Project Number: 2-37928.00

Wairakei Subdivision

Preliminary Geotechnical Assessment Report

21 February 2022

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150 YEARS IN AOTEAROA

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for TW Property Holdings Ltd ('**Client**') in relation to a geotechnical assessment for the Wairakei Golf Course Subdivision ('**Purpose**') and in accordance with the Engineering New Zealand / ACENZ Short Form Agreement for Professional Services Engagement (SFA). The findings in this Report are based on and are subject to the assumptions specified in the Report and our Offer of Service dated 24 November 2021. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Introduction

WSP has been engaged by TW Property Holdings (TWPH) to prepare a Preliminary Geotechnical Assessment Report (PGAR) for the proposed Wairakei Golf Course Subdivision. This report builds on a previous desk study report by WSP[1]. The purpose of the PGAR is to provide an updated assessment of the suitability of the site for the proposed development based on information obtained from intrusive ground investigations and comment on likely effects of the development on land stability.

It is understood that the proposed development comprises a 31 lot rural lifestyle subdivision. It is proposed to construct a private road and rights of way, carry out cut and fill earthworks to create level building platforms and also modify the landform to provide overland flow paths. Stormwater management is proposed to include on-site soakage pits, rain gardens, baffles / check dams within the gully, and a stormwater pond. Wastewater will also be disposed of to ground within each lot. A proprietary secondary treatment plant designed in accordance with ASNZS1547 and AS/NZS1546 and combined discharge field (40m^2) and reserve area (20m^2) of 60m^2 will be required on each lot.

2 Scope of work

The scope of work includes the following:

- Review and update of the previous desk study where relevant;
- Intrusive ground investigation comprising the following:
    - Three machine drilled boreholes to 20m depth;
    - Standpipe piezometers in each borehole;
    - Seismic cone penetration tests (sCPTu) to 20m depth, with seismic measurements taken every metre;
    - Groundwater monitoring for a minimum of three weeks.
- A geotechnical assessment addressing the following:
    - Liquefaction and lateral spreading;
    - Slope stability considering:
        - Existing slopes;
        - Potential cut and fill slopes.
    - Preliminary assessment of foundations and settlement, including evaluation of the presence of “Good Ground” in accordance with NZS3604:2011;
    - Assessment of potential geotechnical impacts from the development;
    - Determination of appropriate mitigations for potential geotechnical impacts; and,
    - Recommendations for investigations required for subsequent stages.
- The preparation of the PGAR summarising the above.

3 Site description

The site is located adjacent to Wairakei Drive with a legal address of Lot 1 DP 426900 (referred to hereafter as ‘the site’). The site has an approximate area of 250,000 m^2. The site is bounded by the Wairakei International Golf Course to the south, Wairakei Drive to the east, and undeveloped land to the north and west. The ground within the site generally slopes down from west to east with

[1] WSP (2021) Technical report. Wairakei Subdivision – Geotechnical Desk Study.

an elevation of 480m RL along the western boundary and 400m RL along the eastern boundary. A gully feature runs from west to east along the southern side of the site with 10m to 20m high slopes at gradients from 1H:1V to 1.5H:1V. A slope along the western boundary rises 20m at a gradient of 5H:1V to 6H:1V. A site location plan is shown on Figure 3-1.

Figure 3-1: Site location

4 Desk study

4.1 Regional geology

The geology of the area is described by Begg et al. (2010) in the 1:250,000 scale map "Geology of the Rotorua Area", and by Grindley (1961) in the 1:63360 scale map "New Zealand Geological Survey – Taupo".

The Begg map indicates that the site is underlain by Oranui Formation (Q3v) deposits. The Oranui Formation is described as comprising non-welded, cream to pale pink-brown rhyolite ignimbrite with pumice clasts in a sandy ash matrix; minor fall deposits. The site is also near to the boundary of the area underlain by the Taupō Pumice Formation (Q1v), which comprises non-welded, loose to sintered, white to pale grey, rhyolite ignimbrite with white to pale pink pumice clasts. Considering the topography of the site it is also inferred that reworked Taupō Pumice Alluvium (Q1a) may be present in some areas of the site.

The Grindley map indicates that the site is underlain by Taupō Pumice Alluvium (ta), which is described as pumice alluvium and pyroclastics below Taupō Terrace deposits. The alluvium is describes as being widespread in the upper Waikato Valley and its tributaries, underlying a pronounced terrace produced by aggradation of the Waikato River system following the last major Taupo eruptions of 120 A.D.

The site location in the context of the regional geology plan from Begg is shown on Figure 4-1.

