Appendix 9

Geotechnical Report

GEOTECHNICAL INVESTIGATION REPORT

FOR

PROPOSED RESIDENTIAL DEVELOPMENT,

131 AND 189 THREE MILE BUSH ROAD, KAMO, WHANGAREI

Project Reference: 18733
24 June 2021

CONTENTS

1 INTRODUCTION

LDE Ltd was engaged to assess a proposed medium density residential development at 131 and 189 Three Mile Bush Road, Kamo, Whangarei (Figure 1).

No scheme plan for the development is presently available, however it is expected to comprise moderate density (~500-700m^2) residential lots serviced by a series of vested public roads and private right of ways.

The purpose of the assessment was to determine the geotechnical suitability of the land for development, consider geotechnical hazards posed to the development, and provide engineering recommendations for subdivision design and future residential construction, in accordance with Section 106 of the Resource Management Act (1991) and the Whangarei District Council (WDC) Environmental Engineering Standards (EES).

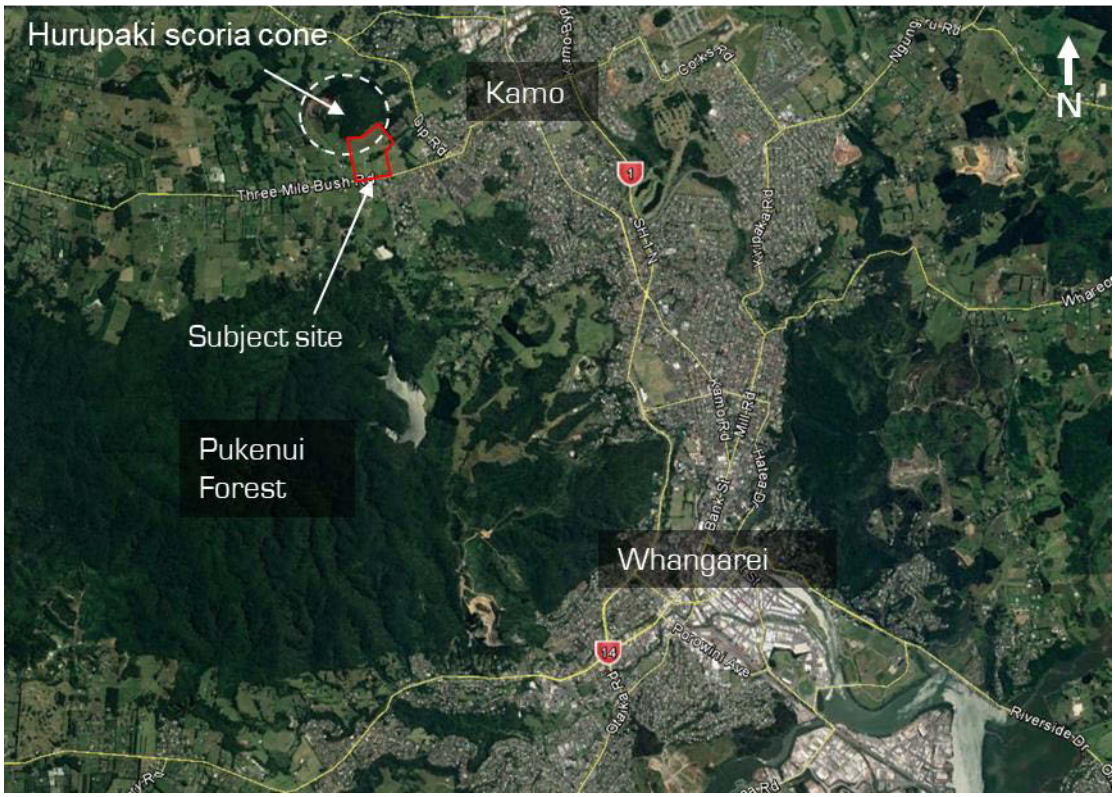

Figure 1: Location of site (Source Google Earth)

2 SITE SETTING

The proposed development encompasses two properties legally described as Lot 2 and Lot 3 DP 99045, being 131 and 189 Three Mile Bush Road, respectively. The properties, referred to hereafter collectively as 'the site', comprise a total area of approximately 13.98ha, positioned to the west of an on-going residential development ('The James', 115 Three Mile Bush Road) and immediately south of the Hurupaki scoria cone, approximately 5.5km northwest of Whangarei CBD (Figure 1).

The site is located at the urban boundary of Kamo township, with the area to the east of the site being entirely developed as residential housing. To the west the surrounding area is predominantly in lifestyle block type properties generally in pasture.

2.1 Site Features and Topography

The site can broadly be divided in to four topographic areas, as described below and shown on the plan in Figure 2 below. The topography has been assessed based on our walkover assessment and desktop study using NRC LiDAR topographic data (2018 survey).

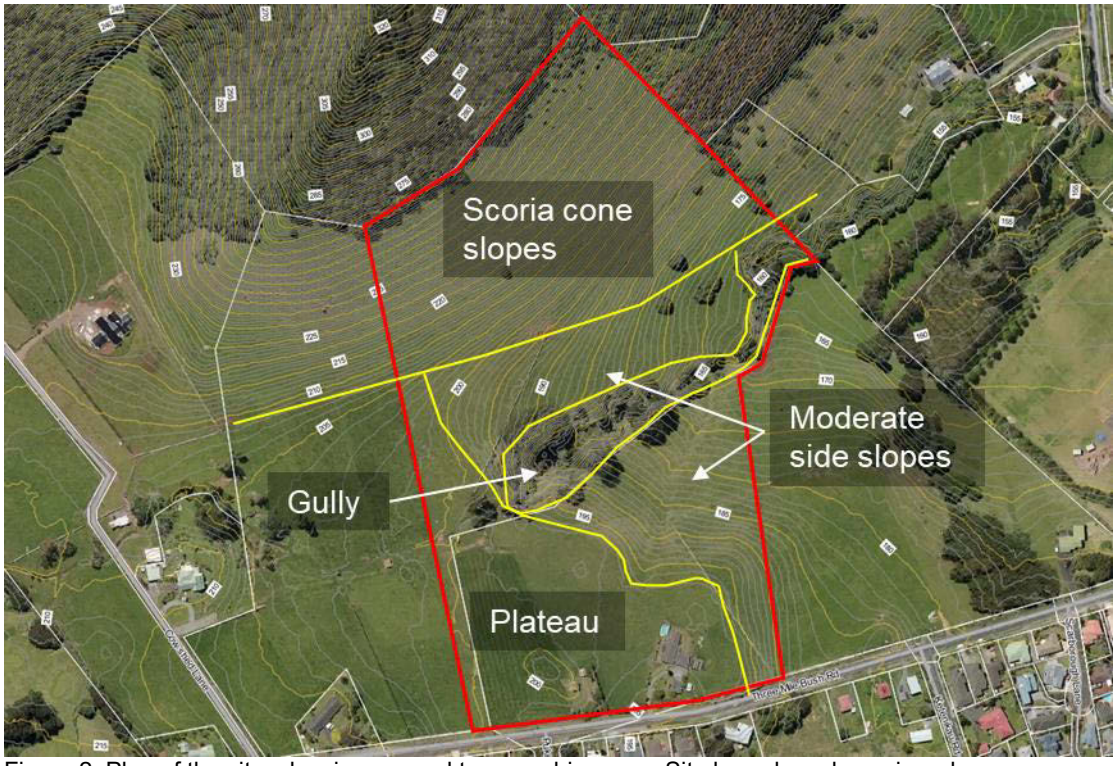

Figure 2: Plan of the site, showing general topographic areas. Site boundary shown in red.

2.1.1 Plateau (southwest of site)

The south-western part of the site comprises a broad, nearly level plateau landform of approximately 3.2ha. There are no notable topographic features within this area.

At the southern edge of this area, adjacent to Three Mile Bush Road, there are two existing dwellings, one main dwelling and one smaller dwelling, each within a fenced area isolated from the surrounding farmland. The larger dwelling (addressed as #131) is approximately 220m^2 in area with several detached sheds and a pool in its vicinity. It is understood that the septic system for this dwelling is located within the fenced area. The smaller dwelling is an old cottage of approximately 55m^2, to the west has a single detached garage. The septic system for this dwelling is understood to lie in the paddock to the east.

At the north-western end of the plateau area is the dwelling at #189. This appears to have been recently constructed and is situated at the end of the panhandle access to #189 and immediately above the head of the gully feature (described below). There is some landscaping and planting around and to the north of the dwelling.

2.1.2 Moderate Side Slopes (central-east of site)

To the north and east of the plateau area there is a sharp break in slope with slopes descending to the north and east beyond this. The upper part of these slopes is moderately steep at up to 1V:3.5H (16°), becoming more gentle through the middle and lower slopes (1V:5H, 11°).

These slopes are smooth and linear and display no features indicative of past or recent instability. There are several small 'bull holes' of exposed earth in the upper slopes.

The slopes are crossed by several fences including two dry-stone walls, one to the southeast and one to the northwest.

A gentle depression through the length of these side slopes appears to form an overland flow path which may drain part of the plateau area. The area appears stable with no active erosion. It is expected that this rarely has any flow.

2.1.3 Scoria Cone Slopes

Above the moderate side slopes, the northern third (approx.) of the subject site covers the lower and middle side slopes of the Hurupaki scoria cone. The slopes are steep (approx. 1V:2H, 27°) but have a smooth and linear geomorphology. The slopes are gently diverging, facing south-east to south, and wane towards the lower slopes. These slopes are entirely in pasture within the property and go into bush above the north-eastern boundary.

The slopes present no evidence of past or recent instability. Some evidence of minor erosion is present around troughs and fence lines, expected to be associated with livestock. No significant soil creep was apparent on the steep slopes.

2.1.4 Gully (central)

A well-defined gully area crosses the site from west to east (draining eastward), with its head at the edge of the plateau. The gully is deeply incised at the western end (approximately 20m depth) and gradually shallows to the east as the surrounding ground slopes down to meet it, becoming only a few metres deep at the eastern edge of the site. The gully invert is very gently sloping (shallower than 1V:10H).

The gully side slopes area very steep around the head at approximately 1V:1.5H (34°) and generally 1V:2H (27°) beyond this. The gully slopes present no signs of significant active or recent instability, and it appears from the topography of the feature that it has been formed through steady erosion rather than periodic regression through instability. However, some evidence of shallow creep type movement was noted on the southern side of the gully, where the fence appears to have been gradually undermined.

Several exposures of large basalt boulders are noted around the crest at the western end of the gully. Several areas of tephra soils are exposures through the mid-section of the steeper slopes. The gully floor is covered by cobble to boulder sizes clasts of loose basalt, with some possibly in situ basalt at the base of the gully head.

Figure 3: View west from the gully floor towards the gully head, showing basalt exposed beneath red tephra soils at the base of the gully slopes.

Figure 4: View west across the southern gully slope, showing large basalt promontory at crest of slope (top left), tephra soils immediately below, and boulders of basalt over the gully floor.

The gully is fed by overland flows through formed drains, originating to the west of the site, and sheet flows from the slopes to the north and south, forming a headwater of the Waitaua Stream. It is likely that groundwater seepage occurs at the head of the gully where it is most deeply incised. It appears to only flow during wet winter conditions and, during and immediately after heavy rainfall.

The gully is vegetated with mature trees, comprising a stand of Puriri on the northern side and a mixture of natives to the south. Several large pines have been removed from the area in preparation for the development.

2.2 Desktop Study

2.2.1 Geological Setting

The site is mapped as being underlain by Pleistocene basalt lava flows of the Kerikeri Volcanic Group (Puhipuhi – Whangarei Volcanic Field). This unit comprises basaltic lava flows stemming from nearby volcanic vents, constrained by modern topography. Lava flows are known to be up to 85m thick (over the Kamo coalfield), however are more typically 20-50m thick. The nearby Hurupaki scoria cone is one of the youngest in the field, and has an approximate age of 300,000 years (White & Perrin, 2003[1]).

[1] P.J. White and N.D. Perrin, 2003. *Geology of the Whangarei Urban Area*, GNS Science.

The volcanic field in the vicinity of the subject site comprises broad flat to gently east-ward sloping lava fields, forming elevated plateaus of the Kamo and Three Mile Bush suburbs, punctuated by a series of three scoria cones aligned west to east, of which Hurupaki is the eastern and largest. The central scoria cone (Rawhitiroa) has an in-tact crater lake, while Hurupaki and the western most scoria cone (Ngararatunua) appear to both have breached craters, indicated by arcuate depressions in the side of the otherwise conical form (Figure 3). The local volcanic field is confined to the south by the greywacke bedrock hills of the Pukenui Forest, and to the north by an older Pleistocene age rhyolite/dacite volcanic dome (Parakiore).

