ALLIED GEOTECH LTD

GEOTECHNICAL SUITABILITY OF PROPOSED HOUSE SITE
25 DARWIN ROAD, OUTER KAITI, GISBORNE
GEOTECHNICAL INVESTIGATION REPORT

Report Prepared for: Malcolm Galloway

Date: 31/05/22

AG Ref: 0150 - 1

ALLIED GEOTECH LTD, GISBORNE, NEW ZEALAND
P: 021 139 3755 E: ross@alliedgeotech.co.nz

Table of Contents

1 INTRODUCTION

Allied Geotech Ltd was engaged by Malcolm Galloway to undertake a geotechnical investigation of a potential house site located within 25 Darwin Road, Outer Kati, Gisborne (Figure 1).

Figure 1: Property location (red outline) and surrounding area. Image source: Tairawhiti Maps[1].

The scope and objectives of the investigation included the following:

1. Select an area of land within the property for potential development of one residential dwelling.
2. Determine the nature and strength distribution of the soils beneath the proposed house site.
3. Determine of the stability of the proposed house site under design conditions.
4. Determination preliminary recommendations for site development and foundation design to address potentially compressible ground, low bearing capacity ground, expansive soils, and other soils which could have a negative impact on a future dwelling, resulting in excessive differential movement of the structure.
5. Consideration of the potential for liquefaction, and if required, provide recommendations to minimise the potential risk that this presents to the structure.

2 SITE DESCRIPTION

The subject property is located in outer Kaiti, approximately 5km east of the Gisborne City Central Business District. The elevated property comprises a 959m² parcel of land located on the lower reaches of a north facing elevated hillside. The property can be characterised as containing a slightly raised spur landform in its east part, which represents the lower reaches of a spur projecting down from the property above to the south, and a slightly depressed zone in its west side, which is an extension of a shallow gully within the hillside, also extending down from the property above.

[1] https://maps.gdc.govt.nz/H5V2_12/

The property generally reduces in overall gradient from approximately 20° to 25° at its upper southern part to 5° to 15° in its lower half. Localised steeper and shallower gradient zones exist within the slope, primary associated with cut and fill works from installation of historic farm accessways.

At the time of the investigation, the property was under pasture, with a number of trees located in its upper central, and lower parts. Access to the site is gained via an approximately 50m long driveway which leads up from Darwin Road to the northwest. The driveway is included in the 959m² parcel size.

Figure 2: Subject property (indicative boundary location shown in bold red outline) and surrounding area. Fine red and green lines represent LiDAR contour lines at 1m intervals. Image source: Tairawhiti Maps[1].

3 PROPOSED HOUSE SITE

An approximately 140m² house site on the backbone of the spur within the east part of the lot is proposed. It needs to be appreciated that this does not preclude possible development in other parts of the property but forms the focus of this report to confirm the viability of one site for residential development within the lot. Extension of the site proposed, or alternative sites, may be viable.

It also needs to be appreciated that as a particular building proposal does not exist, this report does not extend to a full building consent level investigation report, which can only be completed once the final building proposal is known and building specific testing and reporting can be completed.