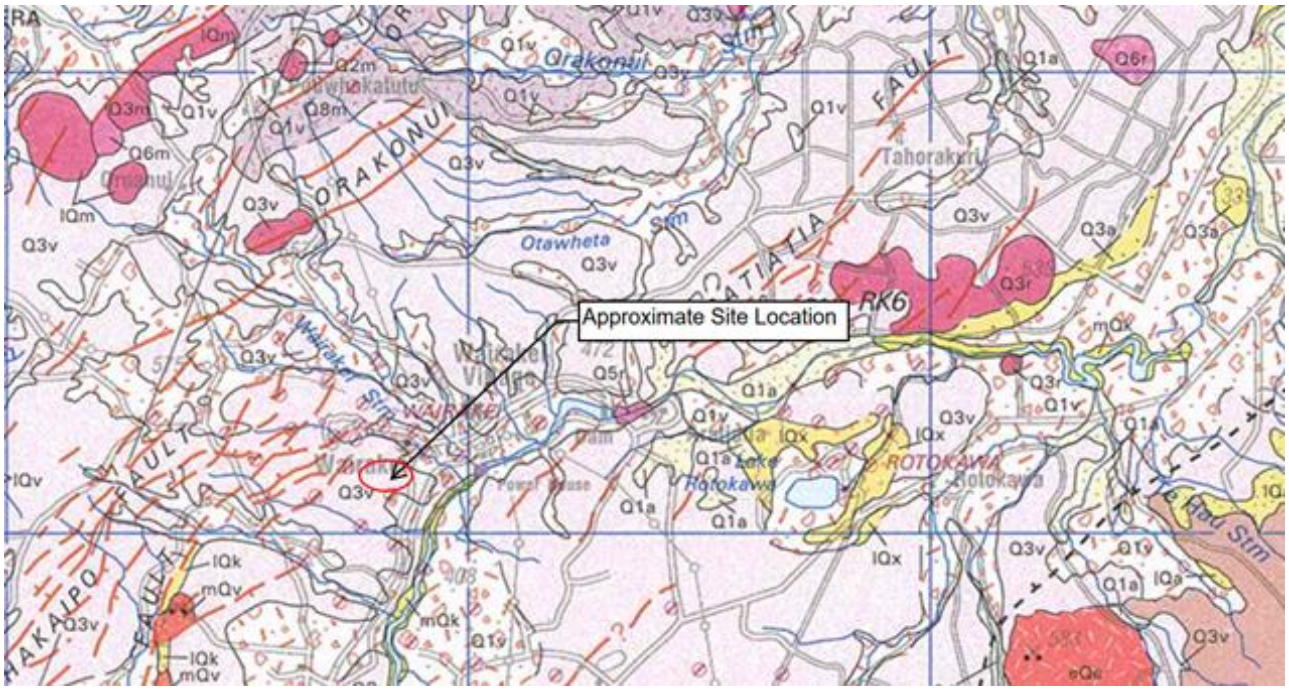

Figure 4-1: Regional geological setting (Leonard, G.S.; Begg, J.G.; Wilson, C.J. J. 2010: Geology of the Rotorua Area. Institute of Geological & Nuclear Sciences Limited.)

4.2 Historical investigation data

The New Zealand Geotechnical Database (NZGD) and the WSP Spatial Database have been reviewed for relevant investigation data that may be present near to the subject site. For the purpose of this report data within a distance of 1.5km of the site boundary has been considered, focusing on investigations located in similar geological units and topography and neglecting investigations in different geological units and topography (for example the investigations for the Eastern Arterial that are adjacent to the Waikato River around 350m RL). The historical investigations are summarised in Table 4-1 with logs attached in Appendix A.

Table 4-1: Historical investigations

Investigation ID	Type	Elevation (m RL)	Depth (m bgl)	Ground water Level (m bgl)	Distance from the site (m)	Soil Description
BH_117657	BH	394	24.5	N/A	1300m north	Interbedded sands, silty sands, sandy gravels
BH_117658	BH	389	12.5	N/A	1300m north	Interbedded sands, silty sands, sandy gravels
BH_117659	BH	399	18.5	N/A	1300m north	Interbedded sands, silty sands, sandy gravels
BH_117660	BH	475	18.5	N/A	1300m north	Interbedded sands, silty sands, sandy gravels
BH_117661	BH	488	22.5	8	1300m north	Interbedded sands, silty sands, sandy gravels

Investigation ID	Type	Elevation (m RL)	Depth (m bgl)	Ground water Level (m bgl)	Distance from the site (m)	Soil Description
BH_117662	BH	495	18.5	N/A	1300m north	Interbedded sands, silty sands, sandy gravels
CPT_117288	CPT	400	31	N/A	1300m north	Interbedded silty sand and sand. Occasional clayey silt and organic silt layers.
CPT_117289	CPT	394	24.6	N/A	1300m north	Interbedded silty sand and sand.[2]
CPT_117290	CPT	389	33.8	12m*	1300m north	Interbedded silty sand and sand.[2]
CPT_117291	CPT	398	28	13m*	1300m north	Interbedded silty sand and sand.
CPT_117292	CPT	398	22	N/A	1300m north	Interbedded silty sand and sand.
TP1	TP	N/A	3.3	N/A	350m northeast	Interbedded gravel, silty sand, sand
TP2	TP	N/A	2.7	N/A	350m northeast	Interbedded gravel, silty sand, sand
CPT1	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT2	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT3	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT4	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT5	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT6	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT7	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.
CPT8	CPT	N/A	10	N/A	350m northeast	Interbedded silty sand and sand.