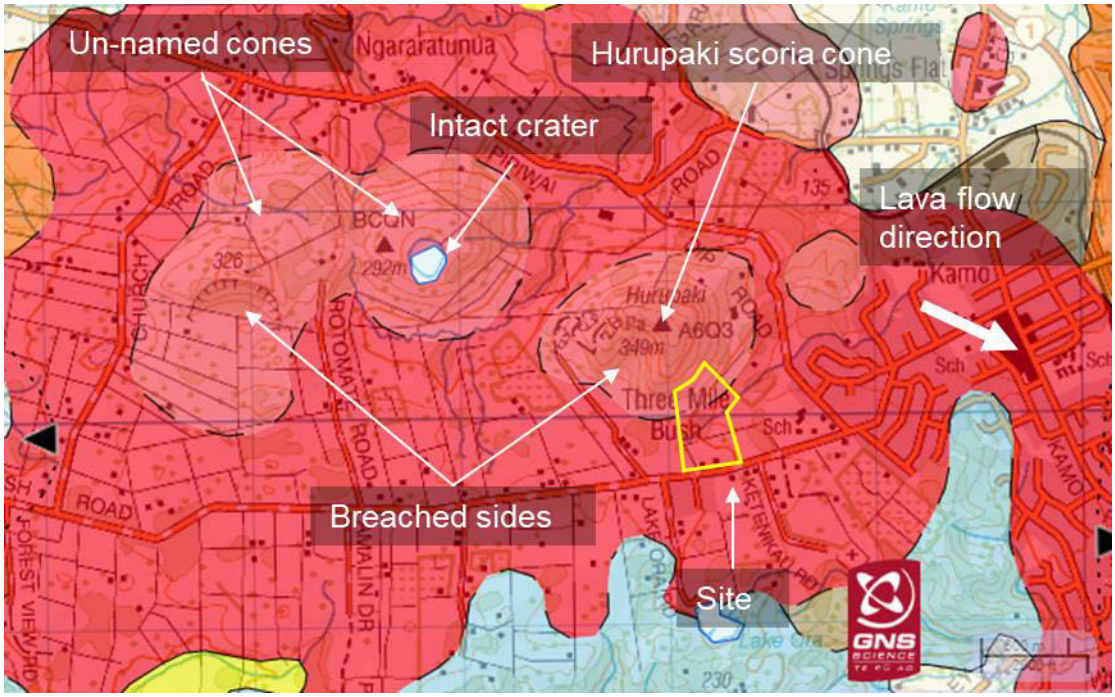

Figure 5: Clip of the NZ Geology Web Map, showing the mapped geological units in the vicinity of the site (outlined yellow). Dark red indicates lava flows, light red indicates scoria cones. Blue to the south indicates greywacke bedrock of the Pukunui Forest, confining the lava flow.

2.2.2 Mapped Hazards

The WDC Hazards Maps show the site as being predominantly low instability hazard through the plateau and side slope areas. The gully is mapped as moderate instability, as are the lower parts of the scoria cone slopes. The middle and upper scoria cone slopes, extending partially within the site boundary, are mapped as high instability hazard.

No flood hazard is mapped at the site, however the water course downstream from the site is mapped as flood susceptible from beyond Dip Road. This eventually drains to the Springs Flat flood plain.

The site is not mapped as being within an acid sulphate soil risk area or a mine subsidence hazard area.

2.2.3 Historical Aerial Imagery

Aerial imagery sourced from Retrolens[2] and Google Earth show no significant changes in site use over the period of available imagery (to 1942). The site appears to have remained in pasture over this period.

Aerial images show some relatively minor earthworks in the vicinity of the dwelling at no. 189, carried out through 2015-2017. This appears to include the placement of fill extending into the head of the gully.

3 Ground Conditions

3.1 Subsurface Investigation Summary

Our investigation of the site included the following work:

- 16 hand augered boreholes (HA01 – HA16) generally taken to 3m depth or refusal across the site, with measurements of undrained shear strength taken at 200mm intervals with a shear vane.
- 13 machine excavated test pits (TP01 – TP13) taken to a target depth of 4.0m using 22t and 14.5t excavators.
- Supplementary Scala penetrometer tests carried out various test pit and hand auger borehole locations, generally to 3m depth or refusal.
- Collection of three disturbed soil samples taken from select test pits (TP02, TP04 and TP05). All samples were taken from 0.5m to 0.7m depth. All samples were tested for Atterberg limits and and linear shrinkage for classification of plasticity and expansive soils properties.

The locations of the subsurface investigations are shown on the attached geotechnical investigation plan (Appendix A). Test logs, including test pit photos are attached as Appendix B, and laboratory test certificates are attached as Appendix C. The field work was completed through December 2020 and January 2021.

Test pits TP01 to TP10 were located by machine GPS calibrated to the bucket, and are therefore expected to be highly accurate for re-location if ever required. TP11 to TP13, and all hand auger boreholes have been located by phone GPS, expected to be accurate to +/-3m.

Table 1: Summary of subsurface geotechnical investigations carried out. Bold indicates Scala carried out from the base of boreholes, while the remainder were generally carried out from the surface adjacent to the relevant test site.

2 http://retrolens.nz/

Test ID	Depth (m)	Scala depth
HA01	0.35	0.25
HA02	0.6	0.80
HA03	0.55	1.35
HA04	1.7	2.4
HA05	3.0	-
HA06	0.9	**1.55**
HA07	3.0	-
HA08	1.1	**1.4**
HA09	0.3	**0.65**
HA10	2.9	-
HA11	0.35	**0.8**
HA12	3.0	-
HA13	3.0	-
HA14	3.0	-
HA15/15A	0.4	-
HA16	4.0	-

Test ID	Depth (m)	Scala depth
TP01	4.1	3.25
TP02	4.0	0.85
TP03	3.5	1.3
TP04	2.3	3.95
TP05	3.0	1.4
TP06	3.6	2.95
TP07	3.0	0.4
TP08	4.0	2.9
TP09	4.0	2.25
TP10	4.0	2.95
TP11	4.2	-
TP12	4.8	-
TP13	4.2	-

3.2 Subsurface Conditions

In summary, the site was found to be underlain by various volcanic deposits of the Kerikeri Volcanic Group, shown as the mapped geology of the site.

3.2.1 Topsoil

Topsoil was encountered across the surface of the site to 0.1 to 0.3m depth, comprising generally dry, slightly organic friable silt. The lower boundary of this unit was not well defined, with a gradational change into the underlying volcanic soils at most test sites. Organic content was predominantly within the upper 50-100mm, with the underlying topsoil being relatively competent silt.

3.2.2 Kerikeri Volcanic Group Soils

The upper soil profile generally comprised very stiff to hard, homogenous silt and clay, inferred to be residually weathered ash soils. These soils were assessed in the field as generally highly plastic, which is consistent with their USCS classification determined from lab testing (summarised below).

Within the plateau area, the shallow soils became gravelly with cobbles and boulders of weak to strong basalt and basalt scoria. Scala penetrometer testing through this unit indicated consistently high densities (moderately dense or greater), generally with refusal met with a short distance of encountering larger gravels. This depth varied between 0.35m and 2.0m, but averaged approximately 1.0m. It appears from the testing that this depth undulates across the plateau somewhat randomly, and that in some cases the tests were able to miss boulders to reach significant depth (e.g. HA10). In several cases the depth varied between tests undertaken in close proximity (e.g TP05 and HA04). At two locations the boulder surface protruded above ground level forming mound type landforms. Shallow pitting in these areas indicate that these are natural, rather than being stockpiled rocks collected from farm paddocks.

Over the moderate side slopes, the upper soils transitioned to generally sensitive silt or silty clay with increasing sand and gravel clasts of basalt scoria and lapilli, inferred to be weathered lapilli tephra (airfall deposit). Some low shear strengths were recorded within this lower unit, including from 2.4m in HA07 (~80kPa), below 2.6m in HA05, below 2.2m in HA14 and below 3.0m in HA16. These deeper sensitive soils appear to be somewhat allophanic and crushable, reducing significantly in volume on retrieval. The size and quantity of gravel clasts appears to generally increase with depth, consistent with the vertical grading of an airfall deposit.

No testing was carried out within the gully. Basalt is exposed on the upper side slopes as large, disjointed boulders. One large promontory of basalt is exposed on the south and may represent a section of flow remnant, with tephra soils exposed at lower elevation beneath this (Figure 4). The base of the gully is largely infilled with *ex-situ* basalt cobbles and boulders, with some possibly *in-situ* basalt at the base of the gully head.

3.3 Soil Moisture Profile and Groundwater Conditions

The soils across the site were generally dry to moist from the surface to termination or 2m to 2.7m, with isolated wet to saturated zones encountered below these depths. The permanent groundwater table was not encountered in our investigation, however based on the elevation of the site relatively to the stream to the north, it is expected that the groundwater table lies at some 3-4m below the lowest point of the site during summer months and is subject to significant seasonal fluctuation.

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 of the surface. In our opinion complete saturation of the ground is unlikely to occur.

3.4 Laboratory Testing

Samples taken from the shallow subsoils were tasted for Atterberg limits and linear shrinkage, for the purpose of classifying plasticity and expansive soil characteristics. Testing was undertaken by an IANZ accredited soils laboratory (GeoCivil).

The results were consistent across samples, with liquid limits in the range of 80 to 87%, plasticity index in the range of 37 to 39%, and linear shrinkage in the range of 19 to 22%. Results are tabulated below (Table 2) and test certificates are appended.

The results have been plotted on a Casagrande plasticity chart for classification in accordance with the USCS. This is shown below as Figure 4. All samples plot below the 'A line' as MH soils.

Table 2: Summary of Atterberg limit and linear shrinkage results. All samples taken from 0.5m to 0.7m depth at the respective test site.

Sample	Liquid Limit %	Plasticity Index %	Linear Shrinkage %
TP02	83	39	19
TP04	80	38	22
TP08	87	37	21

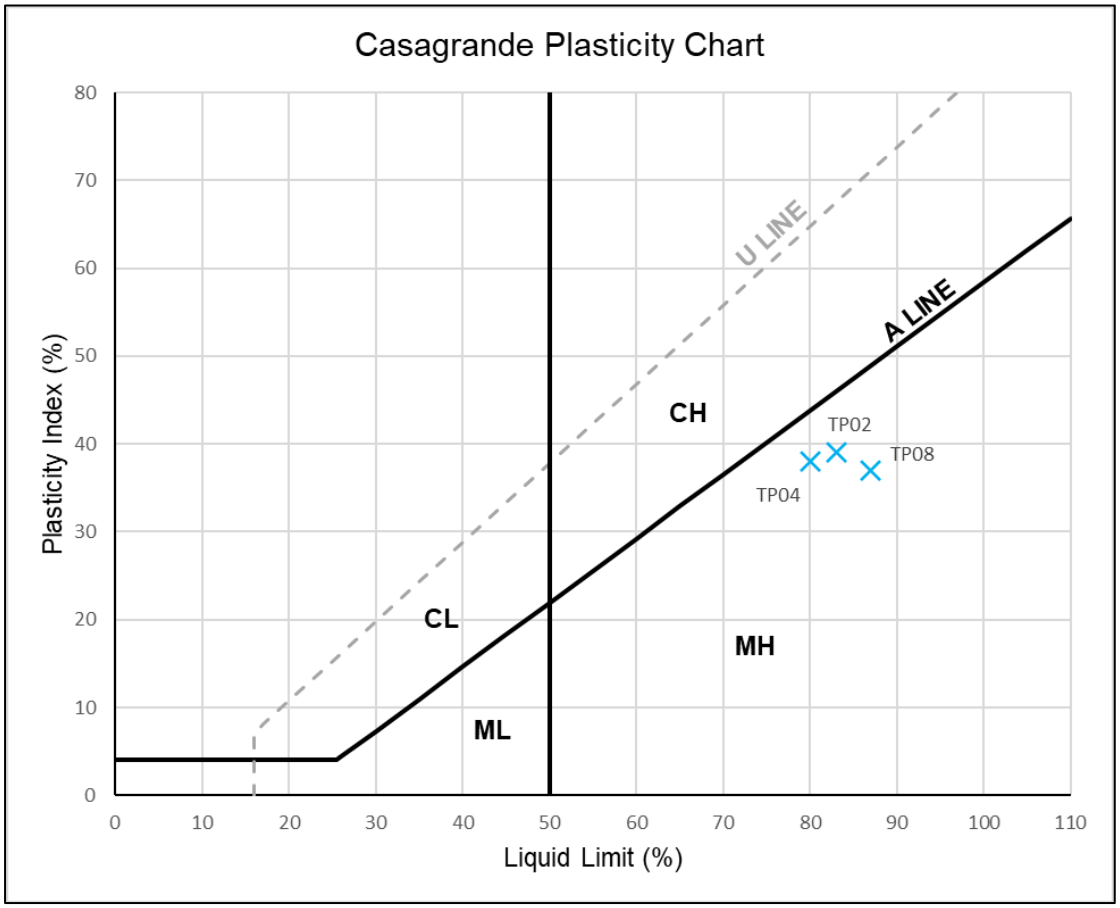

Figure 6: Test results shown against Casagrande plasticity chart for USCS classification.

3.5 Ground Model and Material Strength Parameters

The subsurface profile appears weathering basalt flow remnants across the plateau area, underlain by deeply weathered lapilli and boulder tephra (airfall) deposits which are near the surface across the moderate side slopes. These deposits are capped by a relatively thin layer of generally high strength, residually weathered ash.

The lava flow appears to have been limited in extent by the scoria cone, with the northern portion of the site expected to be underlain by scoria at depth.

Our idealised model of the ground conditions is shown in the attached stability model cross sections.

Based on our knowledge and experience of the subsoil at the site, the material strengths encountered on the site have been assessed against various published and unpublished correlations. Strengths have been factored to design conditions to account for seasonal variations in moisture content. These values are presented in Table 3 below.