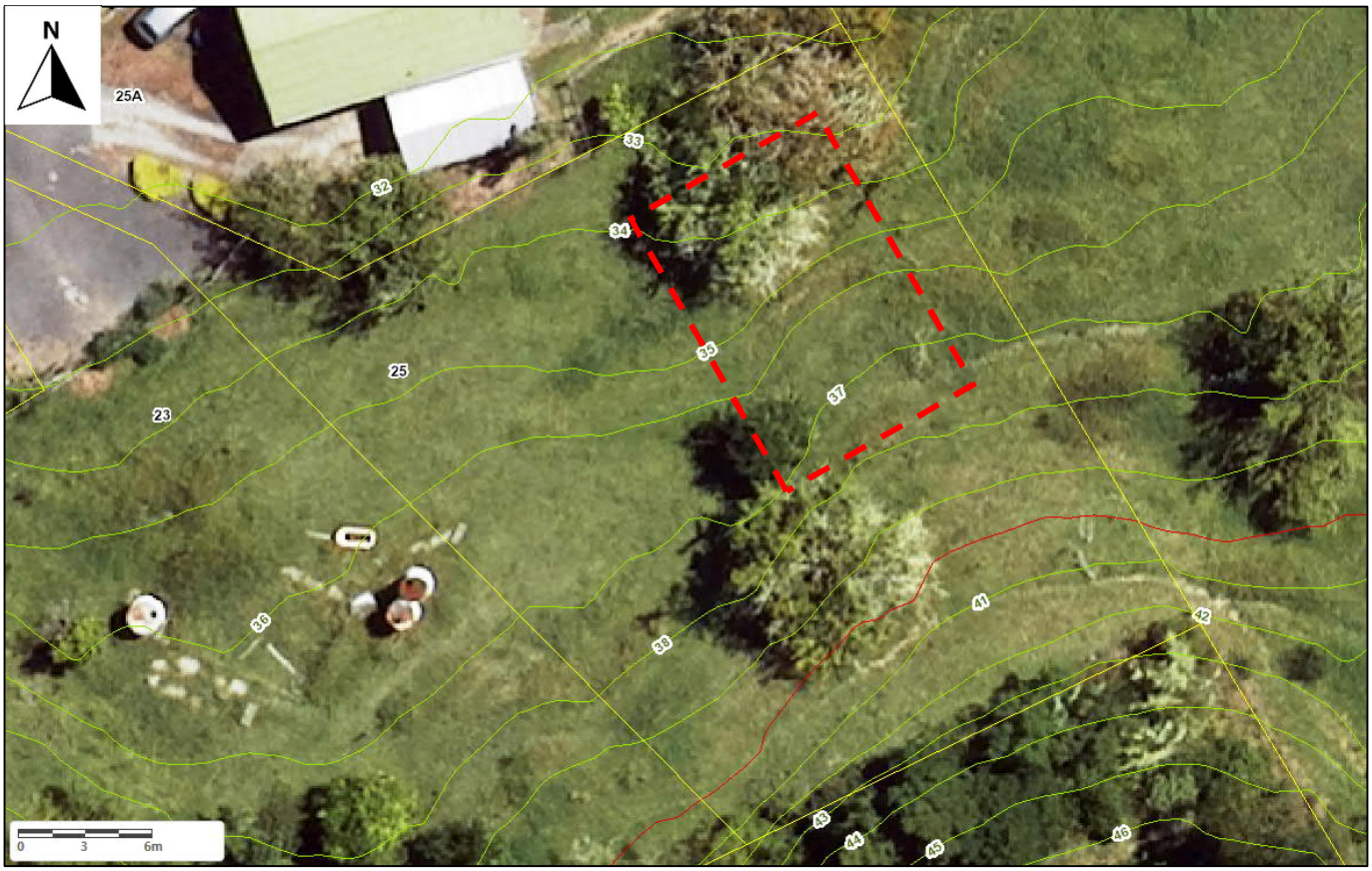


Figure 3: Indicative location of possible house site location (red dashed outline). Image source: Tairawhiti Maps[1].

Figure 4: View southeast over property and indicative position of possible house site (dashed yellow outline).

4 INVESTIGATIONS

Our investigation of the site included the following work:

1. A walkover geomorphological assessment of the site and surrounding area to determine any surface definitions or geological features which may have an influence on the project and any features which may present a slope instability risk to the proposed development.

2. A review of historic aerial and satellite images dating back to 1942, geological maps, and the Allied Geotech database.
3. Three 50mm hand augered boreholes put down to refusal. Shear vane tests were carried out at 200mm intervals down the soil profile where cohesive soils were encountered.
4. Three dynamic penetrometer tests (DCP's) put down in the base of each borehole to refusal.
5. Slope profiling.
6. Development of a geological model and undertaking of qualitative and quantitative (numeric) stability analyses.

The locations of the site investigations are shown within Figure 5. The site investigation logs are appended.

