1 General

It should be appreciated that the recommendations given below are based on the surface and subsurface conditions encountered at the time of the investigation. In addition to the possible variations in the subsurface conditions away from the investigation points within and around the site, changes to the site levels can have a dramatic effect on the recommendations given.

Furthermore, cuts into the slopes above and below the site can significantly jeopardise its stability, unless an appropriate measure is put in place to restore the stability of the slope. Accordingly, we should be contacted prior to commencing any earthworks within the slopes to assess how this may affect the subject development. We should also be contacted immediately should the ground conditions encountered vary from that described in this report.

6.2 Building Platform Development

6.2.1 Building Platform

Careful construction of the platform will be required to ensure its long-term integrity and availability of good ground beneath the proposed building site. To achieve this the following recommendations should be adopted.

6.2.2 Cuts

The rear slope of the platform should be cut at 1.5H to 1V, with the top 1m cut back to a gentler gradient of 2.5H to 1V. Cut slopes are expected to remain stable at heights of up to 6m at this gradient.

During the excavation of the cut there may be defects (e.g. planes of weakness) or materials exposed which were not identified or differ from that described in this report. We should be contacted without delay to assess how these may alter the stability of the slope at the design gradient. A reduction in the slope gradient, or slope support (e.g. soil nailing, retaining walls etc.) may be required to maintain the level of stability required for the building.

6.2.3 Fills

The fill forming the outer edge of the building platforms needs to be limited to a maximum height of 1m to avoid instability. The slope of the fill needs to be kept below a maximum gradient of 2H to 1V, unless reinforced with appropriate geotextile placed at regular intervals within the fill to an engineering design.

Placement of fill in any areas of existing instability should be avoided at all costs, unless an engineering solution is determined to maintain the integrity of the fill and to avoid reducing the stability of the slope. We should be contacted if filling in these areas is proposed.

All fill forming part of the building platform needs to be placed in a controlled manner to an engineering specification that follows the general methodology given in NZS 4431 (1989) “Code of practice for earthfill for residential development”. This includes the design, inspection and certification of the fill by a Chartered Professional Engineer or Professional Engineering Geologist. This will be particularly important to enable the building proposed for the site to be able to be constructed in accordance with NZS3604 (2011) “Timber Framed Buildings” or NZS 4229 (2013) “Concrete Masonry Buildings Not Requiring Specific Design”.
The following specification is recommended:

1. All topsoil and unsuitable materials, including low strength ground, uncontrolled fill, rubbish etc shall be stripped from the footprint area of the fill.
2. All slopes greater than 1V to 4H shall be benched.
3. The fill footprint area shall be inspected by the certifying engineer’s representative prior to the placement of fill.
4. The fill shall be placed uniformly in horizontal layers not exceeding 200mm in thickness at the optimum moisture content recommended by the suppliers of the material. Alternatively, the material should be inspected and approved as suitable material by a Suitably Qualified Professional. Material which is wet or saturated shall not be placed unless that is the optimum moisture content for the fill. The fill should be compacted to achieve the strengths given in the Table 1 below.

Table 1: Recommended Fill Compaction Criteria

Clegg Hammer (CIV – Clegg Impact Value)		
	Average value not less than	25
	Minimum single value	22
Air voids percentage		
	Average value not more than	10%
	Maximum single value	12%
Maximum dry density percentage		
	Average value not less than	95%
	Minimum single value	92%

Specific gravity and NZ Standard (or heavy) Compaction laboratory tests will be required to be undertaken prior to the commencement of earthworks for each proposed fill source to establish the compaction criteria associated with the air voids and dry density earthworks controls.

Provision should be made to ensure that the earth works are conducted with due respect for the weather, particularly due to the low permeability of the underlying ground. The fill should not be placed on to wet ground, especially if ponded water is present.