Some low strength values were indicated by *in-situ* testing of the tephra deposit. However, in our experience with these materials, *in-situ* testing generally fails to characterise their strength due to their collapsible soil structure. Based on previous lab testing, back analyses and observations of slope performance, the below strength parameters are considered appropriate for stability analysis.

Table 3: Material strength parameters. *Basalt modelled with anisotropic strength to account for persistent vertical discontinuities.

Material	**γ (kN/m³)**	**C' (kPa)**	**Ø' (°)**	**S_u (kPa)**
Weathered ash (clay/silt)	17.5	5	30	120
Gravelly/lapilli tephra (sensitive silt with scoria/basalt gravel and lapilli)	13	10	30	100
Bouldery basalt (remnant lava flow)*	24	20	40	-

3.6 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", based on the depth of soil (including fragmented basalt) being generally greater than 3.0m.

4 NATURAL HAZARDS AND GROUND DEFORMATION POTENTIAL

4.1 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 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.

4.2 Slope Instability

The stability hazard for the various site areas have been assessed below through both qualitative, geomorphological assessment and qualitative (numerical) stability analysis where appropriate.

Numerical stability analysis has been carried out using RocScience software Slide v9. Cuckoo search was used to find critical failure surfaces. As the groundwater table was not encountered, and the near surface soils appear well draining, the Ru parameter was used to model pore pressures as a function of vertical stress.

Factor of safety criteria have been adopted from WDC *Land Development Stabilisation – Technical Design Requirements*[3] document dated April 2018, prepared by Tokin and Taylor.

4.2.1 Plateau and Moderate Side Slopes

The site comprises mostly flat to gently sloping land, with some areas of broad moderate slopes. These areas present no evidence of past instability, and given the high strength of the underlying ground and relatively low slope angles, we considered these areas to have a low instability hazard, consistent with the council hazard mapping.

[3] http://old.wdc.govt.nz/PlansPoliciesandBylaws/Policies/Documents/Land-Development-Stabilisation-Technical-Design-Requirements.pdf

We expect the proposed development will have minimal impact on the stability of these areas, provided the depth of unsupported cut and fill batters is limited as outlined in Section 5. Any proposed earthworks beyond these limitations should be subject to specific geotechnical assessment to confirm that any negative effects on slope stability are mitigated.

4.2.2 Gully

The gully area, extending east-ward through the centre of the site, is mapped as moderate instability hazard on the WDC hazard maps. The gully has very steep and tall side slopes which appear generally stable but show evidence of soil creep at their crest.

The gully feature appears to have formed through gradual erosion rather than periodic instability, giving it a relatively uniform shape with no evidence of active instability. The slopes are however expected to have eroded to a natural equilibrium and are therefore likely to have an existing factor of safety below acceptable criteria for residential development.

To assess the stability hazard of the gully feature, numerical slope stability analysis has been carried out for a critical side slope section (CS-2), on the southern side of the gully head. Back analysis was used to calibrate modelled groundwater conditions and material strength parameters, using an assumed minimum factor of safety of just above 1.0 under extreme conditions.

The remnant basalt flow was modelled using an anisotropic strength, with the design parameters used for horizontal strength and reduced strength in line with a weak soil used for vertical failure. This reflects the expected nature of failures through this unit, which would follow vertical joints which are expected to be relatively continuous through the unit. This is a conservative assumption given the basalt, where exposed, was not pervasively jointed.

The stability analysis was used to determine minimum setback distances from the slope crest to meet factor of safety criteria. Results are summarised below.

Table 4: Stability analysis results to determine minimum gully setback.

Scenario	Minimum FoS[3]	Setback required
Normal (design conditions)	1.5	14m
Extreme groundwater	1.3	8m
Seismic (500-year/ULS)	1.1	10m

The analysis has been undertaken at the critical point where the gully slope is steepest and highest (~15m). Towards the east the slope height tapers down to a minimum of approximately 4m, and the slope angle gradually becomes shallower. The minimum setback requirement from this slope may be reduced in line with the slope height, to a minimum of 5m from the top of bank without site specific assessment.

The northern side of the gully is generally less steep with the slope rounding over at the crest. A nominal 7m setback from the crest is recommended across the upper slopes without specific assessment.

Building close to the slope may be possible if mitigation measures are incorporated into the development of individual lots. Mitigation measures could include down-cutting of the lots or slope retention.

The building setback line has been plotted on the attached plan. This should be accounted for in development plans. The setback line and any further stability requirements should be reaffirmed on completion of subdivision works and referenced by way of title notice on any affected lots, unless otherwise mitigated as part of the subdivision works.

4.2.3 Scoria Cone

The development is expected to extend across the moderate slopes immediately below the scoria cone, with some lots extending onto the base of the cone. As a result, the risk of inundation from the scoria cone slopes onto the development area has been assessed.

The nature of scoria cone deposition makes them fundamentally stable features when undisturbed. Scoria is deposited as viscous molten rock through fire-fountaining and hardens over time. During the eruption period failure of the cone can occur resulting in breaches (such as that to the west of the site). However, as the deposited scoria solidifies, the factor of safety of the slope is expected increase rapidly from a minimum of 1, and therefore is inferred to be significantly greater than 1 in its present state.

The scoria quarry on the western side of Hurupaki serves as a test of the slopes' stability. The quarry is cut into a series of benches directly into the cone. The batters between benches are cut near-vertical to heights of 10 to 15m. In our review of recent aerial imagery, no evidence of past slope failure at the quarry was observed.

As a result, we consider that the existing cone slopes are stable and have a factor of safety well above acceptable criteria. Bulk earthworks associated with the proposed development are not expected to have an appreciable effect on global stability. However deep cuts into the toe of the slope as part of individual lot development may result in an increased risk of shallow instability.

As a result it is recommended that all cuts into the steep scoria cone slopes be retained or otherwise subject to specific geotechnical assessment to confirm stability.

4.3 Compressible Ground and Consolidation Settlement

The soils encountered in the subsurface investigation comprised silt and clay soils of high strength, which are expected to have very low compressibility, underlain by clast supported basalt cobbles/boulders in a silt/clay matrix, which is expected to be practicably incompressible.

The development is expected to involve the construction of conventional single level residential dwellings of light timber frame construction, with distributed loads up to approximately 10kPa. Earthworks are expected to involve cutting and fillings several metres in depth across the sloping areas of the site. Imposed loads from filling are expected to be limited to approximately 70kPa (i.e. up to approximately 4m of fill).

Under the expected loads from the development, the risk presented by consolidation settlement is expected to be negligible.

4.4 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.

Laboratory testing of linear shrinkage and liquid limit was carried out on three discrete samples collected from across the subject site, to inform the expansive soils classification.

Lab results are presented in Section 3.5 (Table 2) above. All samples showed liquid limits and linear shrinkage values in excess of the criteria for expansive soils as outlined in NZS3604 (2011). The soils therefore lie outside of the definition of good ground and required classification in accordance with AS2870 (2011) and B1/AS1. Direct laboratory testing of shrink swell index (I_{ss}) has not been adopted as suggested in AS2870 and B1/AS1, due to recent published data on the limitations of this testing, particularly during summer.

The shrinkage and swelling potential of the shallow soils depends on both the clay fraction of the soil, and the activity (or reactivity) of the clay fraction. This is further augmented by climatic conditions and local topographic factors such as water table and rock head depth, cut to fill, and the presence of trees.

The soils appear to be generally silt dominated from field assessment and fall below the Casagrande ‘A-line’ as shown on Figure 5. The soils plot as very highly plastic on the basis on liquid limit (70% < LL < 90%).

The findings of the investigation and laboratory testing generally indicate moderate clay fraction and high clay activity. We consider the shallow soils to be broadly consistent with Class M –

Moderately Expansive soils as described in AS2870 (2011) with an upper bound design characteristic surface movement (Y_s) of 44mm (factored for the 500-year drought event).

Where the soil mass becomes gravel dominated within 1.5m of finished ground level, the site class can be reduced on the assumption that gravel dominated soil masses are broadly non- or very slightly expansive. This is likely the case over much of the plateau area.

Where finished ground level is cut or filled, design characteristic surface movements should be factored in accordance with AS2870.

Final expansive soil site classes should be specified as part of earthworks completion reporting for the subdivision, based on finished cut-fill depths and any further testing carried out.

4.5 Conclusions

From our assessment of the natural hazard and ground deformation risks presented to the proposed development we consider that the land is adequately safe from natural hazards, provided that the recommendations given in Section 5 are adhered to.

5 Engineering Recommendations

5.1 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. We should be contacted immediately should the ground conditions encountered vary from that described in this report.

5.2 Building Platform Development

It is anticipated that as part of the subdivision works, level building platforms will generally be provided in each lot.

Within the plateau area minimal earthworks will be required to form level platforms. Minor re-levelling may be required to provide stormwater flow paths and to take down the slight mounds present within the area. Earthworks are expected to involve cuts and fills up to approximately 1m in depth.

On the moderate side slopes, more significant earthworks will be required to provide level platforms. Slopes within this area are generally at about 1V:5H and locally up to approximately

1V:4H. For a nominal building platform width of up to 15m, platforms are expected to cover an elevation range of up to approximately 3-4m. Cut/fill depths between platforms are expected to be around this figure, although this may vary where there is bulk re-levelling of the site (i.e. to flatten to moderate slope through cutting down significantly at the crest).

Preliminary, simplified stability checks indicate that terracing of the site into building platforms of 15m width with cut and fill batters, while maintaining the existing average slope gradient, will not significantly impact the factor of safety for localised failures or global instability. It is however recommended that this be re-affirmed during the subdivision earthworks design process though further stability checks.

Engineered retaining walls may be used to support batter slopes and increase flat areas within sites, and may be required with design beyond the cut and fill batter limitations. Recommendations for retaining wall design are given below.

Careful construction of building platforms will be required to ensure their long term stability and to ensure good founding soil is available for the future dwellings at each site. To achieve this the following recommendations should be adopted.

5.2.1 Cuts

Permanent cut slopes are expected to remain stable at 1V:2H (27°), for vertical heights up to 3.0m. For vertical heights up to 4.0m the batter slope should be reduced to 1VL2.5H (22°). Cuts in excess of 4.0m should be subject to specific assessment, with retaining or benching potentially required.

5.2.2 Fills

Earth-fills should be limited to a maximum height of 4m without specific geotechnical assessment. The slope of the fill needs to be kept below a maximum gradient of 1V:2H (27°), or otherwise may be retained.

The near surface residually weathered ash material (clay and silt) is considered to be suitable for use as earth-fill.

Cobbly soils comprising a high proportion of basalt rock clasts are considered generally unsuitable for earthfill without processing to screen out larger clasts or otherwise crush this material into a suitably graded PSD curve. It is generally recommended that the cut-fill design for the subdivision avoid deep cuts (>1.0m) into the plateau area wherever possible.

Cuts within the moderate slopes to a depth of 3.5m to 4.0m are expected to yield relatively clean fine soil which is considered suitable for use as engineered earthfill. Below 3.5 - 4.0m the soils are expected to become cobbly and likely bouldery. Cutting below this depth should be avoided.

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. The toe of all fill slopes should be checked into sloping subgrade with a level pad at least the width of the roller. Filling over subgrades steeper than 1V:4H should be subject to specific assessment.
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.
5. The fill should be compacted to achieve the criteria given in the Table 4 below.

Table 4: Recommended fill compaction criteria.

Undrained shear strength for cohesive fill (measured by *in situ* vane to plasticity corrected shear strength values)		
	Average not less than	140kPa
	Minimum single value	110kPa
Dynamic penetrometer (non-cohesive fill)		
	Average value not less than	2 blows/50mm
	Minimum single value	1.5blows/50mm
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%

Provision should be made to ensure that the earthworks are conducted with due respect for the weather. The fill should not be placed on to wet ground, especially if ponded water is present.

5.2.3 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 on building platforms or against any retaining walls. 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.

5.2.4 Retaining Walls

The following recommendations are made to assist with the engineering design of any retaining walls:

1. The wall design should assume material strength parameters has given in Section 3.6. The appropriate material parameters should be selected based on location, and if there is any uncertainty specific geotechnical advice should be sought, and in some cases it may be appropriate to carry out specific geotechnical investigations for retaining walls.
2. Retaining wall systems should be selected as appropriate for the ground conditions at the proposed location. Embedded pile walls may not be feasible in areas underlain by shallow bouldery ground.
3. Allowances should be made for sloping ground above and below the walls, and for any surcharge loads that may be applied to the wall.
4. Enhanced behind wall drainage is recommended. The excavation for the drainage unit should be lined in a non-woven geotextile (filter cloth) prior to placement of the drainage metal to minimise the potential for siltation. A 100mm diameter slotted drainage coil surrounded with at least 50mm of drainage metal should be placed at the base of the drainage unit. Drainage metal should comprise clean 10mm to 20mm angular durable

gravel (drainage metal) which should extend up to 70% of the wall height. The top of the drainage unit should be wrapped in filter cloth.

5. Low permeability soil should be placed into the top of the excavation above the drainage unit. The soil should be compacted in layers not exceeding 200mm using a small compactor (e.g. “wacker packer”) to achieve a minimum strength of 1 blow per 50mm using a Scala penetrometer or 80kPa using a hand held shear vane.
6. The drainage coil should be connected to the stormwater system for the development.