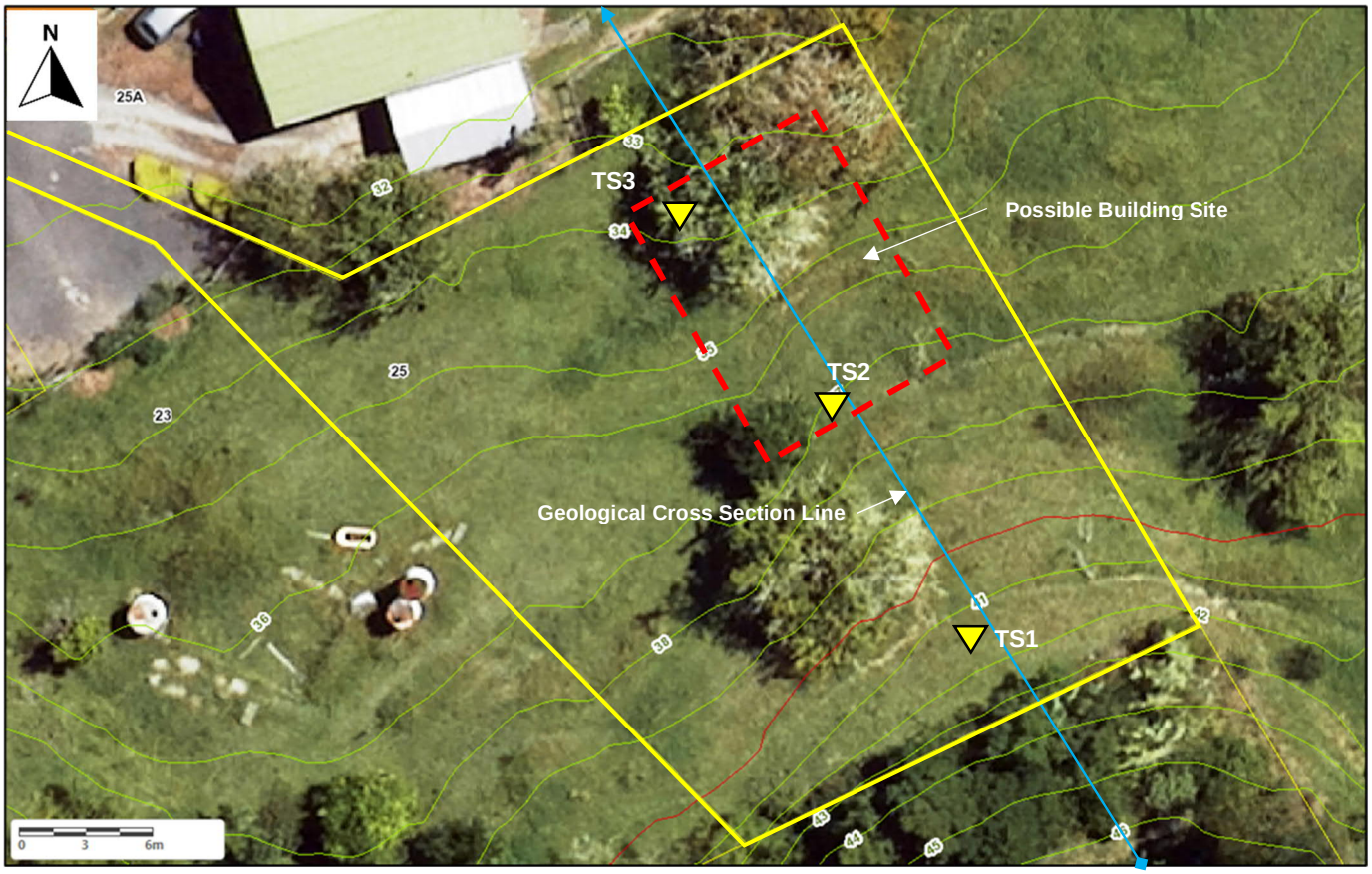


Figure 5: Geotechnical Investigation Plan. Property boundary line indicated with bold yellow line. Proposed building site indicated with bold dashed red outline. Slope profile used in numeric stability analyses indicated with blue line. Each test site (yellow triangle) corelates to a hand auger and dynamic cone penetrometer test location. Fine green and red lines correlate to LiDAR contour lines at 1m intervals. Image source: Tairawhiti Maps[1].

5 SUBSURFACE CONDITIONS

5.1 Published Information

The 1:250,0000 geological map of the region[2] shows the site as being underlain by Miocene mudstone, with intercalations of breccia and limestone.

[2] Mazengarb, C.; Speden, I.G. (compilers) 2000: Geology of the Raukumara area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 6.

5.2 Soil Profile and Strength

In summary, the investigations encountered a relatively uniform soil profile above and within the proposed house site. The testing generally encountered dark grey clayey silt (Topsoil and Topsoil fill) extending down to between 0.2 and 0.5m depth. The fill was encountered at TS2 on top of the original topsoil, being located on the outside edge of an historic farm track which runs through the site. Undrained shear strength testing in both units returned values ranging between 67 and 153kPa, indicating a variable stiff to very stiff strength regime.

Underlying the fill and topsoil layers, relatively homogenous light brown clayey silt with highly to completely weathered gravel (mudstone residual soils) was encountered down to 2.2 to 3.2m depth beneath the site. Undrained shear strength testing indicates that the unit is high to very high strength, returning values ranging between 100 and in excess of 185kPa, indicating a very stiff to hard regime. Many parts of the unit were found to be so high strength that the test was unable to be performed.

Near the base of the hand auger tests, an increase in highly to completely weathered mudstone gravel content in the residual soils was identified. At one test site (TS1) the material was observed to change to a grey colour and was found to be dry, indicating transitioning into the underlying mudstone regolith. Due its high strength, undrained shear strength testing was unable to be performed in the unit. Dynamic penetrometer testing was put down in the base of each borehole. Instant refusal (>14 blows/50mm) was returned from TS1 at 2.6m depth put down at the top of the property, and values increasing from 2 blows/50mm up to refusal (>10 blows/50mm), which was achieved between 4.4 and 3m depth in the base of TS2 and TS3, respectively.

5.3 Ground Water

Groundwater was not encountered in the investigation. Given the elevation of the site within the hillside we expect the water table to exist at least 4 to 5m depth beneath the site. The near surface soils (topsoil and fill) are expected to be high in moisture levels in winter and could become saturated following a prolonged/extreme wet weather event. Full saturated of the hill is, however, considered unlikely.

5.4 Seismic Subsoil Classification

Based on the site testing results and the Allied Geotech database, we consider that the building site is a Class C Shallow Soil site as outlined in NZS 1170.5:2004.