6.2.4 Site Contouring and Topsoiling

As soon as possible, all final cut-slopes and fill slopes should be covered with topsoil a minimum of 0.10m thick to prevent the ground from drying out readily resulting in the development of cracks. This is particularly important for the fill materials that are particular to this site due to their high reactivity (shrink – swell behaviour).

The finished ground level should be graded so that water cannot pond against, or around the building for the economic life of structure. To achieve this it will be important that the building platform beneath the topsoil grades away from the site.

Contouring should avoid the potential for concentration and discharge of surface water over point locations which could result in soil erosion or instability.

6.3 Foundation Design and Construction Recommendations

Our shear vane testing completed on Lot 2 indicates a geotechnical ultimate bearing capacity of at least 300 kPa from 0.4m depth, however expansive clay soils onsite require a specifically engineered foundations. The expansive soils are classed as highly ‘H’, having an Iss range of 3.8–6.5%and a 500 year design characteristic surface movement return (ys) of 78 mm, from B1/AS1 Amendment 19.

We consider that a timber pile foundation or a specifically designed waffle concrete slab foundation system is appropriate for both of the sites.

Shallow bored and poured timber pile foundations, strip footings or driven timber piles may be sized in accordance to NZS3604 (2011) provided they are embedded a depth of 0.9m below cleared ground level where significant changes in soil volume from seasonal soil moisture variations are not expected to occur.

Alternatively, a commercially available raft foundation e.g. Firth ribraft, X-pod, Cupolex system or equivalent proprietary system are considered suitable for the lots following the removal of the topsoil layer. The investigation results should be reviewed following the completion of the building design in order to confirm that the ground conditions meet the minimum requirements of the proprietary system. It should be confirmed by the suppliers of the raft foundation that the design is sufficient to address the highly expansive characteristics of the soils identified at the site. Alternatively, we can provide a specific engineering design solution for the raft foundation in accordance with AS2870 (2011) in order to achieve compliance with the NZS3604 (2011) requirements for “class H” expansive soils.

A conventional slab on grade may be constructed in accordance with B1/AS1 Amendment 19 for highly expansive if the structure meets the limitations as defined within this amendment.

The foundation drawings should be reviewed by LDE Ltd at the building consent stage to determine if the proposed structures and foundations are suitable for the ground conditions. Additional subsurface investigations will be required to support the building consent applications.

6.4 Verification Checks

6.4.1 Fill Placed beneath Foundations

As required by NZS3604 (2011) and NZS4229 (2013), any fill beneath the building will need to be certified by a Chartered Professional Engineer or Professional Engineering Geologist in accordance with NZS4431 (1989). A “Certificate of Suitability of Earthfill for Residential Development” will also be required in accordance with NZS3604 (2011) and NZS4229 (2013).

In order for the fill to be certified, the excavation will need to be inspected by the certifying Engineer or Engineer’s representative to ensure that all compressible materials are removed prior to the placement of the new fill.

Verification strength testing of the backfill by the certifying Engineer or Engineer’s representative will also be required to ensure that the minimum fill strengths specified in this report have been achieved.

6.4.2 Foundation Excavations

Verification testing of the ground by a Building Inspector or Suitably Qualified Professional is recommended to ensure that the ground conditions at the base of the foundation excavations are as described in this report, and that all unsuitable and loose materials have been removed as required by NZS3604 (2011) and NZS4229 (2013). We should be contacted immediately if these conditions vary from that described in this report. Deepening of the foundations or a modification to the recommendations or design may be required.

6.5 Surface Water Disposal

It is important to ensure that all surface water from roof, paved and retaining wall areas is appropriately collected and discharged to a suitable point sufficiently away from the building and areas of fill. The discharge point should be protected to inhibit erosion.

Disposal using soakage pits is not recommended due to the negative effect that this can have on the stability of the site. In addition, the effectiveness of the soakage pit reduces in the long term without regular maintenance.

The stormwater system for the building should be operational as soon as the roof is in place. This is to ensure that the ground within the vicinity of the building is not compromised by the negative effects and potential consequences of soil saturation.