At the construction stage the pole holes or foundation excavation should be checked by a Building Inspector or Suitably Qualified Professional to ensure that the soils encountered are consistent with those described in this report and that the depth of the excavation meets or exceeds the engineering design requirements. The wall designer should be contacted immediately should differing conditions be encountered. Alteration of the design may be required.

5.3 Building Setback Lines

The slopes around the head of the gully feature in the centre of the site have been found to be of marginal stability, not meeting acceptable factor of safety criteria for residential development. Building setback lines have been determined to provide safe building sites meeting the minimum factor of safety criteria.

The building setback has been specified as 10m from the top of bank line at the head of the gully, tapering to 5m at the eastern end of the gully.

Structural fills supporting dwellings should be kept behind the setback line, and no landscaping fill should be placed within the setback area.

Building or filling within the setback area may be possible subject to site specific assessment to ensure the instability hazard adequately mitigated.

5.4 Foundation Design and Construction Recommendations

Preliminary recommendations for foundation design are given below based on the existing site condition and our general understanding of the earthworks likely to be carried out. The foundation design recommendations should be reaffirmed or amended at the earthworks completion stage on a lot by lot basis. Due to the variability in ground conditions and ground strength across the site, it is recommended that verification testing within each building platform is carried out at the completion stage of the development or at the building consent stage of development of individual lots.

Due to the expansive nature of the soils across the site, and the presence of variable weak sensitive soils at depth, we consider that raft-slab foundations designed in accordance with AS2870 (2011) to be most appropriate for the site.

Foundations should be designed to accommodate the expansive soils at the site. Site specific classification will be required to account for final cut and fill depths and to incorporate any further testing to be carried out during earthworks as part of geotechnical completion reporting. The shallow soils appear consistent with Class M, and it is expected that most sites will fall into this category on completion.

Foundation design should account for 500 and 1000-year drought events in accordance with B1/AS1 and BRANZ Study Report SR120A, which provide factors for design characteristic surface movements above those given in AS2870.

A geotechnical ultimate bearing capacity in excess of 300kPa is expected to be available for shallow bearing slab foundations on cut natural ground or engineered fill.

5.5 Surface Water Disposal

The subdivision will be serviced by a reticulated stormwater system vested in council. The stormwater system is expected to discharge to the natural watercourse at the low point of the site. All runoff from impervious areas should be collected by this primary stormwater system.

A site specific stormwater assessment and attenuation design will be required to support the resource consent for the development. It is expected that a stormwater pond/ponds will be utilised to control runoff from the site and meet WDC EES and catchment management plan requirements. Conceptual design for the stormwater system is not yet available.

The design and siting of any stormwater pond should be subject to geotechnical assessment. Site specific investigation and assessment is recommended for the sites of any large embankments to form ponds, following preliminary design.

5.6 Roading

It is expected that the development will be served by one or several public roads and a series of private right of ways.

Earthworks for the road should be carried out in general accordance with the recommendations above for building platforms.

Based on the Scala penetrometer testing carried out across the site, a subgrade CBR in excess of 7% is expected to be available. This should be confirmed once the proposed roading layout is available.

6 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.

7 OTHER CONSIDERATIONS

This report has been prepared exclusively for Hurupaki Holdings Ltd 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. Land Development & Exploration 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.

This report has been prepared for Resource Consent purposes. As such, recommendations given may be conservative to allow for differing ground conditions that may not have been identified in the level of investigation carried out for this purpose. The recommendations given may be able to be refined at the Building Consent Stage with detailed subsurface investigation and analysis that is specifically undertaken for the particular structures proposed for the sites.

For and on behalf of LDE Ltd

Report prepared by:

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Report reviewed & authorised by:

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CPEng, IntPE(NZ), CMEngNZ
Chartered Professional Engineer – Geotech/Civil/Structural

Find out more about LDE professionals

L:\18700 to 18799\18733 131 and 189 Three Mile Bush Road, Whangarei\05 Reporting\18733 GIR 131 - 139 Three Mile Bush Road_final.docx

APPENDIX A

GEOTECHNICAL INVESTIGATION PLAN

LDE LAND DEVELOPMENT & ENGINEERING LTD.	Geotechnical Investigation Plan 131 and 189 Three Mile Bush Road, Whangarei	Project Number: 18733 Date: 18/03/2021 Drawn by: Finlay Wallen Scale A3: 1 : 2000

APPENDIX B

SUBSURFACE INVESTIGATION DATA

1. HAND AUGER BOREHOLE LOGS

2. TEST PIT LOGS

Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA01**				
Project ID:	18733				
Sheet:	1 of 1				
Client:	CC Developments LTD	**Coordinates:**	6049848mN, 1716125mE	**Test Date:**	11/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2864

Depth (m)	Graphic Log	Material Description	Geology	Water
0.0	TS	Organic silty SAND (OL); brown. Dry; non plastic.	Topsoil	Groundwater Not Encountered
0.5	×	Sandy SILT (ML); light brown. Dry; low plasticity.	Kerikeri Volcanic Group	
1.0				
1.5				
2.0				
2.5				
3.0				

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm)

2 4 6 8

Shear Vane, Su (kPa)

50 100 150 200

Test Values	Depth (m)
79 / 20	0.0
10	-0.5
	-1.0
	-1.5
	-2.0
	-2.5
	-3.0

Hole Depth: 0.35m

Termination: inferred underlying boulders

Remarks:

Materials are 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

UTP = Unable to Penetrate

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Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA02**				
Project ID:	18733				
Sheet:	1 of 1				
Client:	CC Developments LTD	**Coordinates:**	6049792mN, 1716122mE	**Test Date:**	11/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

Depth (m)	Material Description	Geology
0.0	Organic sandy SILT (OL); brown. Dry; non plastic. Friable.	Topsoil
0.5	SILT (MH), with minor clay; brown. Dry; high plasticity. Friable.	Kerikeri Volcanic Group
1.0		
1.5		
2.0		
2.5		
3.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values: ▶12, ▶20

Hole Depth: 0.60m

Termination: inferred underlying boulders

Remarks:

Materials are 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

UTP = Unable to Penetrate

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Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA03**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049819mN, 1716177mE	**Test Date:**	11/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

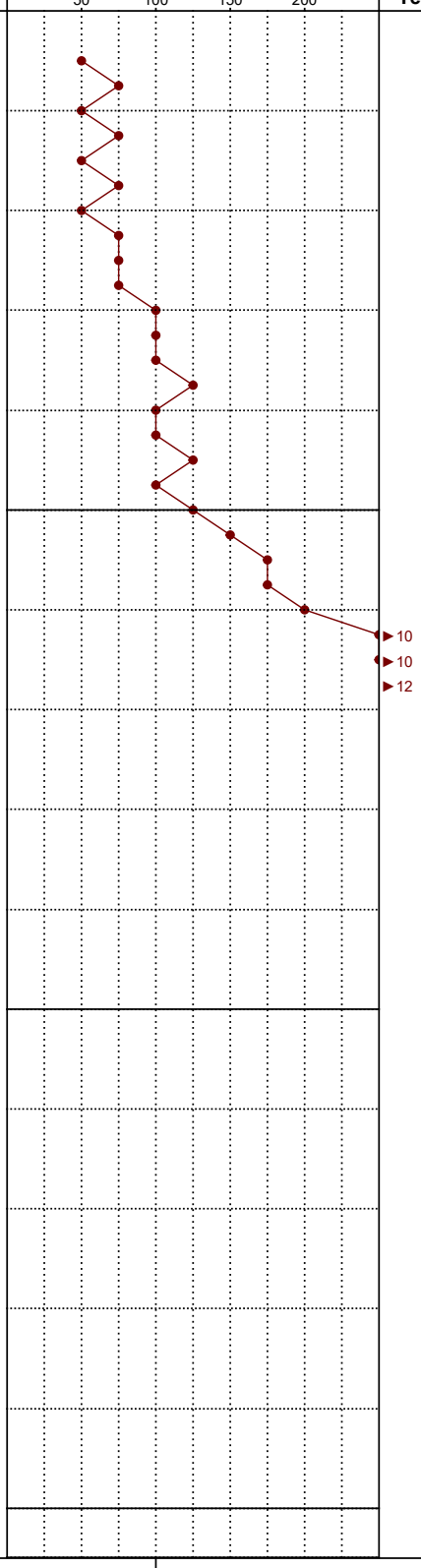
Depth (m)	Graphic Log	Material Description	Geology
0.0	TS	Organic sandy SILT (OH); brown. Dry; non plastic. Minor rootlets.	Topsoil
0.5		SILT (MH), with some clay; light brown. Very stiff; dry; high plasticity. 0.4m: becomes dry to moist and mottled yellow.	Kerikeri Volcanic Group

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm)

Shear Vane, Su (kPa)



Test Values

Depth (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

Hole Depth:	0.55m
Termination:	inferred underlying boulders
Remarks:	

- Vane peak
- Vane residual
- Vane UTP
- Standing water level
- Groundwater inflow
- Groundwater outflow

UTP = Unable to Penetrate

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

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Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA04**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049766mN, 1716162mE	**Test Date:**	11/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	1945

Depth (m)	Material Description	Geology
0.0	Organic SILT (OH); brown. Dry, high plasticity.	Topsoil
0.5	SILT (MH), with minor clay and trace gravel; brown. Very stiff; moist; high plasticity. Gravel, fine; friable.	Kerikeri Volcanic Group
	0.8m: becomes sandy and minor gravel. Sand, fine to coarse; gravel, fine.	
1.0	1.0m: becomes some sand and dark brown. Sand, fine to coarse.	
	1.1m: becomes sandy and minor gravels; brownish grey. Sand, fine to coarse; gravel, fine.	
1.5	Gravelly sandy SILT (MH); dark brown. Very stiff; moist; high plasticity. Gravel, fine to medium; sand, fine to coarse.	
2.0		
2.5		
3.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values	Depth (m)
255+	-0.5
219 / 55	-1.0
223 / 55	-1.5
UTP	-2.0
164 / 64	-2.5
UTP	-3.0
▶10	
▶10	

Hole Depth: 1.70m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

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Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA05**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049804mN, 1716246mE	**Test Date:**	11/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	1945

Depth (m)	Material Description	Geology
0.0	Clayey SILT (MH); brown. Very stiff, dry, high plasticity.	Topsoil
0.5	SILT (MH), some clay and trace sand; brownish orange. Stiff; moist to dry; high plasticity. Sand, coarse.	Kerikeri Volcanic Group
1.0	0.9m - 2.6m: becomes orangish brown.	
1.5		
2.0	2.1m: becomes minor clay and minor sand. Sand, fine to coarse.	
2.5	SILT (ML), with minor sand and trace clay; greyish brown with black and purple mottling. Very soft; wet; low plasticity. Sand, fine to coarse.	
	2.8m - 2.9m: becomes brownish orange.	
3.0	Silty sandy GRAVEL (GP); brownish orange. Stiff; wet. Gravel, medium to coarse; sand, fine to medium.	

Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Depth (m)	Test Values
0.0	201 / 62
-0.5	255+
	255+
	255+
-1.0	128 / 27
	137 / 36
	150 / 29
-1.5	142 / 36
	150 / 49
-2.0	128 / 53
	99 / 36
	142 / 26
-2.5	15 / 0
	128 / 33
-3.0	128 / 27

Hole Depth: 3.00m

Termination: Reached target depth

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

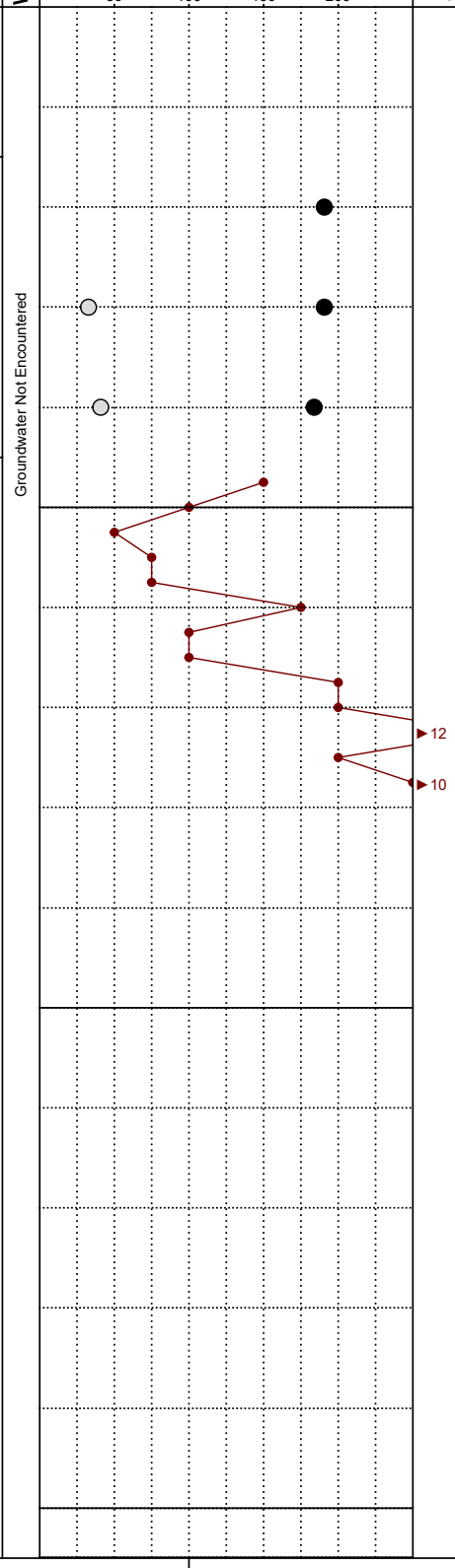
Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA06**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049893mN, 1716159mE	**Test Date:**	22/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); reddish brown. Dry; no plasticity. Trace rootlets; friable.	Topsoil
0.5	Silty CLAY (CH); brownish red. Stiff; dry; high plasticity. 0.6m: becomes mottled orange. 0.7m: becomes some sand. Sand, fine, grey.	Kerikeri Volcanic Group
1.0		
1.5		
2.0		
2.5		
3.0		