6 NATURAL HAZARDS

6.1 Slope Stability

6.1.1 Qualitative Assessment

The hillside which the proposed house site is located on is considered to be fundamentally stable. The site is located on the lower reaches and backbone of a hillside spur which extends down from the top of hillside above. Our review of historic aerial photography and satellite imagery taken between 1942 and 2022 identified no evidence of active instability above, within, or below the house site. Prior to establishment of the thick vegetation which now occupies

the property immediately up slope, evidence of historic shallow seated instability can be observed in the 1953 aerial photographs in the steeper parts of the hillside to the southwest and southeast in the form of localised undulating ground and arcuate landslip scars. However these areas and possible run-out zones below, are offset from the proposed house site. On this basis we consider that the proposed site is at a low risk of being affected by inundation or evacuation landslipppage from the properties above and below, during a standard residential building's design life.

On a localised scale, undulating ground, terracettes, tension cracks or other evidence of indicative of instability were not identified above, within, or below the site, which is consistent with the general high strength nature of the ground encountered in the site investigation from a shallow depth. The only area within the house site zone considered to be at risk of possible ground movement comprises the localised wedge of fill and buried topsoil located on the outside edge of the historic farm track which traverses through the site. This wedge is standing at a relatively steep grade of some 40° and may be at risk of movement as a result of an extreme weather or seismic event. This is expected to be able to be address through site preparation/remediation works. There was no other evidence of instability identified above, within or below the house site within the image review or walkover assessment.

Figure 6: 1953 aerial image of property and surrounding area. Approximate proposed house site position indicated with yellow rectangle.

6.1.2 Numeric Stability Assessment

To confirm the localised stability of the land above, within, and below the proposed house site, we have undertaken numeric slope stability analyses on the site using specialist geotechnical software (Slide). The assessment was carried on a model developed of the underlying geology, using the site testing data and site profile survey information. The location and orientation of the slope profile analysed is shown in Figure 5. The geological model utilised in the analysis is shown in Figure 7.

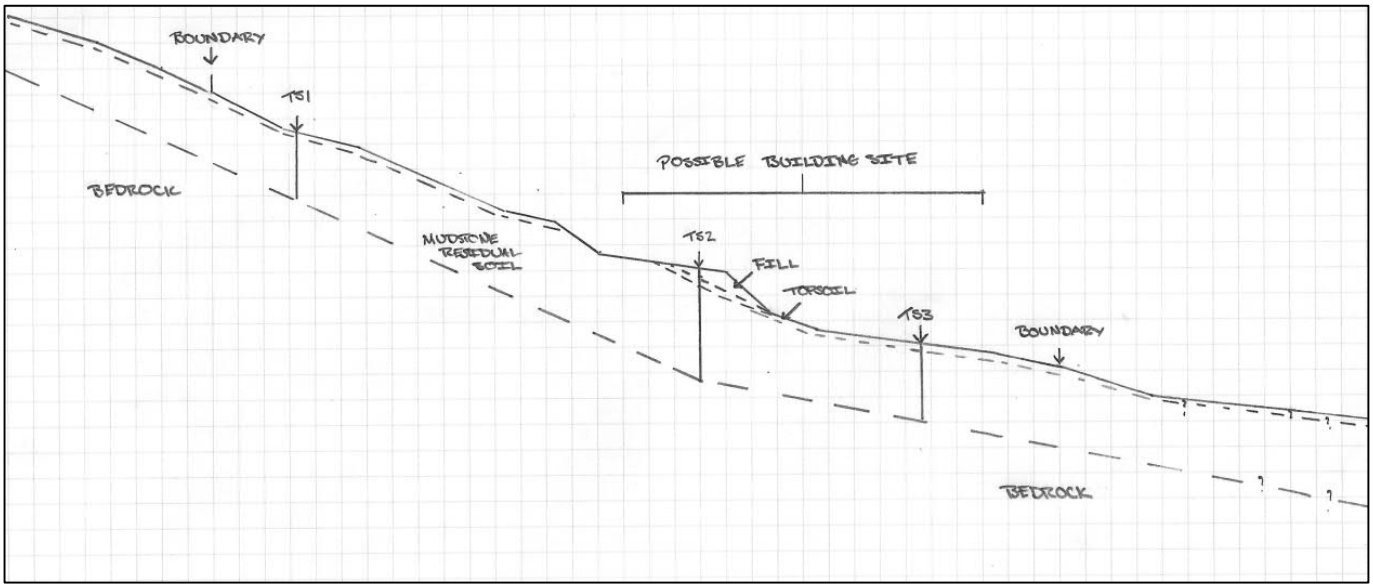


Figure 7: Geological cross section through possible building site.

The analyses included assessment of slope stability under prevailing, worse case groundwater conditions, and SLS and ULS seismic loads. Both circular and non-circular stability modelling has been undertaken, with the non-circular being determined to be the most conservative.

The material parameters given in Table 1 have been used in our analyses of the site. These were derived from published and unpublished correlation charts and papers for the particular materials encountered in the investigation. Undrained shear strength values were utilised in the seismic modelling. Summary printouts from that work are attached.