6.6 Effluent Disposal

Onsite effluent disposal plan has been already undertaken, and the report provided by our client, completed by Kerikeri Drainage Ltd dated 17th September 2020, and recommends that widely spaced dripper irrigation lines would be most appropriate for on-site wastewater management within this property. The disposal fields should be located within areas that have not been affected by slope instability, as defined in the report.

We recommend that the effluent disposal field be located at least 3m away from all footings and 1.5 times the height of any retaining walls. We recommend that as-built drawings be prepared documenting the position of the effluent treatment system, including all connecting pipe work.

6.7 Service Pipes

All service pipes, stormwater structures, and culverts should be designed and constructed to ensure adequate capacity, strength, and water tightness to prevent leakage into the platform through blockage, running under pressure, or structural failure.

All service pipes installed within the fill should be flexible, or flexibly joined, so that they may deflect without breaking if the ground settles.

A record should be kept of the position, type, and size of all subsoil drains, and in particular of their outlets.

7 SUMMARY OF CONCLUSIONS

Following development of the site in accordance with our recommendations, we consider that:

(a) The land in respect of which a consent is sought, or any structure on the land built in accordance with our recommendations, is unlikely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; and

(b) Any subsequent use that is likely to be made of the land is unlikely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source; and

(c) Sufficient provision has been made for physical access to each allotment to be created by the subdivision.

8 OTHER CONSIDERATIONS

This report has been prepared exclusively for our client with respect to the particular brief given to us. Information, opinions and recommendations contained in it cannot be used for any other purpose or by any other entity without our review and written consent. LDE Ltd accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report by any third party.

This report was prepared in general accordance with current standards, codes and practice at the time of this report. These may be subject to change.

Opinions given in this report are based on visual methods, and subsurface investigations at discrete locations. It must be appreciated that the nature and continuity of the subsurface materials between these locations are inferred and that actual conditions could vary from that described herein. We should be contacted immediately if the conditions are found to differ from that described in this report.

This report should be read in its entirety to understand the context of the opinions and recommendations given.

For and on behalf of LDE Ltd

Report prepared by:	Report reviewed by:
Andrew Jones	Gareth Harding
BSc	*CPEng, IntPE(NZ), BE, BSc, CMEngNZ*
Engineering Geologist	*Chartered Professional Engineer*
	(Geotechnical and Civil)

Find out more about LDE professionals

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APPENDIX A

GEOTECHNICAL INVESTIGATION PLAN

Satellite imagery obtained from Thomson Survey Ltd's Proposed Subdivision Plan (Dated: 28th May 2020).
All Soil Locations are approximate only.

LDE LAND DEVELOPMENT & ENGINEERING LTD.