Water: Groundwater Not Encountered



Hole Depth: 0.90m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA07**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049949mN, 1716231mE	**Test Date:**	22/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); reddish brown. Dry; non plastic. Trace rootlets; friable.	Topsoil
	CLAY (CH), with some silt; brownish red with some black mottling. Stiff; dry to moist; high plasticity.	Kerikeri Volcanic Group
0.5	0.5m: becomes moist. Black mottling ceases.	
1.5	1.6m: becomes trace gravel. Gravel, medium to coarse.	
2.0	1.9m - 2.2m: becomes trace gravel; brown. Gravel, fine, yellow.	
	Clayey SILT (ML), with trace gravel; brownish orange. Stiff; moist to wet; low plasticity. Gravel; medium; black.	
2.5	2.4m: becomes mottled brownish orange.	
3.0		

Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values	Depth (m)
82 / 30	-0.5
65 / 27	
191+	
191+	-1.0
157 / 33	
191+	-1.5
163 / 49	
191+	
191+	-2.0
191+	
82 / 22	-2.5
79 / 18	
76 / 22	
82 / 26	-3.0

Hole Depth: 3.00m

Termination: Reached target depth

Remarks:

Materials are 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

UTP = Unable to Penetrate

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Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA08**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049868mN, 1716158mE	**Test Date:**	22/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2864

Depth (m)	Graphic Log	Material Description	Geology
0.0	TS	SILT (ML); brown. Dry; non plastic. Trace rootlets; friable.	Topsoil
0.5		Silty CLAY (CH); reddish brown. Stiff; dry to moist; high plasticity.	Kerikeri Volcanic Group
1.0		0.9m: becomes mottled orange and brown.	
1.5			
2.0			
2.5			
3.0			

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values	Depth (m)
116 / 27	-0.5
123 / 38	
125 / 30	
102 / 27	-1.0
	-1.5
	-2.0
	-2.5
	-3.0

▶30

Hole Depth: 1.10m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA09**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049861mN, 1716222mE	**Test Date:**	22/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

Depth (m)	Graphic Log	Material Description	Geology
0.0	TS	SILT (ML); brown. Dry; non plastic. Trace rootlets; friable.	Topsoil
0.3		SILT (MH); brown. Dry; high plasticity. Friable.	Kerikeri Volcanic Group

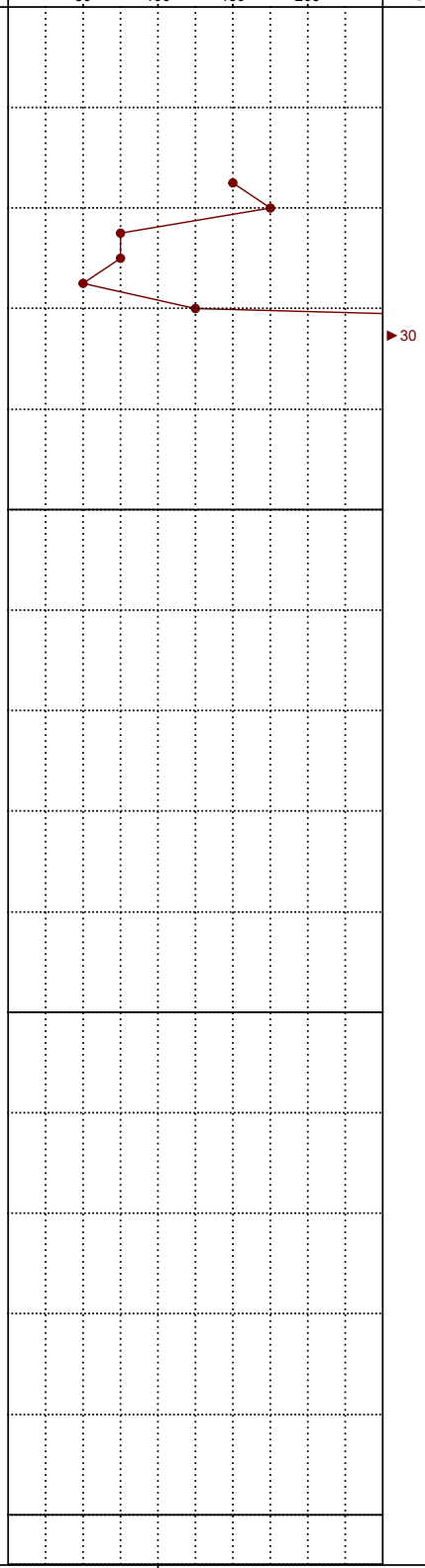
Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values



Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 (-0.5, -1.0, -1.5, -2.0, -2.5, -3.0)

Hole Depth: 0.30m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

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Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA10**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049751mN, 1716092mE	**Test Date:**	22/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8; Shear Vane, Su (kPa) 50 100 150 200	Test Values	Depth (m)
0.0	Organic SILT (OL); brown. Dry; non plastic. Trace rootlets; friable.	Topsoil	Groundwater Not Encountered			0.0
0.5	Silty CLAY (CH); brown. Stiff; dry to moist; high plasticity. 0.4m - 2.0m: becomes reddish brown.	Kerikeri Volcanic Group			191+ 163 / 41 123 / 27 UTP UTP 136 / 19 163 / 23 140 / 29 129 / 20 109 / 25 106 / 27 104 / 20 UTP	-0.5 -1.0 -1.5 -2.0 -2.5
2.0	Gravelly CLAY (CL), with some silt; reddish brown. Stiff; wet; low plasticity. Gravel; fine to coarse; orange.					
3.0						-3.0

Hole Depth: 2.90m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger & Scala Penetrometer Tests

Test ID:	**HA11**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049800mN, 1716312mE	**Test Date:**	25/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

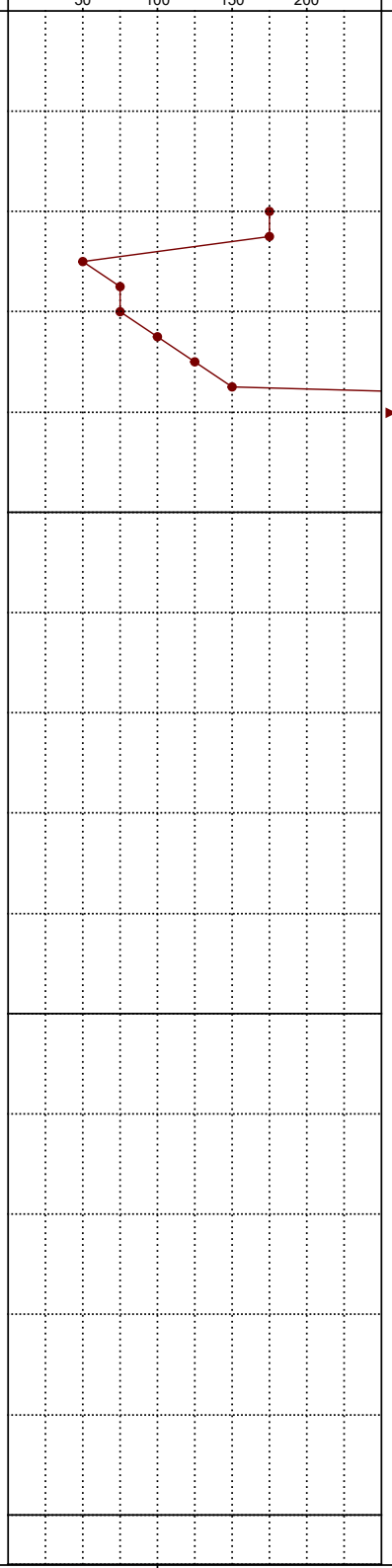
Depth (m)	Graphic Log	Material Description	Geology
0.0	TS	Organic SILT (ML); dark brown. Dry; non plastic. Trace rootlets; friable.	Topsoil
0.3		Clayey SILT (MH); dark brown. Stiff; dry to moist; high plasticity.	Kerikeri Volcanic Group

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm)

Shear Vane, Su (kPa)



Test Values

Depth (m)

Hole Depth: 0.35m **Termination:** impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA12**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049850mN, 1716295mE	**Test Date:**	25/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8; Shear Vane, Su (kPa) 50 100 150 200	Test Values	Depth (m)
	Organic SILT (ML); dark brown. Dry; non plastic. Trace rootlets; friable.	Topsoil				
	Clayey SILT (MH); reddish brown. Stiff; dry; high plasticity. Friable; water content below plastic limit.	Kerikeri Volcanic Group			UTP	
0.5					210+	-0.5
	0.7m: becomes black mottling				120 / 27	
1.0					UTP	-1.0
					165 / 36	
	1.3m: becomes minor gravel and moist. Gravel; fine to medium.				150 / 21	
1.5						-1.5
					180 / 27	
2.0					165 / 52	-2.0
	2.2m: becomes moist to wet				165 / 90	
2.5	2.5m: becomes minor gravel. Gravel; fine to medium.				150 / 36	-2.5
	2.8m: becomes wet				97 / 21	
3.0					96 / 25	-3.0

Groundwater Not Encountered

Hole Depth: 3.00m **Termination:** Reached target depth

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA13**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049984mN, 1716284mE	**Test Date:**	25/01/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	HM
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); dark brown. Dry; non plastic. Trace rootlets; friable.	Topsoil
0.5	Clayey SILT (CH); dark reddish brown. Very stiff; dry to moist; high plasticity. 0.5m: becomes black mottling	Kerikeri Volcanic Group
1.0	Silty CLAY (CH); reddish brown. Stiff; moist; high plasticity. 1.2m: becomes minor gravel. Gravel; fine to coarse.	
2.5	CLAY (CH), with some silt; dark brown. Very stiff; moist to wet; high plasticity. 2.8m: becomes wet	
3.0		

Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm) — 2, 4, 6, 8

Shear Vane, Su (kPa) — 50, 100, 150, 200

Depth (m)	Test Values
0.5	UTP
0.5	UTP
0.5	UTP
1.0	210+
1.0	150 / 42
1.5	168 / 48
1.5	180 / 60
1.5	165 / 45
2.0	UTP
2.0	UTP
2.5	156 / 31
2.5	165 / 33
3.0	111 / 22

Hole Depth: 3.00m

Termination: Reached target depth

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA14**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049980mN, 1716034mE	**Test Date:**	18/06/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	FWH
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology
0.0	Organic SILT; dark brown. Moist.	Topsoil
	SILT, with minor clay, with trace sand and gravel; homogeneous. Very stiff; low plasticity; sand, fine to coarse, gravel, fine; friable.	Kerikeri Volcanic Group
0.5		
	Silty CLAY; dark reddish brown; homogeneous. Very stiff; high plasticity; moist.	
1.0		
1.5		
	Clayey SILT, with trace sand. Stiff to very stiff; high plasticity; moist to wet; sand, fine to coarse; highly sensitive; greasy/allophanic.	Kerikeri Volcanic Group (Lapilli Tephra)
2.0	2.0m: minor clay, minor fine to coarse sand, trace fine gravel. Sand/gravel is weak scoria/lapilli clasts.	
2.5		
3.0		
3.5		
4.0		
4.5		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Depth (m)	Test Values
0.0	
0.5	121 / 46
	99 / 46
	202 / 52
	190 / 79
1.0	167 / 90
	155 / 73
	127 / 64
1.5	155 / 36
	108 / 24
2.0	95 / 23
	108 / 32
	148 / 23
2.5	83 / 42
	67 / 35
3.0	115 / 29
3.5	
4.0	
4.5	

Hole Depth: 3.00m

Termination: Reached target depth

Remarks: Shear vanes through lapilli tephra expected to be unreliable..