Table 1: Soil Material Parameters

Material	Unit Weight (kN/m³)	C' (kPa)	Ø' (°)	Su (kPa)
Fill	17	5	30	20
Stiff Soils	18	5	30	50
Very Stiff Soils	18	7	32	150
Hard Soils	18	9	34	200
Mudstone	22	Generalised Hoek-Brown Parameters UCS = 3MPa, GSI = 50, mi = 7, D = 0		

Earthquake magnitude and peak ground acceleration parameter selection for seismic modelling is based on that outlined in Cubrinovski et al[3], as per the recommendation of the New Zealand Geotechnical Society. Seismic parameters used for this site for Serviceability Limit State (SLS) and Ultimate Limit State (ULS) modelling at this site are detailed in Table 2.

Table 2: Seismic Parameters

[3] Cubrinovski M, Bradley B, Wentz F, Balachandra, A (2020). "Re-evaluation of New Zealand seismic hazard for geotechnical assessment and design" *Bulletin of the New Zealand Society for Earthquake Engineering*, Vol 54 No 2. 2021

Earthquake Magnitude (M)	Peak Ground Acceleration (PGA)	Design Water Table Depth	Building Design Life	Building Importance Level
SLS = 6.3 (25-year return period) ULS = 7.5 (500-year return period)	SLS=0.12 ULS=0.65	4 to 5m	50 Years	2

Minimum Factor of Safety (FoS) criteria used in the analyses consist of a Factor of safety >1.5 for prevailing groundwater conditions, and >1.2 for extreme groundwater conditions. The criteria used in the seismic modelling were a FoS of >1.0, or if yielding was indicated, maximum of 25mm under Serviceability Limit State seismic loads and 100mm or lateral movement under a significant Ultimate Limit State seismic event.

In summary the following results were obtained in the stability analyses:

- Under prevailing ground water conditions all slip surfaces FoS values are shown to exceed 1.5.
- Under extreme groundwater conditions (fully saturated) slip surface FoS values as low as 0.97 are shown indicating failure. These slip surfaces and slip surfaces less than 1.2 are shown to be isolated to the wedge of fill within the site (on outside edge of historic farm track).
- Under SLS seismic loads, all slip surface FoS values are shown to exceed 1.0.
- Under a significant Ultimate Limit State event all slip surface FoS values are shown to exceed 1.0.

Based on the stability assessments measures are considered to be required to address the wedge of fill (and topsoil beneath) which exists within the building site. Recommendations regarding this are outlined in Section 7. Summary printouts of the critical stability assessment results are appended to this report.

6.2 Fault Lines

The 1:250,0000 geological map of the region[2] shows no faults running through the property. In addition, the GNS Active Fault Database does not show any active faults running through the property.

There were no obvious geomorphological features which suggest faulting through the site. We therefore consider that the risk of fault rupture to the proposed building site is low.

6.3 Liquefaction

Saturated silts and sands were not encountered under the site and the residual soils (clayey silt) which are indicated to grade into bedrock, are considered to be non-liquefiable. We therefore consider that the site is at a very low risk of being affected by liquefaction.

6.4 Shrink-Swell Soils

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

The near surface soils comprise clayey silt and are therefore expected to have a liquid limit of about 50% based on their physical characteristics determined during the investigation. Taking foundations down to a depth where significant changes in moisture content are not expected is recommended to address this risk (outlined in Section 7).

6.5 Compressible & Low-Density Ground

The topsoil and fill units within the site are considered to present a consolidation/settlement or bearing capacity failure risk under building loads. Recommendations to address these elements are outlined in Section 7.

6.6 Trees

At the time of the investigation there were a number of small to medium sized trees located either within or immediately adjacent to the possible building site. These will need to be removed. There were no other trees within the vicinity of the site which could present a risk to the building through tree root growth and moisture uptake.

7 ENGINEERING RECOMMENDATIONS

7.1 General

Based on the work carried out, we consider that the proposed house site is suitable for residential development. However, measures are required to address:

- The compressible topsoil/buried topsoil and fill layers beneath the site.
- The risk of instability of the small wedge of fill which exists in the site.
- The shrink-swell risk of the near surface soils.

Preliminary site development options and recommendations are given in the following sections.

7.2 Preliminary Site Development

The proposed building zone (approximately 10m wide x 14m long) is sloping, with an elevation difference across it of approximately 4m from its top south end down to its lower northern end. Given the fall across the site and with the installation of an historic farm track through its upper part, the site lends itself to being developed with a stepped or split-level type dwelling recessed into, and/or built on the slope. Alternatively a pole-type house constructed on the slope may be considered. For both options, the wedge of fill within the house site will need to be removed to address the instability risk it poses to the site. If a block-basement type installation is proposed for the lower part of the site, the topsoil and fill will likely need to be replaced with engineered fill and a drainage unit behind the wall on its upper side. Other site development options may exist.

7.3 Preliminary Foundation Design

Based on the work carried out, and provided that the wedge of fill and underlying topsoil within the proposed house site is removed (where required), foundation extension down to a minimum depth of 0.6m below ground level into the underlying residual mudstone soils is considered appropriate. At the recommended foundation depth, the topsoil

is expected to be extended through, and significant changes in soil moisture are not expected, thus minimising the risk and potential consequences of shrink/swell activity on the building's foundations. Utilising the bearing capacity verification method B1:VM4 in the New Zealand Building Code, a minimum allowable bearing capacity of 100kPa (FoS of 3) is expected to be available from this depth. NZS3604:2011 foundation solutions may be able to be utilised, subject to confirmation of the final site development proposal. If retaining of the ground within the site is proposed (e.g. block basement or timber pole and backboard wall) specific engineering design will likely be required given the surcharge slope above. Subject to final site development and building proposal, other elements requiring specific engineering design may also be necessary.