Soil Test Location Plan

Lot 2, 184 Koutu Loop Road, Whirinaki

DRAWN	AJ
CHECKED	GH
DATE	02.12.2020
PROJECT	18655

APPENDIX B

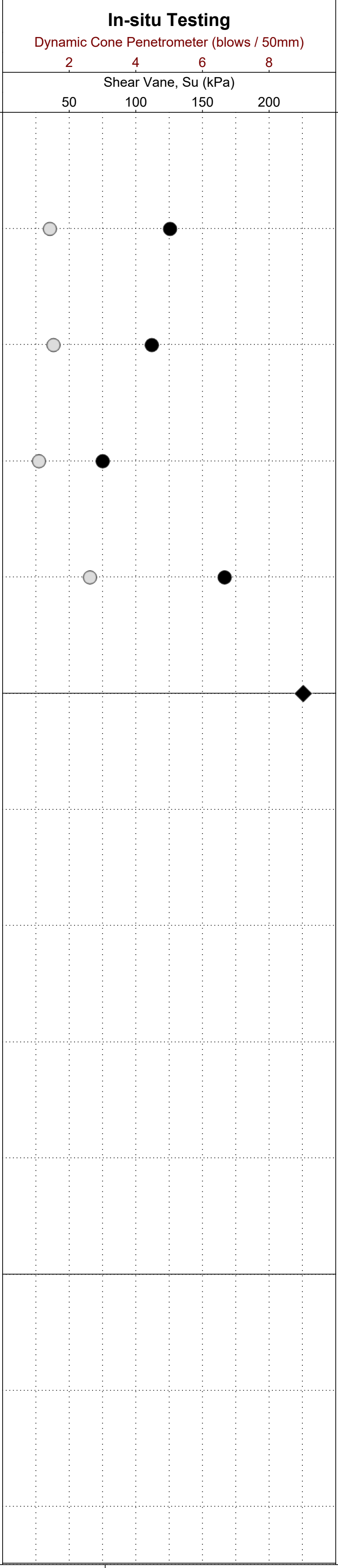
SUBSURFACE INVESTIGATION DATA

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA-01**				
Project ID:	18655				
Sheet:	1 of 1				
Client:	Darius and Pearl Williams	**Coordinates:**	6075539mN, 1640283mE	**Test Date:**	04/11/2020
Project:	Site Suitability For Subdivision	**System:**	NZTM	**Logged By:**	GH
Location:	184 Koutu Loop Road, Whirinaki	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**		**Vane ID:**	2864

Depth (m)	Material Description	Geology	Water	Test Values
0.0	Organic clayey SILT (OL); dark brown. Moist.	Topsoil	Groundwater Not Encountered	