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA15**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049953mN, 1716083mE	**Test Date:**	18/06/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	FWH
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

Depth (m)	Graphic Log	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8 / Shear Vane, Su (kPa) 50 100 150 200	Test Values	Depth (m)
0.0	TS	Organic SILT; dark brown. Moist.	Topsoil	dwater Not Encou			0.0
		SILT, with minor clay; dark reddish brown; homogeneous. Very stiff; low plasticity; moist.	Kerikeri Volcanic Group				
0.5							-0.5
1.0							-1.0
1.5							-1.5
2.0							-2.0
2.5							-2.5
3.0							-3.0
3.5							-3.5
4.0							-4.0
4.5							-4.5

Hole Depth: 0.40m **Termination:** impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA15A**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049945mN, 1716074mE	**Test Date:**	18/06/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	FWH
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	

Depth (m)	Graphic Log	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8 / Shear Vane, Su (kPa) 50 100 150 200	Test Values	Depth (m)
0.0		Organic SILT; dark reddish brown. Moist.	Topsoil	Not Encountered			0.0
0.5		Clayey SILT; dark reddish brown; homogeneous. High plasticity; moist.	Kerikeri Volcanic Group				-0.5
1.0							-1.0
1.5							-1.5
2.0							-2.0
2.5							-2.5
3.0							-3.0
3.5							-3.5
4.0							-4.0
4.5							-4.5

Hole Depth: 0.40m

Termination: impenetrable material (boulders)

Remarks:

Materials are 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

UTP = Unable to Penetrate

Hand Auger Borehole Log

Method: 50mm Hand Auger

Test ID:	**HA16**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049994mN, 1716161mE	**Test Date:**	18/06/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	FWH
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**		**Vane ID:**	2249

Depth (m)	Material Description	Geology
0.0	Organic SILT; dark brown. Moist.	Topsoil
	SILT, with minor clay; dark reddish brown; homogeneous. Very stiff to hard; low plasticity; moist.	Kerikeri Volcanic Group
0.5	0.6m: becomes clayey, highly plastic	
2.5	Silty CLAY; dark reddish brown; homogeneous. Very stiff to hard; high plasticity; moist.	
3.0	Silty CLAY, with trace sand and gravel. Stiff; wet; sand, fine to coarse, gravel, fine, weak scoria/ lapilli; very sensitive, collapsing structure, greasy/allophanic.	Kerikeri Volcanic Group (Lapilli Tephra)
3.5	SILT, with some sand, with minor clay and gravel. Low plasticity; wet; sand, fine to coarse; gravel, fine, weak scoria/lapilli; very sensitive; collapsing structure, greasy/allophanic..	
4.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Depth (m)	Test Values
0.0	175 / 52
	194 / 65
0.5	210+
	210+
1.0	181 / 82
	210+
1.5	210+
	205 / 120
	208 / 108
2.0	169 / 93
	210
2.5	210
	186 / 73
	169 / 67
3.0	105 / 35
	79 / 32
3.5	64 / 38
4.0	61 / 32
4.5	

Hole Depth: 4.00m

Termination: Reached target depth

Remarks: Shear vanes through lapilli tephra expected to be unreliable..

Materials are 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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP01**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049775mN, 1716279mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	FWH
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	197.56m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); dark brown. Dry; containing rootlets.	Topsoil
0.5	SILT (ML), with some clay; reddish brown. Low plasticity; dry; containing rare basalt/scoria gravels and cobbles.	Kerikeri Volcanic Group
1.0	1.0m: increasing gravels and cobbles to 20%	
2.5	Clayey SILT (ML), with minor gravel and cobbles; reddish brown. Low plasticity; moist; gravel, fine to coarse; (approximately 20% Gravel / Cobbles).	
3.5	GRAVEL (GM), with some silt and cobbles. Gravel, fine to coarse; cobbles, up to 200mm; Mixture of red weak & some grey strong weathered basalt & scoria.	
4.5		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm) — 2, 4, 6, 8

Shear Vane, Su (kPa) — 50, 100, 150, 200

Test Values
UTP
UTP
UTP
UTP
UTP
150 / 76
143 / 98
91 / 25
▶14

RL (m): 197.0, 196.0, 195.0, 194.0, 193.0

Hole Depth: 4.10m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP02**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049830mN, 1716263mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	197.09m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); dark brown. Dry; containing rootlets.	Topsoil
0.5	Clayey SILT (ML), with minor gravel and cobbles; dark reddish brown. Dry; gravel, coarse.	Kerikeri Volcanic Group
1.5	Cobbly GRAVEL (GW), with some silt; dark brown. Moist; well graded; gravel, fine to coarse; soft to stiff soil matrix (variable). 2.2m: encountering large boulders (approximately 0.5m dia.) 3.6m: 90% Gravel / Cobbles, with some boulders. Mixture of Red weak weathered basalt / scoria, and grey very strong basalt / scoria in a silt matrix. Silt Matrix is wet to saturated, no groundwater present.	
4.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values

UTP

10

UTP

RL (m): 197.0, 196.0, 195.0, 194.0, 193.0

Hole Depth: 4.00m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP03**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049828mN, 1716218mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	196.71m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology	Water	In-situ Testing	Test Values	RL (m)
0.0	Organic SILT (OL); dark brown. Dry; containing rootlets.	Topsoil	Groundwater Not Encountered	Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8; Shear Vane, Su (kPa) 50 100 150 200		196.0
0.5	SILT (ML), with minor clay and gravel, with trace cobbles; brownish orange. Low plasticity; moist; gravel, coarse; 10% Gravels & Cobbles present.	Kerikeri Volcanic Group			106 / 14	
1.0	1.0m: becoming clayey				177 / 41	
1.5					123 / 48	195.0
2.0					10	
2.5	Silty cobbly GRAVEL (GM), with some boulders; brownish grey. Moist; gravel, fine to coarse; boulders, up to 400mm; (70% Gravel/cobbles, 5% boulders). Mainly Grey strong basalt & scoria.				106 / 27	194.0
3.0						
3.5						193.0
4.0						
4.5						192.0

Hole Depth: 3.50m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP04**				
Project ID:	18733				
Sheet:	1 of 1				
Client:	CC Developments LTD	**Coordinates:**	6049774mN, 1716206mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	197.11m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	

Depth (m)	Material Description	Geology
0	Organic SILT (OL), with trace clay; dark brown. Dry; containing rootlets.	Topsoil
0.5	SILT (ML), with some clay, with minor gravel, with trace cobbles; brownish orange. Low plasticity; moist; gravel, coarse; cobbles, up to 200mm.	Kerikeri Volcanic Group
1.0	Cobbly GRAVEL (GW), with some silt; brownish orange. Well graded; gravel, fine to coarse; cobbles, up to 200mm; 50% Gravel / Cobbles, generally grey strong basalt & scoria.	
	1.0m - 1.2m: becoming grey and gravel/cobbles increasing to 80% with some boulders	
1.5	1.2m - 1.8m: Gravels, cobbles and boulders increasing to 95%, avg. 200mm	
2.0	1.8m - 2.3m: increasing in average size of boulders (avg. 350mm, max. 600mm)	
2.5		
3.0		
3.5		
4.0		
4.5		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values: 10, 10

RL (m): 197.0, 196.0, 195.0, 194.0, 193.0

Hole Depth: 2.30m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP05**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049820mN, 1716180mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	197.82m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	

Depth (m)	Material Description	Geology
0.0	Organic gravelly SILT (OL), with minor cobbles; dark brown. Dry; gravel, coarse; cobbles, up to 200mm; containing rootlets.	Topsoil
0.5	Silty cobbly GRAVEL (GM), with some boulders; brownish grey. Dry; cobbles, up to 200mm; boulders, up to 400mm; generally comprised of a mixture of strong grey, and weak reddish brown basalt / scoria. Approximately 50% of soil are gravels, cobbles. 0.5m - 2.5m: gravels, cobbles and boulders increase to 90% of material. Average size 200mm, Max. 400mm.	Kerikeri Volcanic Group
1.0		
1.5		
2.0		
2.5	2.5m: encountering either larger boulders or solid rock	
3.0		
3.5		
4.0		
4.5		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values: 10

RL (m): 197.0, 196.0, 195.0, 194.0, 193.0

Hole Depth: 3.00m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP06**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049772mN, 1716162mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	198.43m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); brown. Dry to moist; containing rootlets.	Topsoil
0.5	SILT (ML), with some gravel and cobbles, with minor clay; dark brown. Low plasticity; moist; gravel, fine to coarse, cobbles, up to 200mm; gravels and cobbles approximately 25% of soil.	Kerikeri Volcanic Group
1.0	Silty cobbly GRAVEL (GM), with some boulders; brown. Moist; boulders, up to 250mm; gravels and cobbles approximately 60%, and consist of mainly grey strong basalt and scoria.	
1.5	1.0m: increasing to 90% gravels, cobbles and boulders up to 400mm	
2.0		
2.5		
3.0		
3.5	3.5m - 3.6m: silt matrix becoming wet to saturated	
4.0		
4.5		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values: 10, 12, 10

RL (m): 198.0, 197.0, 196.0, 195.0, 194.0

Hole Depth: 3.60m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP07**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049870mN, 1716117mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	198.5m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	

Depth (m)	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm)	In-situ Testing: Shear Vane, Su (kPa)	Test Values	RL (m)
0.0	Organic SILT (OL); brown. Moist.	Topsoil	Groundwater Not Encountered	2 4 6 8	50 100 150 200	10 20	198.0
0.5	SILT (ML), with some gravel, with minor clay and cobbles; brownish orange. Low plasticity; moist; gravel, fine to coarse; cobbles, up to 150mm; approximately 25% gravel / cobbles.	Kerikeri Volcanic Group					
1.0	Silty cobbly GRAVEL (GM), with some sand, with minor boulders; brownish orange. Moist; cobbles, up to 150mm; sand, fine to coarse; boulders, up to 300mm; gravels and cobbles approximately 60% of soil.						197.0
1.5	1.0m: Average size of gravel, cobbles and boulders increased to 300mm. 1.5m: increasing to 90% gravels, cobbles and boulders. larger boulders increasing to 600mm						
2.0							196.0
2.5							
3.0							195.0
3.5							
4.0							194.0
4.5							

Hole Depth: 3.00m

Termination: large boulders/rock, unable to

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP08**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049906mN, 1716207mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	186.73m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology	Water	In-situ Testing	Test Values	RL (m)
0.0	Organic SILT (OL), with minor clay; dark brown. Moist; containing rootlets.	Topsoil	Groundwater Not Encountered	Dynamic Cone Penetrometer (blows / 50mm) 2 4 6 8; Shear Vane, Su (kPa) 50 100 150 200	UTP	186.0
0.5	SILT (ML), with minor clay and gravel; reddish brown. Hard; low plasticity; dry to moist; gravel, fine to coarse; Gravel content less than 10%. 0.5m - 3.5m: Becoming orange	Kerikeri Volcanic Group			UTP	
1.0					UTP	
1.5						185.0
2.0						
2.5						184.0
3.0	3.0m: containing minor sand and becoming wet					
3.5	Sandy SILT (ML), with minor clay and gravel; brownish orange. Low plasticity; wet to saturated; sand, fine to coarse; gravel, fine; no groundwater encountered (no free water).					183.0
4.0						
4.5						182.0

Hole Depth: 4.00m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP09**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049935mN, 1716271mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	178.07m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); dark brown. Dry; containing rootlets.	Topsoil
0.5	SILT (ML), with some clay; reddish brown. Hard; low plasticity; dry to moist.	Kerikeri Volcanic Group
2.5	SILT (ML), with some sand, with trace clay; brownish orange. Low plasticity; wet to saturated; sand, fine to medium.	
4.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values
UTP
UTP
191+
98 / 14
10
10
10
191+

RL (m): 178.0, 177.0, 176.0, 175.0, 174.0

Hole Depth: 4.00m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 22t Excavator

Test ID:	**TP10**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049878mN, 1716272mE	**Test Date:**	14/12/2020
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	188.24m	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Excavator GPS	**Vane ID:**	2864

Depth (m)	Material Description	Geology
0.0	Organic SILT (OL); dark brown. Dry; containing rootlets.	Topsoil
0.5	SILT (MH), with some clay; reddish brown. Hard; high plasticity; moist.	Kerikeri Volcanic Group
3.5	Sandy SILT (ML), with minor gravel and cobbles; brown. Low plasticity; moist; sand, fine to coarse; gravel, fine to coarse, cobbles, up to 150mm; gravels and cobbles approximately 20% of soil.	
4.0		

Water: Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values
UTP
UTP
UTP
191+
10

RL (m): 188.0, 187.0, 186.0, 185.0, 184.0

Hole Depth: 4.00m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 14.5t Excavator

Test ID:	**TP11**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6050017mN, 1716218mE	**Test Date:**	19/05/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology
0	Organic SILT (OL), with some clay; dark brown. Moist; friable.	Topsoil
0.5	Organic SILT (OL), with some clay, with minor sand, with trace boulders; brownish orange. Stiff; moist; sand, coarse; boulders, up to 200mm, Basalt scoria; friable.	Kerikeri Volcanic Group
2.0	2.0m - 4.2m: becoming reddish brown	
4.5		

Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Test Values	Depth (m)
93 / 35	
196 / 71	-1.0
137 / 23	
79 / 35	-2.0
101 / 20	
137 / 35	-3.0
UTP	
	-4.0

Hole Depth: 4.20m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 14.5t Excavator

Test ID:	**TP12**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6050035mN, 1716159mE	**Test Date:**	19/05/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology
0	Organic SILT (OL), with some clay; dark brown. Moist; friable.	Topsoil
0.5	SILT (ML), with some clay, with minor sand; brownish orange. Stiff to very stiff; low plasticity; moist; sand, medium; friable.	Kerikeri Volcanic Group
2.0	2.0m - 2.5m: containing trace boulders (max. 300mm diameter) 2.1m - 3.0m: becoming brown	
3.0	3.0m - 4.8m: becoming brownish orange	
4.5		

Groundwater Not Encountered

In-situ Testing

Dynamic Cone Penetrometer (blows / 50mm): 2, 4, 6, 8

Shear Vane, Su (kPa): 50, 100, 150, 200

Depth (m)	Test Values
0.5	108 / 23
1.0	167 / 35
1.5	93 / 23
2.0	199 / 49
2.5	137 / 35
3.0	196 / 49
3.5	105 / 41
4.0	
4.5	