7.4 Vegetation

It is important that gardens do not interfere with any ventilation or drainage systems of the future building. Excessive watering of gardens adjacent to building foundations should also be avoided as this can promote settlement and/or erosion.

Trees can remove moisture from the soil for a radius equal to the height of the tree. This can cause expansive soils to shrink to varying degrees, and heave through tree root growth leading to differential settlement occurring under foundations and possible damage to the building superstructure. To reduce this risk, trees should be planted a minimum of 1 times the mature height of the tree away from the foundation. Alternatively, the expertise of an experienced arborist may be sought with regard to the risk a particular tree type may pose to the building.

7.5 Surface Water

It is paramount that runoff from roof, tank overflows, and paved areas is collected or disposed of in a suitable location away from buildings. Fully contained, piped discharge to the stormwater intake present at the northwest corner of the site (top of driveway) appears suitable, provided that the system can accommodate the calculated discharge volumes. Soak pits are not recommended at this site.

To minimise the potential for foundation settlement, heave and erosion, the stormwater disposal system for the building should be functional as soon as the roof is in place.

8 APPLICABILITY

This report has been prepared for the benefit of Malcolm Galloway with respect to the particular brief given to us. It may not be relied upon in any other context or for any other purpose without out our prior review and written consent.

Recommendations and opinions contained in this report are based on observations, and subsurface investigations put down at point locations. Inferences are made with regard to the continuity of the ground between and beyond the investigation locations. By nature, ground conditions are inherently variable, and it must be appreciated that ground conditions could vary from those assumed. We should be contacted immediately if the conditions are found to differ from that described in this report.

It needs to be appreciated that building specific site testing and reporting needs to be completed for the specific building and site development proposal by a Geotechnical Professional once that proposal is known. Cut and fill proposals which vary from those recommended herein may alter the findings and recommendations made in this report, thus it is important that this document is reviewed as part of the building specific investigation to confirm if additional testing and stability modelling is required to be carried out.

Yours Sincerely

Allied Geotech Ltd

Ross Cumming
MEngNZ
Engineering Geologist
CMEngNZ (PEngGeol)

Attached:

Geotechnical Investigation Logs

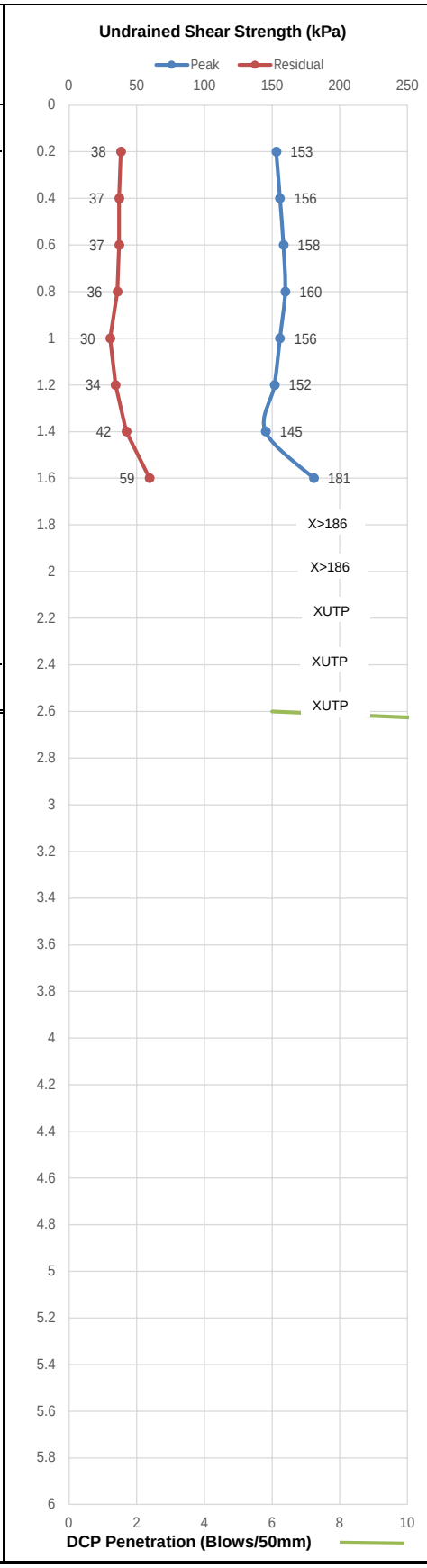
Stability Analyses Printouts

https://netorgft8386503-my.sharepoint.com/personal/ross_alliedgeotech_co_nz/Documents/Projects/100 to 199/150 23 and 25 Darwin Road, Gisborne (Galloway)/Report/25 Darwin Road/Allied Geotech 25 Darwin Road, Outer Kaiti Gisborne Geotechnical Investigation Report 29052022.docx