0.2	Silty CLAY (CH); brown. High plasticity; moist.	Mangakahia Complex		125/35
0.4				112/38
0.6	CLAY (CH); orange grey mottled. Stiff to very stiff; high plasticity; moist.			75/27
0.8				166/65
1.0	End of hole at 1.00m, refusal due to due to inferred boulder / bedrock			UTP



Remarks:

Materials described in general accordance with NZGS Field Description of Soil and Rock (2005).
No correlation is implied between shear vane and DCP values.

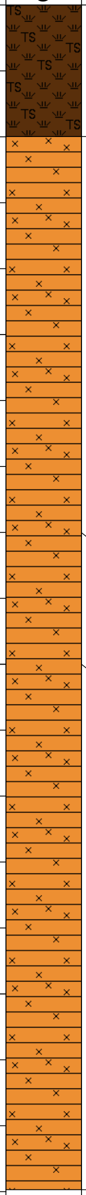
● Vane peak
○ Vane residual
◆ Vane UTP
▼ Standing water level
◁ Groundwater inflow
▷ Groundwater outflow

Hand Auger Borehole Log

Method: 50mm Hand Auger

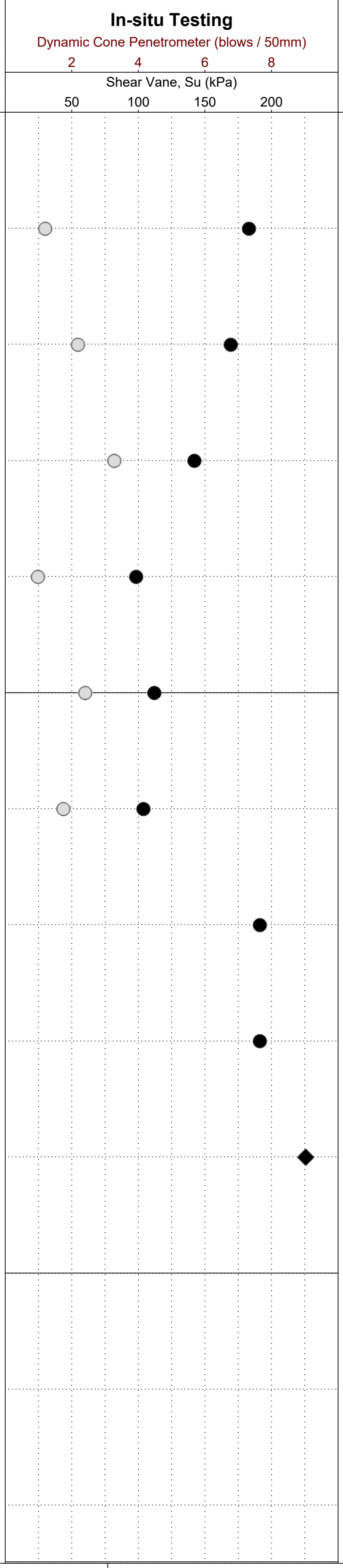
Test ID: HA-02
Project ID: 18655
Sheet: 1 of 1