Hole Depth: 4.80m

Termination: Reached target depth

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

UTP = Unable to Penetrate

Test Pit Log

Method: 14.5t Excavator

Test ID:	**TP13**
Project ID:	18733
Sheet:	1 of 1

Client:	CC Developments LTD	**Coordinates:**	6049987mN, 1716119mE	**Test Date:**	19/05/2021
Project:	Geotechnical Investigation	**System:**	NZTM	**Logged By:**	AJ
Location:	131 - 189 Three Mile Bush Road, Whangarei	**Elevation:**	Ground	**Checked By:**	GH
Test Site:	Refer to site plan	**Located By:**	Phone GPS	**Vane ID:**	2249

Depth (m)	Material Description	Geology	Water	In-situ Testing: Dynamic Cone Penetrometer (blows / 50mm)	In-situ Testing: Shear Vane, Su (kPa)	Test Values
0	Organic SILT (OL), with some clay; dark brown. Moist; friable.	Topsoil	Groundwater Not Encountered	2, 4, 6, 8	50, 100, 150, 200	
0.5	Clayey SILT (ML), with minor sand, with trace boulders; brownish orange. Stiff to hard; low plasticity; moist; sand, coarse; boulders, up to 200mm; friable.	Kerikeri Volcanic Group				181 / 57
1.0						174 / 49
1.5						123 / 20
2.0						UTP
2.5	2.5m - 3.0m: minor cobbles and boulders encountered (max. 150mm diameter)					UTP
3.0						UTP
3.5						UTP
4.0						
4.5						

Hole Depth: 4.20m

Termination: Reached target depth

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

UTP = Unable to Penetrate

APPENDIX C

LABORATORY TEST CERTIFICATES

Whangarei Laboratory
166 Bank Street
Whangarei
M: 027 656 5226
E: info@geocivil.co.nz

TEST REPORT

Lab Job No: 8334-019

Your ref.: 18733

Date of Issue: 21/01/2021

Date of Re-Issue: -

Page: 1 of 7

Test Report No. W21-059

PROJECT: **Soil Classification Testing**

CLIENT: LDE Ltd
192 Bank Street,
Regent, Whangarei 0110

ATTENTION: Conor Pullman

TEST METHODS: Determination of the liquid & plastic limits, Plasticity index and water content
NZS 4402:1986 Tests 2.1,2.2,2.3,2.4
Determination of the Linear Shrinkage
NZS 4402:1986 Test 2.6

SAMPLING METHOD: Sampled by client - sampling not accredited
Hand bore hole sampled

TEST RESULTS: As per attached sheets

D. Krissansen
Technical Director

S. Kokich
Approved Signatory

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Whangarei Laboratory
166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz

DETERMINATION OF THE LIQUID & PLASTIC LIMITS, PLASTICITY INDEX & WATER CONTENT

NZS 4402:1986 Test 2.2,2.3,2.4

Lab Job No:	8334-019	**Sample No.:**	21-003
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date Tested:**	13/01/2021
	TP2 0.5 - 0.7m	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date Checked:**	21/01/2021
Report No:	W21-059	**Page:**	2 of 7
REF:	18733		
Sampling Method:	Sampled by client – Sampling not accredited	**Sampled By:**	Client
Date Sampled:	14/12/2020		

Test Details:

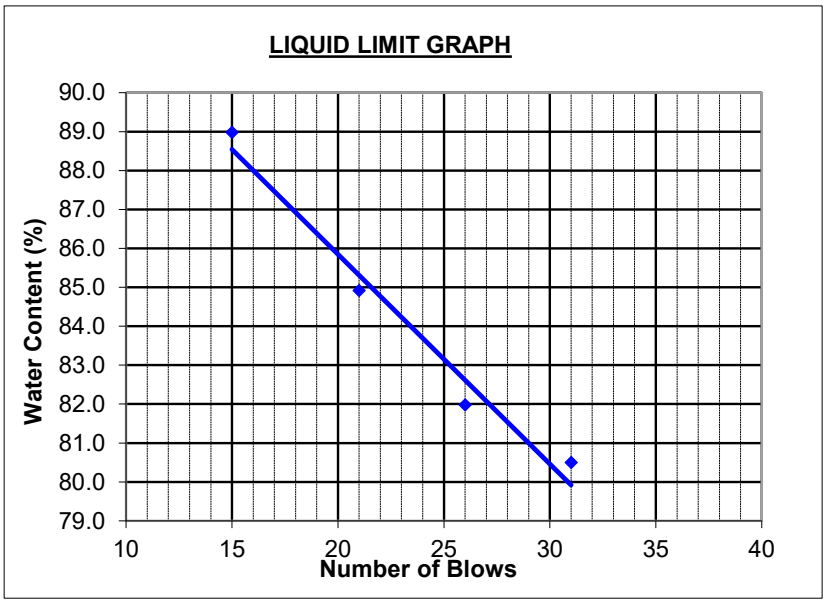
Test performed on: Fraction passing 425μm sieve

Sample history: Natural state

Description of Sample: Clayey SILT, traces of rootlets and gravels up to 10mm, damp, red brown

	Liquid Limit				Plastic Limit	
No. of blows	15	21	26	31		
Water content (%)	89.0	84.9	82.0	80.5	44.3	44.6

NWC	**42.6**
Liquid Limit	**83**
Plastic Limit	**44**
Plasticity Index	**39**



S. Kokich
Approved Signatory

Whangarei Laboratory
166 Bank Street
Whangarei
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DETERMINATION OF THE LINEAR SHRINKAGE

NZS 4402:1986 Test 2.6

Lab Job No:	8334-019	**Sample No:**	21-003
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date:**	13/01/2021
	TP2 0.5 - 0.7m	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date:**	21/01/2021
Report No:	W21-059	**Page:**	3 of 7
REF:	18733		

Test performed on: Fraction passing 425mm sieve
History: Natural state

Description of Sample: Clayey SILT, traces of rootlets and gravels up to 10mm, damp, red brown

Linear shrinkage	**19**

S. Kokich
Approved Signatory

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DETERMINATION OF THE LIQUID & PLASTIC LIMITS, PLASTICITY INDEX & WATER CONTENT

NZS 4402:1986 Test 2.2,2.3,2.4

Lab Job No:	8334-019	**Sample No.:**	21-004
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date Tested:**	12/01/2021
	TP4 0.5 - 0.7m	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date Checked:**	21/01/2021
Report No:	W21-059	**Page:**	4 of 7
REF:	18733		
Sampling Method:	Sampled by client – Sampling not accredited	**Sampled By:**	Client
Date Sampled:	14/12/2020		

Test Details:

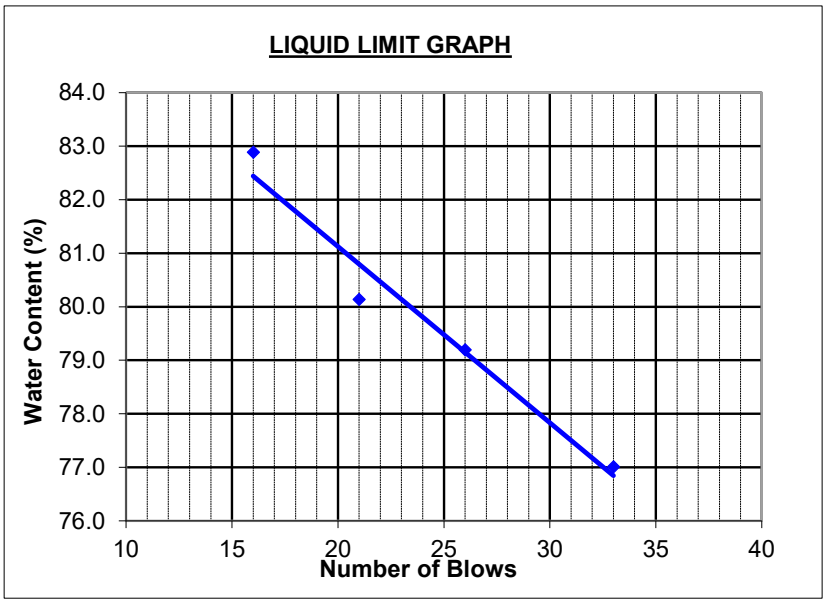
Test performed on: Fraction passing 425μm sieve

Sample history: Natural state

Description of Sample: Clayey SILT, traces of rootlets and fine sands, damp, brown

	Liquid Limit				Plastic Limit	
No. of blows	16	21	26	33		
Water content (%)	82.9	80.1	79.2	77.0	42.1	41.8

NWC	**36.1**
Liquid Limit	**80**
Plastic Limit	**42**
Plasticity Index	**38**



S. Kokich
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DETERMINATION OF THE LINEAR SHRINKAGE

NZS 4402:1986 Test 2.6

Lab Job No:	8334-019	**Sample No:**	21-004
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date:**	12/01/2021
	TP4 0.5 - 0.7m	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date:**	21/01/2021
Report No:	W21-059	**Page:**	5 of 7
REF:	18733		

Test performed on: Fraction passing 425mm sieve
History: Natural state

Description of Sample: Clayey SILT, traces of rootlets and fine sands, damp, brown

Linear shrinkage	**22**

S. Kokich
Approved Signatory

Whangarei Laboratory
166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz

DETERMINATION OF THE LIQUID & PLASTIC LIMITS, PLASTICITY INDEX & WATER CONTENT

NZS 4402:1986 Test 2.2,2.3,2.4

Lab Job No:	8334-019	**Sample No.:**	21-005
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date Tested:**	13/01/2021
	TP8 0.5 - 0.7	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date Checked:**	21/01/2021
Report No:	W21-059	**Page:**	6 of 7
REF:	18733		
Sampling Method:	Sampled by client – Sampling not accredited	**Sampled By:**	Client
Date Sampled:	14/12/2020		

Test Details:

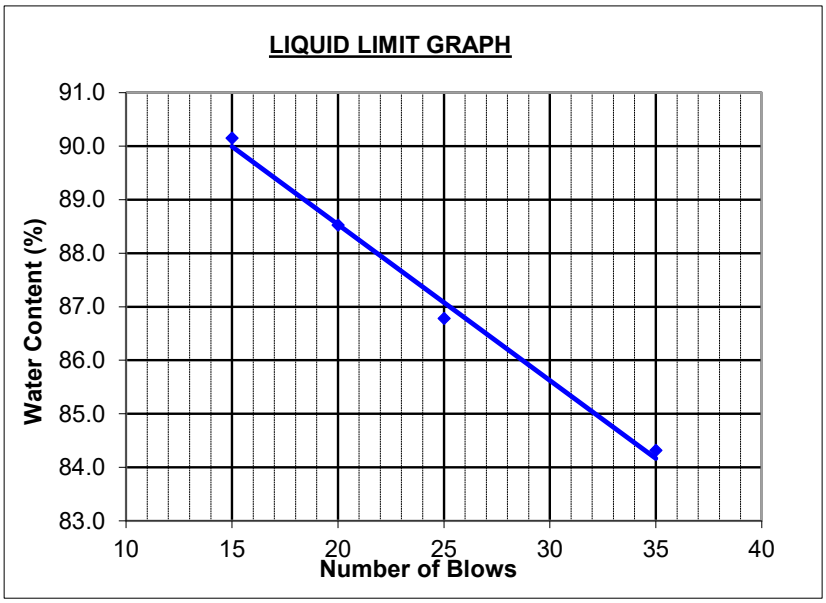
Test performed on: Fraction passing 425μm sieve

Sample history: Natural state

Description of Sample: Clayey SILT, traces of rootlets, moist, red orange brown

	Liquid Limit				Plastic Limit	
No. of blows	15	20	25	35		
Water content (%)	90.2	88.5	86.8	84.3	49.8	49.3

NWC	**47.4**
Liquid Limit	**87**
Plastic Limit	**50**
Plasticity Index	**37**



S. Kokich
Approved Signatory

Whangarei Laboratory
166 Bank Street
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DETERMINATION OF THE LINEAR SHRINKAGE

NZS 4402:1986 Test 2.6

Lab Job No:	8334-019	**Sample No:**	21-005
Client:	LDE	**Tested By:**	N.K
Location:	-	**Date:**	13/01/2021
	TP8 0.5 - 0.7	**Checked By:**	D.K.
Date Received:	18/12/2020	**Date:**	21/01/2021
Report No:	W21-059	**Page:**	7 of 7
REF:	18733		