ALLIED GEOTECH LTD	Client: Malcolm Galloway	AG Project No.: 0150-1	Test No.: TS1
	Project: Confirmation of Geotechnical Suitability of Proposed House Site	Logged By: RGC	Date: 26/05/2022
	Property Location: 25 Darwin Road, Kaiti, Gisborne	Test Site Location: Refer to Site Investigation Plan	
	Test Methods: 50mm Hand Auger, Calibrated Hand-Held Shear Vane, & Dynamic Cone (Scala) Penetrometer		

HANDAUGER BOREHOLE & DYNAMIC CONE PENETROMETER (DCP) TEST LOG

Depth (m)	Colour	Moisture	Strength	Description	Geology
0.0		D-M	VSt	SILT, some clay, dark grey, very stiff, dry to moist	Topsoil
0.2		D-M	VSt	SILT, clayey, light brown, very stiff, dry to moist	Mudstone Residual Soil
1.0				minor highly to completely weathered fine angular mudstone gravel	
1.8			VSt-H	very stiff to hard	
2.4		D-M	H	SILT, clayey, light brown to grey, difficult to auger, some highly to completely weathered mudstone gravel, hard, dry	Mudstone Regolith
2.6				End of borehole @ 2.6m Cannot advance through high strength ground DCP put down in base (instant refusal - 14 blows/50mm recorded) Hole dry on completion	

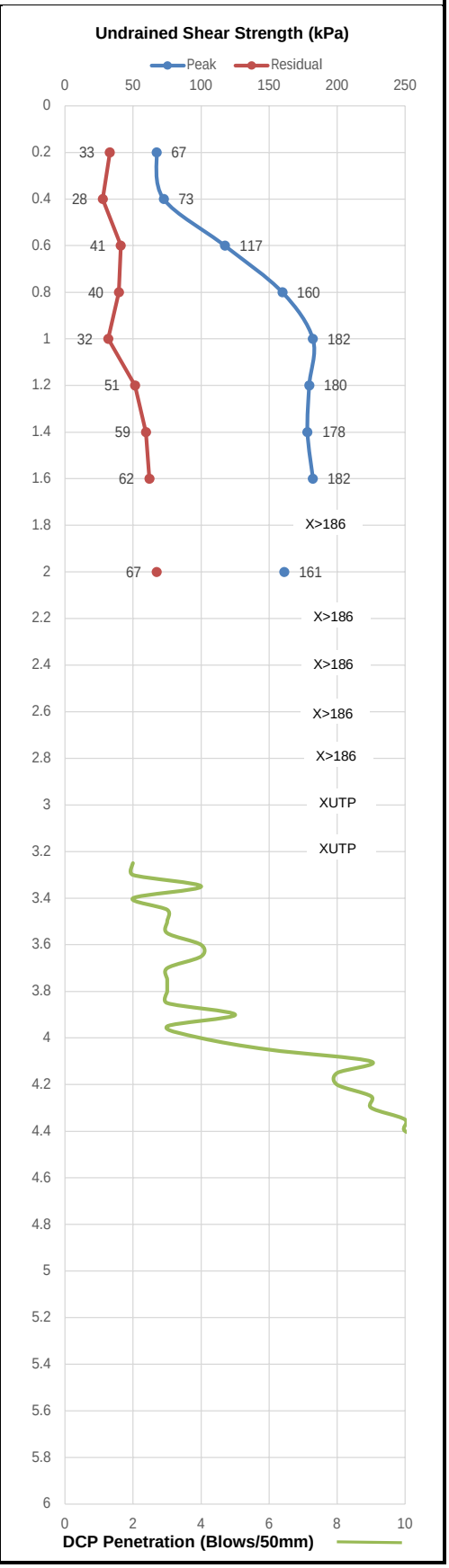


Notes: Soils are logged in general accordance with NZGS field guide sheet description of soil and rock (2005)
Undrained shear strength lines are indicative only.
Undrained shear strength corrected for plasticity (Bjerrum 1973)
UTP = Unable To Penetrate

ALLIED GEOTECH LTD	Client: Malcolm Galloway	AG Project No.: 0150-1	Test No.: TS2
	Project: Confirmation of Geotechnical Suitability of Proposed House Site	Logged By: RGC	Date: 26/05/2022
	Property Location: 25 Darwin Road, Kaiti, Gisborne	Test Site Location: Refer to Site Investigation Plan	
	Test Methods: 50mm Hand Auger, Calibrated Hand-Held Shear Vane, & Dynamic Cone (Scala) Penetrometer		