Client:	Darius and Pearl Williams	**Coordinates:**	6075552mN, 1640270mE	**Test Date:**	04/11/2020
Project:	Site Suitability For Subdivision	**System:**	NZTM	**Logged By:**	GH
Location:	184 Koutu Loop Road, Whirinaki	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**		**Vane ID:**	2864



Depth (m)	Material Description	Geology	Water	Test Values
0.0	Organic clayey SILT (OL); dark brown. Very stiff; moist.	Topsoil	Groundwater Not Encountered	
0.2				183/30
0.2	Silty CLAY (CH); orange grey mottled. Very stiff; high plasticity; moist.	Mangakahia Complex		
0.4				169/54
0.6				142/82
0.8	0.8m: Becoming stiff			98/25
1.0	1.0m: Becoming very stiff			112/60
1.2				104/44
1.4				191+/-
1.6				191+/-
1.8	End of hole at 1.80m, refusal due to due to inferred boulder / bedrock			UTP

In-situ Testing



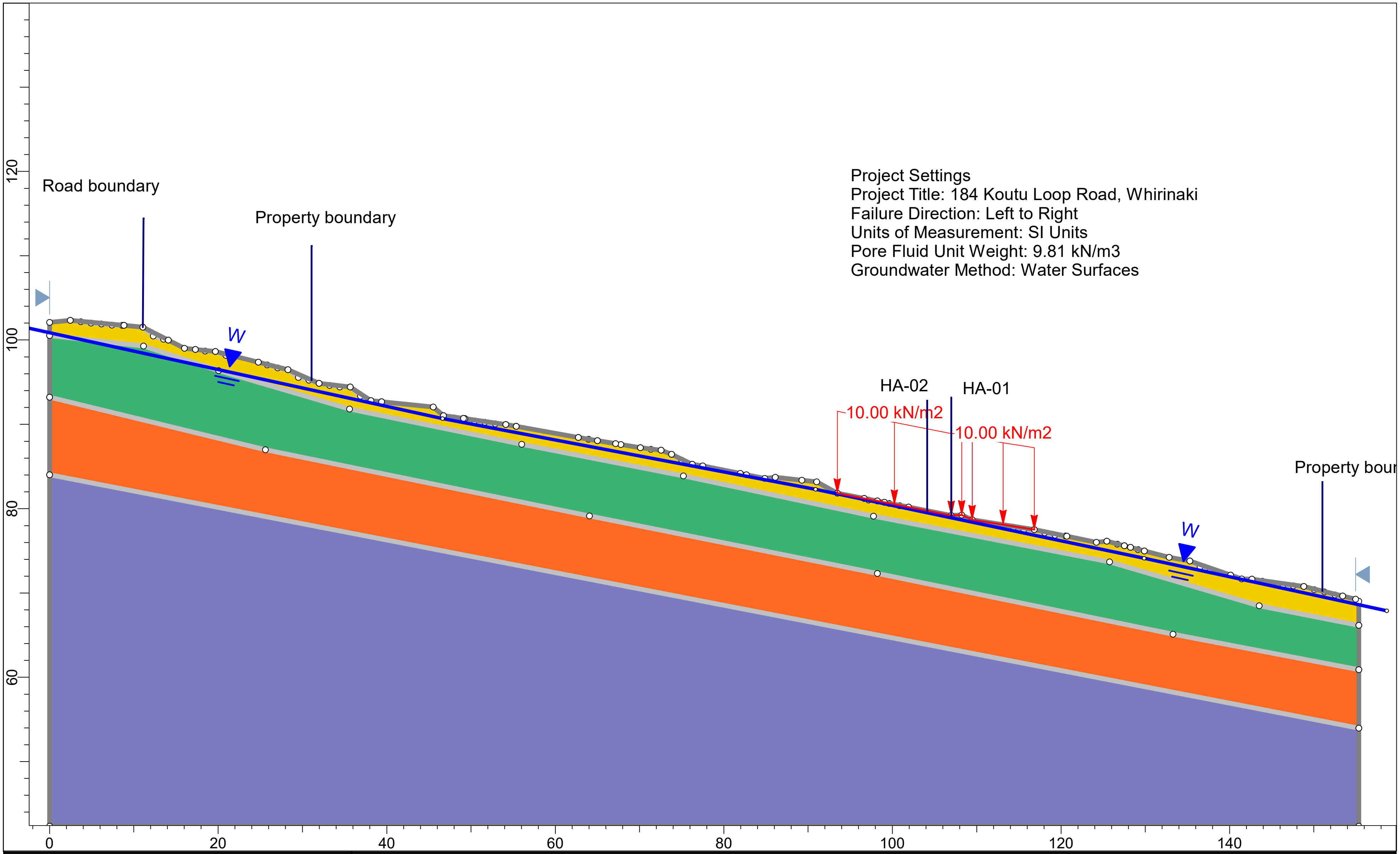
Remarks:

Materials described in general accordance with NZGS Field Description of Soil and Rock (2005).
No correlation is implied between shear vane and DCP values.

● Vane peak	▼ Standing water level
○ Vane residual	◁ Groundwater inflow
◆ Vane UTP	▷ Groundwater outflow

APPENDIX C

STABILITY ANALYSES

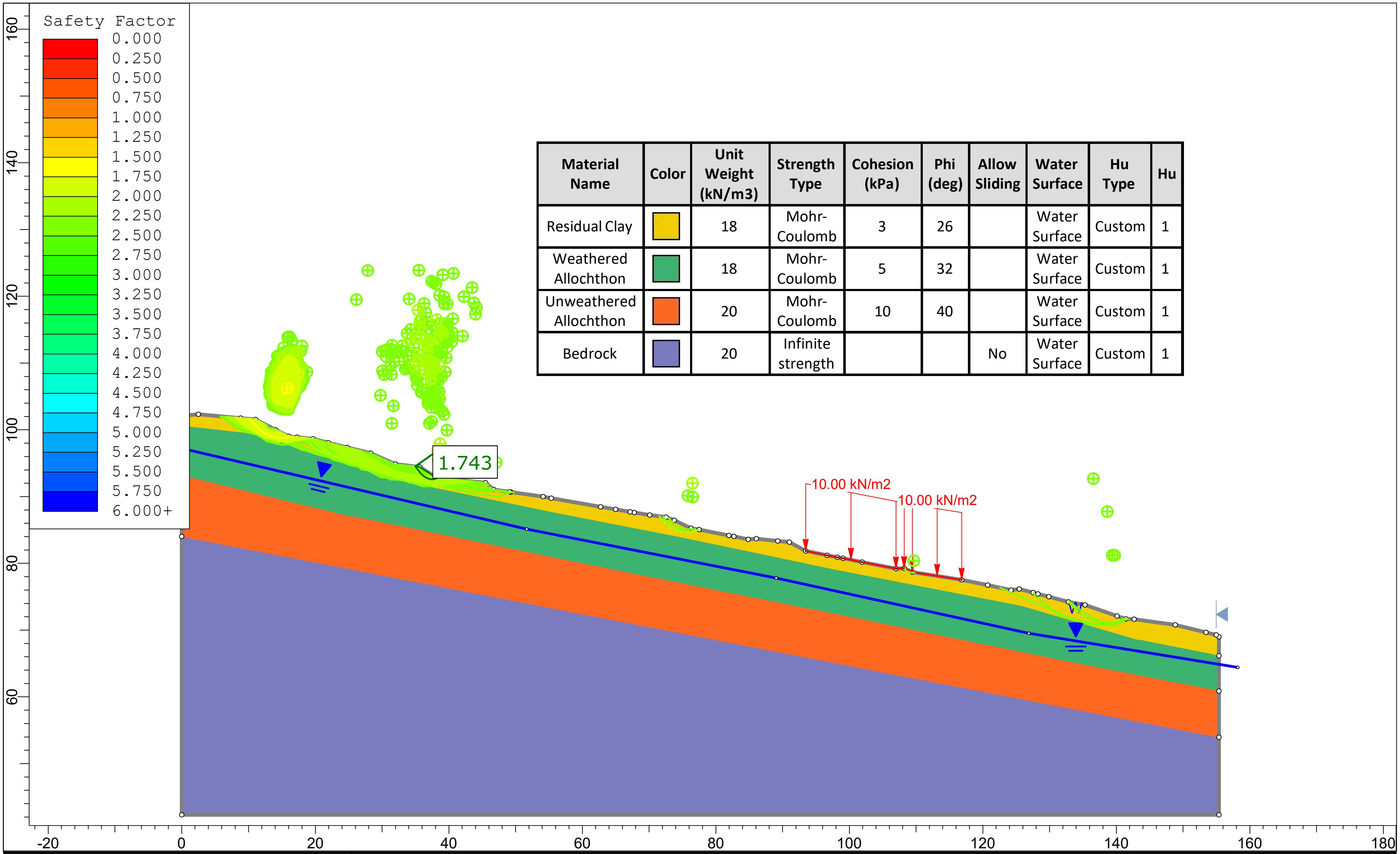


Project Settings
Project Title: 184 Koutu Loop Road, Whirinaki
Failure Direction: Left to Right
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces

LAND DEVELOPMENT & ENGINEERING

SLIDE 9.008

Project	18655 - 184 Koutu Loop Road, Whirinaki		
Group	Surcharge loads from dwelling	*Scenario*	Lot 2
Drawn By	G Harding	*Company*	LDE Ltd
Date	03/12/2020	*File Name*	18655 - 184 Koutu Loop Road, Whirinaki.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu
Residual Clay	🟨	18	Mohr-Coulomb	3	26		Water Surface	Custom	1
Weathered Allochthon	🟩	18	Mohr-Coulomb	5	32		Water Surface	Custom	1
Unweathered Allochthon	🟧	20	Mohr-Coulomb	10	40		Water Surface	Custom	1
Bedrock	🟪	20	Infinite strength			No	Water Surface	Custom	1