Test performed on: Fraction passing 425mm sieve
History: Natural state

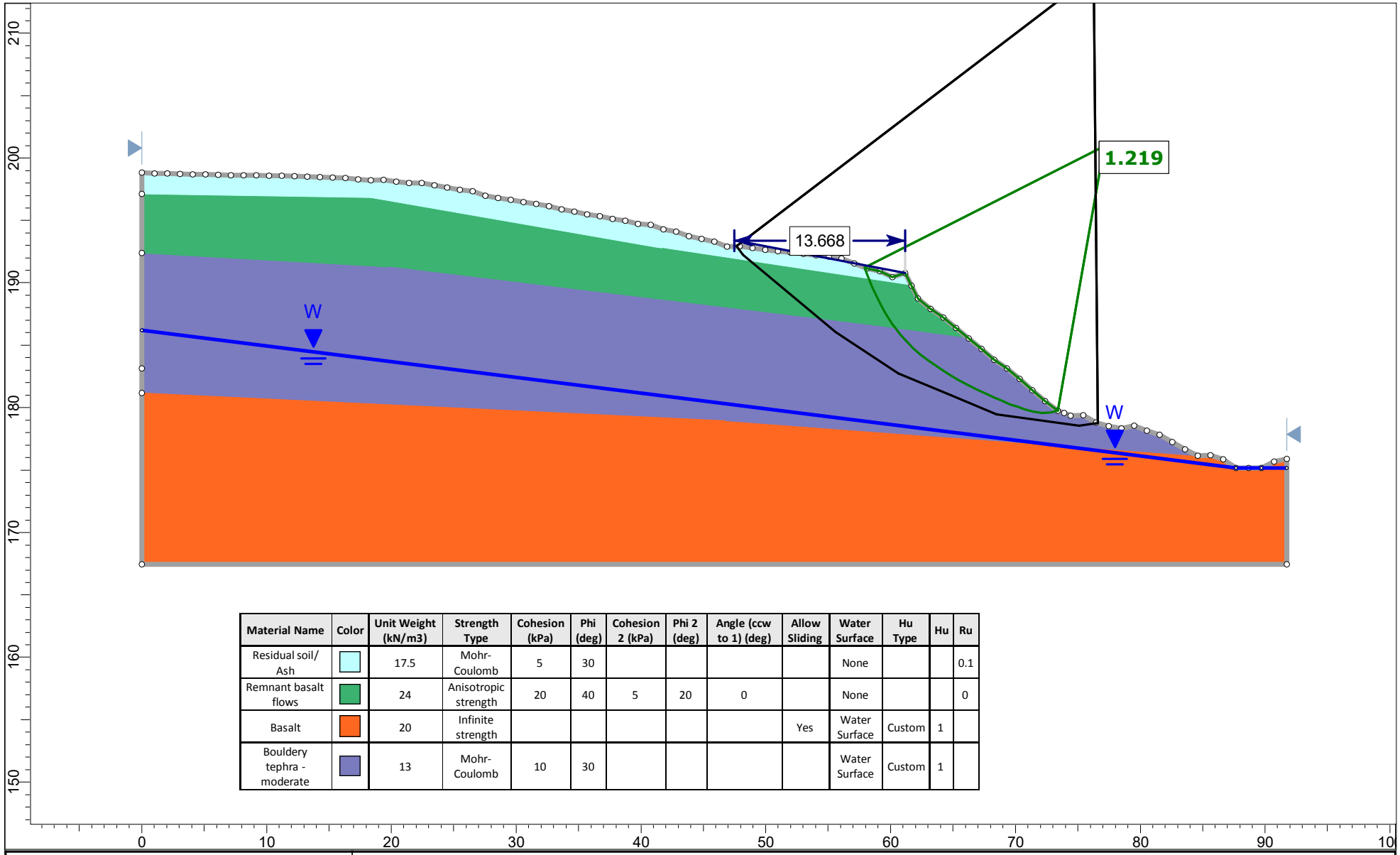
Description of Sample: Clayey SILT, traces of rootlets, moist, red orange brown

Linear shrinkage	**21**

S. Kokich
Approved Signatory

APPENDIX D

STABILITY ANALYSES

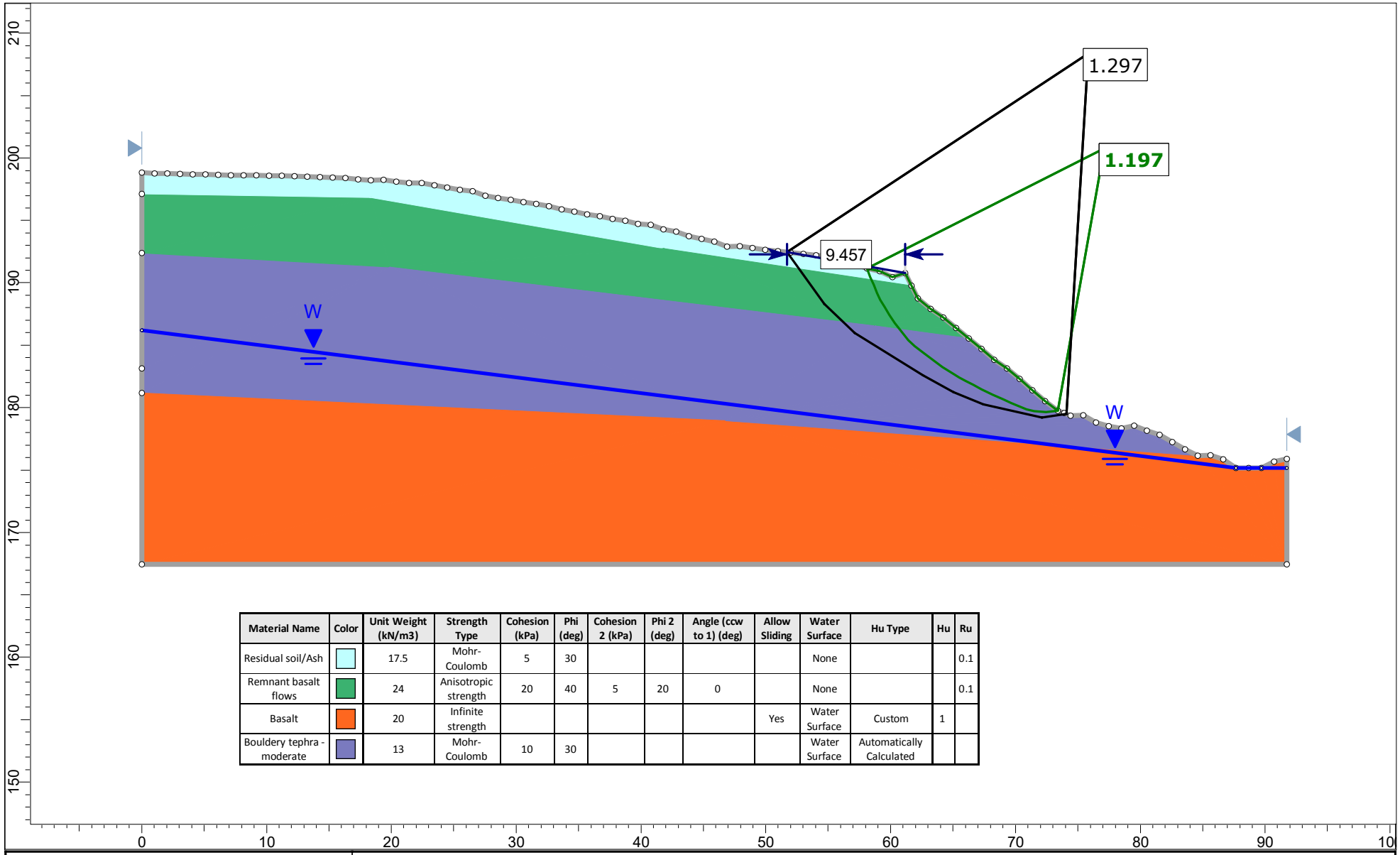


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion 2 (kPa)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Allow Sliding	Water Surface	Hu Type	Hu	Ru
Residual soil/ Ash		17.5	Mohr-Coulomb	5	30					None			0.1
Remnant basalt flows		24	Anisotropic strength	20	40	5	20	0		None			0
Basalt		20	Infinite strength						Yes	Water Surface	Custom	1	
Bouldery tephra - moderate		13	Mohr-Coulomb	10	30					Water Surface	Custom	1	

LAND DEVELOPMENT & ENGINEERING LTD.

SLIDEINTERPRET 9.012

Project	131 and 189 Three Mile Bush Road		
Analysis Description	CS-2 - Design conditions		
Drawn By FWH	*Scale* 1:430	*Company*	LDE Ltd
Date 22/06/2021		*File Name*	18733.slmd

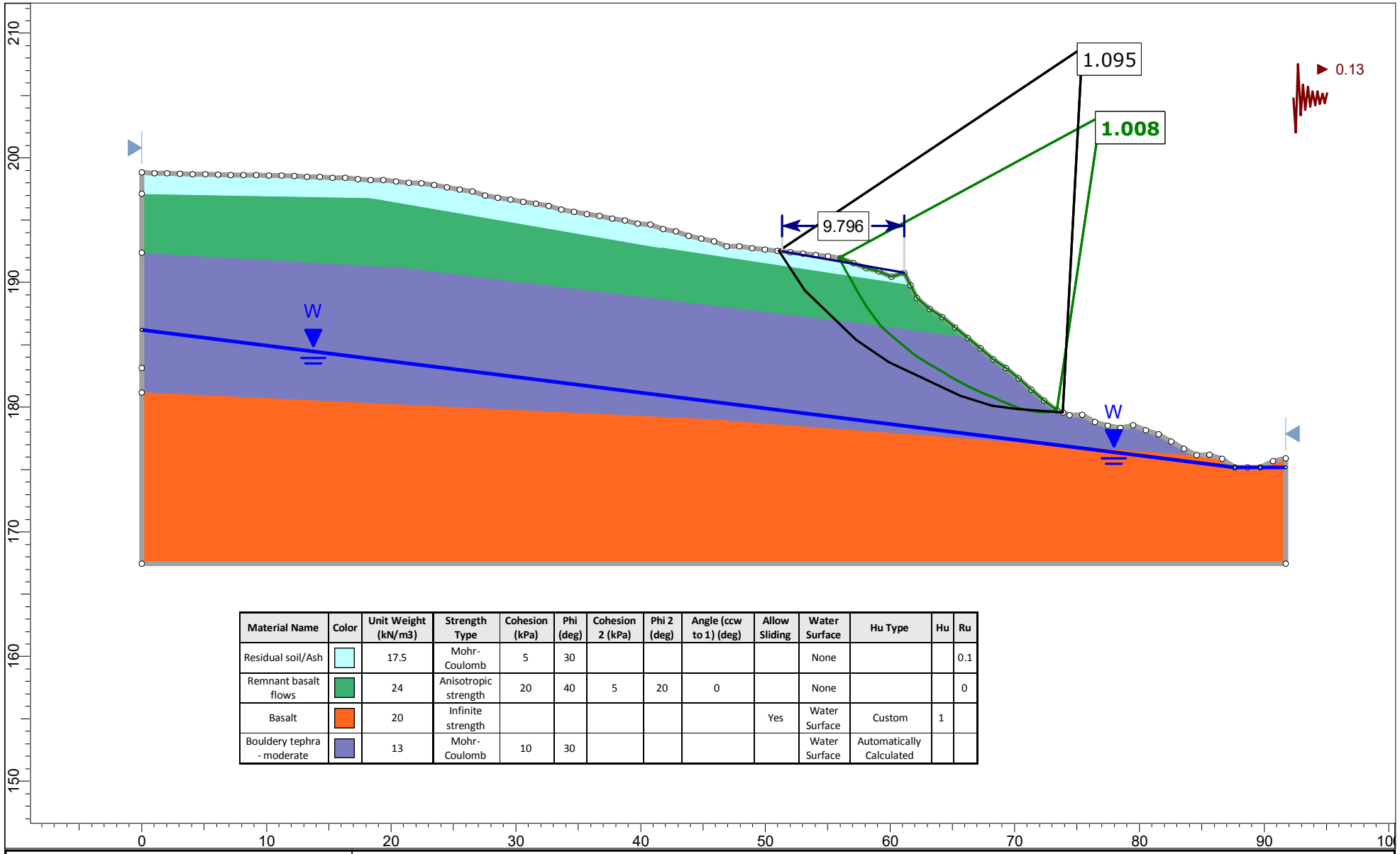


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion 2 (kPa)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Allow Sliding	Water Surface	Hu Type	Hu	Ru
Residual soil/Ash		17.5	Mohr-Coulomb	5	30					None			0.1
Remnant basalt flows		24	Anisotropic strength	20	40	5	20	0		None			0.1
Basalt		20	Infinite strength						Yes	Water Surface	Custom	1	
Bouldery tephra - moderate		13	Mohr-Coulomb	10	30					Water Surface	Automatically Calculated		

LAND DEVELOPMENT & ENGINEERING LTD.

SLIDEINTERPRET 9.012

Project	131 and 189 Three Mile Bush Road		
Analysis Description	CS-2 - Extreme groundwater		
Drawn By	FWH	*Scale* 1:430	*Company* LDE Ltd
Date	22/06/2021		*File Name* 18733.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion 2 (kPa)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Allow Sliding	Water Surface	Hu Type	Hu	Ru
Residual soil/Ash		17.5	Mohr-Coulomb	5	30					None			0.1
Remnant basalt flows		24	Anisotropic strength	20	40	5	20	0		None			0
Basalt		20	Infinite strength						Yes	Water Surface	Custom	1	
Bouldery tephra - moderate		13	Mohr-Coulomb	10	30					Water Surface	Automatically Calculated		

LAND DEVELOPMENT & ENGINEERING LTD.

SLIDEINTERPRET 9.012

Project	131 and 189 Three Mile Bush Road		
Analysis Description	CS-2 - Seismic		
Drawn By	FWH	*Scale* 1:430	*Company* LDE Ltd
Date	22/06/2021		*File Name* 18733.slmd

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