HANDAUGER BOREHOLE & DYNAMIC CONE PENETROMETER (DCP) TEST LOG

Depth (m)	Colour	Moisture	Strength	Description	Geology
0.0–0.4		M	VSt	SILT, some clay, minor fine to medium pumice sand, dark grey with minor orange brown, stiff, moist	Topsoil Fill
0.3–0.4		M	VSt	SILT, some clay, dark grey, stiff, dry to most	Buried Topsoil
0.5–1.7		D-M	VSt	SILT, clayey, light brown, very stiff, dry to moist	Mudstone Residual Soil
0.7–1.7				mottled orange brown and light brown, minor highly to completely weathered fine angular mudstone gravel	
1.8–2.9			VSt-H	very stiff to hard	
2.5–2.9				some highly to completely weathered fine angular mudstone gravel	
3.0				difficult to auger	
3.1				cannot advance through very high strength ground	
3.2				End of borehole @ 3.25m	
3.3				Cannot advance through high strength ground	
3.4				DCP put down in base and advanced to refusal (4.4m)	
3.5				Hole dry on completion	

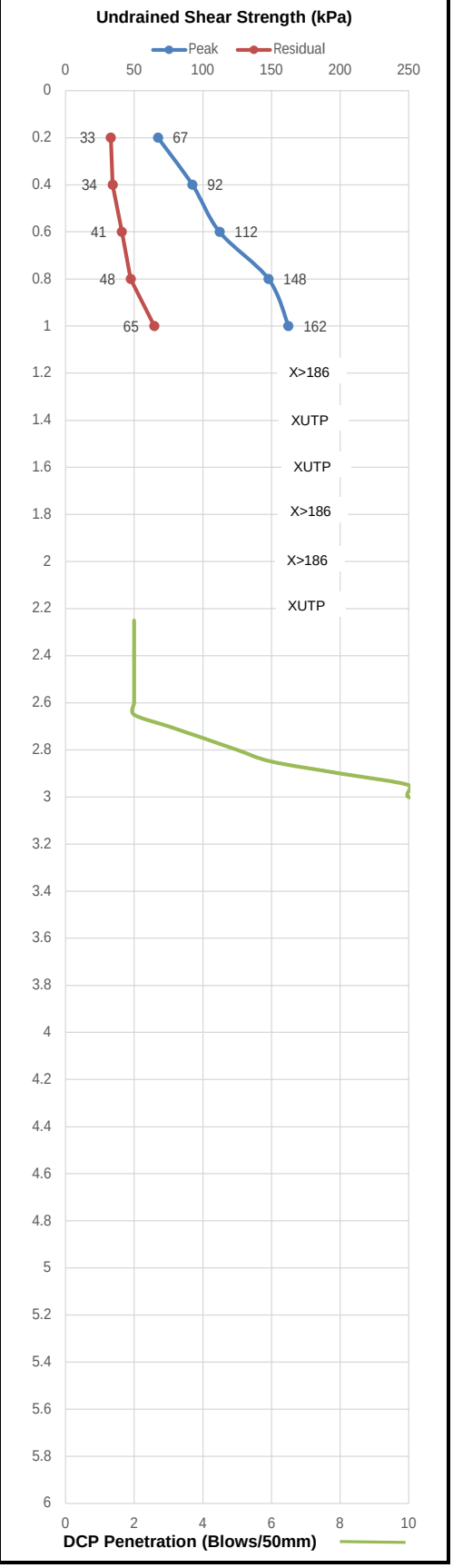


Notes: Soils are logged in general accordance with NZGS field guide sheet description of soil and rock (2005)
Undrained shear strength lines are indicative only.
Undrained shear strength corrected for plasticity (Bjerrum 1973)
UTP = Unable To Penetrate

ALLIED GEOTECH LTD	Client: Malcolm Galloway	AG Project No.: 0150-1	Test No.: TS3
	Project: Confirmation of Geotechnical Suitability of Proposed House Site	Logged By: RGC	Date: 26/05/2022
	Property Location: 25 Darwin Road, Kaiti, Gisborne	Test Site Location: Refer to Site Investigation Plan	
	Test Methods: 50mm Hand Auger, Calibrated Hand-Held Shear Vane, & Dynamic Cone (Scala) Penetrometer		

HANDAUGER BOREHOLE & DYNAMIC CONE PENETROMETER (DCP) TEST LOG

Depth (m)	Colour	Moisture	Strength	Description	Geology
0.0		M	VSt	SILT, some clay, dark grey, moist	Topsoil
0.4		M	St	SILT, clayey, some fine to medium pumiceous sand to 0.6m, mottled orange brown and light brown, stiff, moist	Mudstone Residual Soil
0.6			VSt	very stiff	
0.7				minor highly to completely weathered fine angular mudstone gravel	
1.1			VSt-H	very stiff to hard	
1.9				some highly to completely weathered fine angular mudstone gravel	
2.0				difficult to auger	
2.1				cannot advance through very high strength ground	
2.2				End of borehole @ 2.2m	
2.3				Cannot advance through high strength ground	
2.4				DCP put down in base and advanced to refusal (3m)	
2.5				Hole dry on completion	



Notes: Soils are logged in general accordance with NZGS field guide sheet description of soil and rock (2005)
Undrained shear strength lines are indicative only.
Undrained shear strength corrected for plasticity (Bjerrum 1973)
UTP = Unable To Penetrate