LAND DEVELOPMENT & ENGINEERING

SLIDEINTERPRET 9.008

Project
Geotechnical Investigation for Proposed Subdivision

Scenario
Lot 2

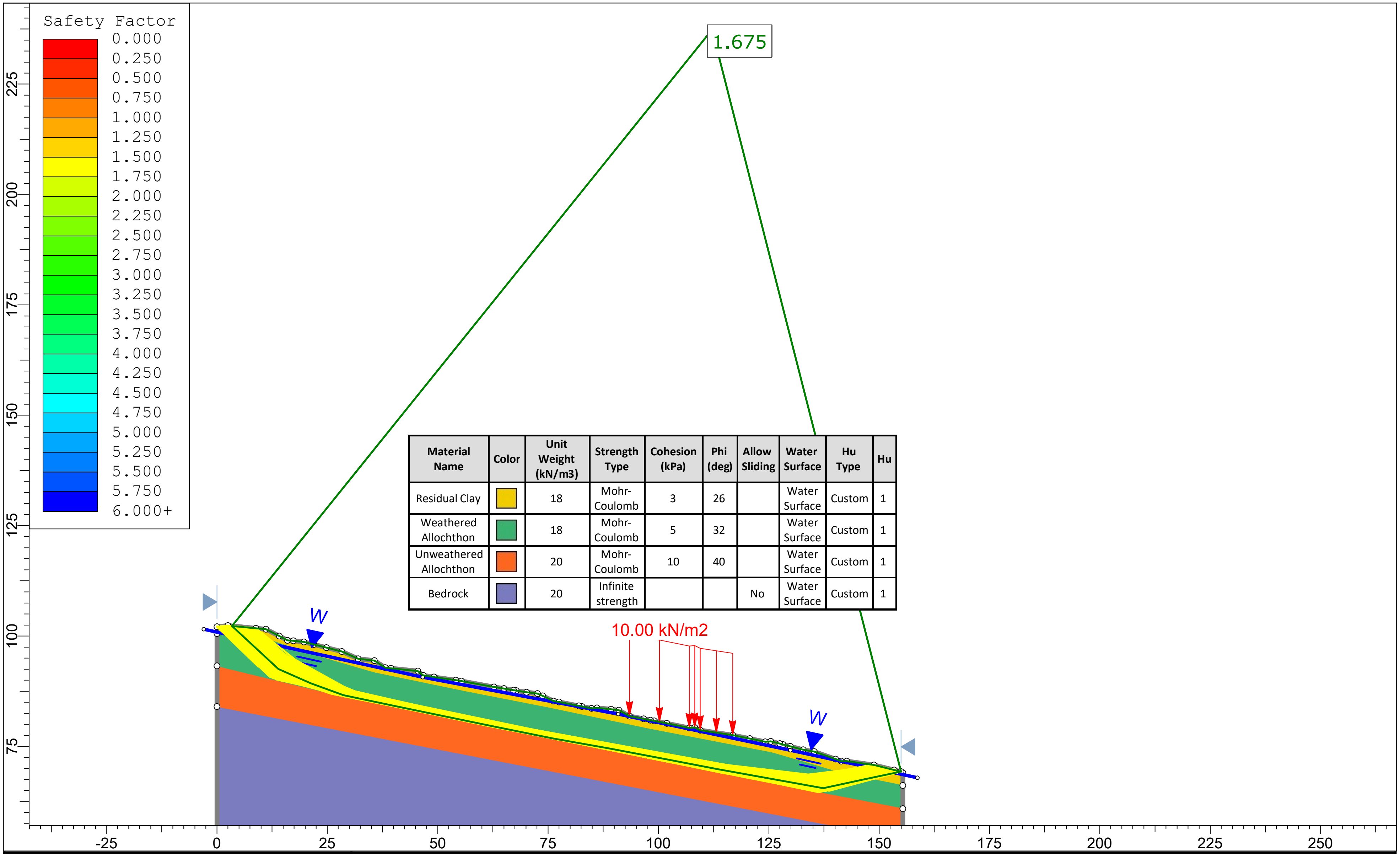
Scenario
Normal groundwater conditions

Drawn By
G Harding

Company
LDE Ltd

Date
03/12/2020

File Name
18655 - 184 Koutu Loop Road, Whirinaki.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu
Residual Clay	🟨	18	Mohr-Coulomb	3	26		Water Surface	Custom	1
Weathered Allochthon	🟩	18	Mohr-Coulomb	5	32		Water Surface	Custom	1
Unweathered Allochthon	🟧	20	Mohr-Coulomb	10	40		Water Surface	Custom	1
Bedrock	🟪	20	Infinite strength			No	Water Surface	Custom	1

LAND DEVELOPMENT & ENGINEERING

SLIDEINTERPRET 9.008

Project	Geotechnical Investigation for Proposed Subdivision		
Scenario	Lot 2	*Scenario*	Extreme groundwater conditions
Drawn By	G Harding	*Company*	LDE Ltd
Date	03/12/2020	*File Name*	18655 - 184 Koutu Loop Road, Whirinaki.slmd

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