**Note that from the CPTu pore pressure profiles it is possible to infer groundwater levels at depths of between 12m bgl to 15m bgl*

[2]Note that for these two CPTs the original soil behaviour chart for the CPT indicates the presence of clay soils. However, based on the pore pressure profile and the modified normalized plot and the schneider plots, it is inferred that this is an erroneous result

4.3 Topography

Topographical data has been sourced from the contour data available in the 'TDC Mapi Service' and is shown on Figure 4-2. The site slopes from a high of 480m RL along the western boundary to 400m RL along the eastern boundary, with the slope generally running from west to east. A gully feature is present with 10m to 20m high slopes ranging from 1H:1V to 1.5H:1V, and a 20m high 5H:1V slope is located along the western boundary near the existing stormwater pond.

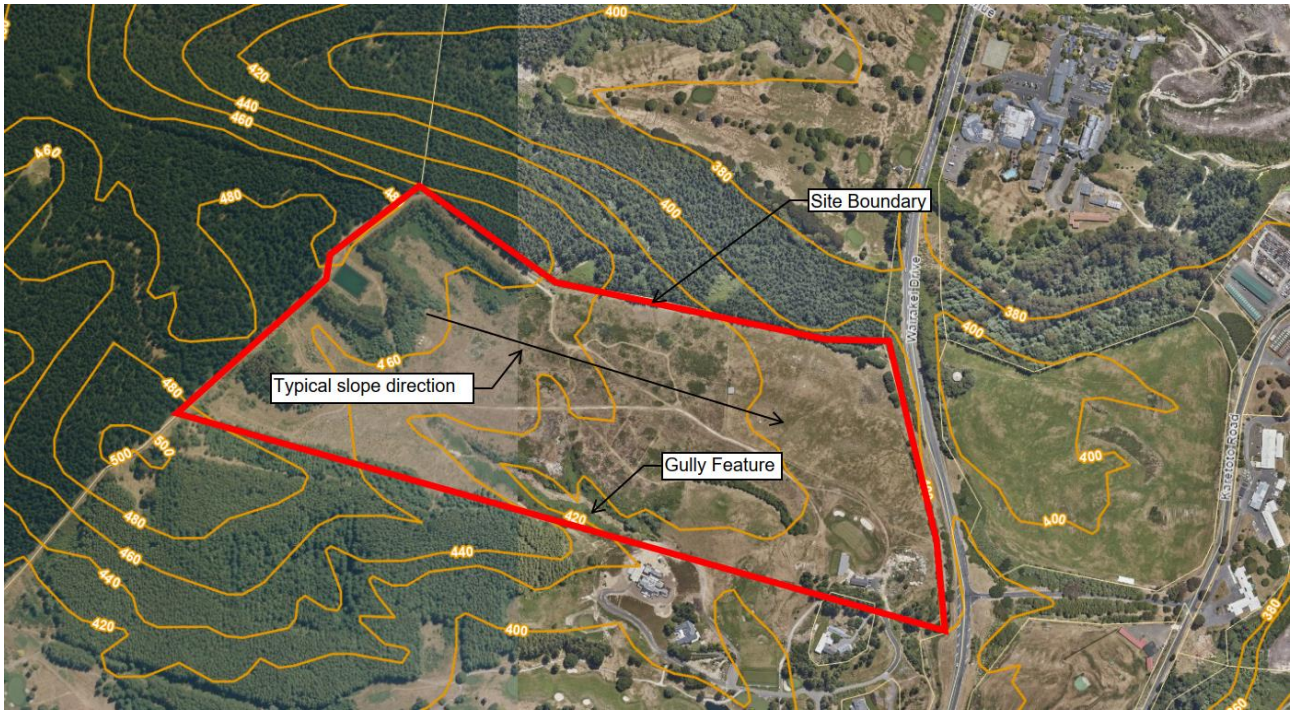

Figure 4-2: Site Topography (from TDC Mapi Service)

4.4 Fault maps

According to the GNS Active Fault Database, there are three identified active faults within 5km of the site, the Karapiti Fault, multiple traces of the Kaiapo Fault, and two traces of the Aratiatai fault. The fault locations are presented in Figure 4-3.

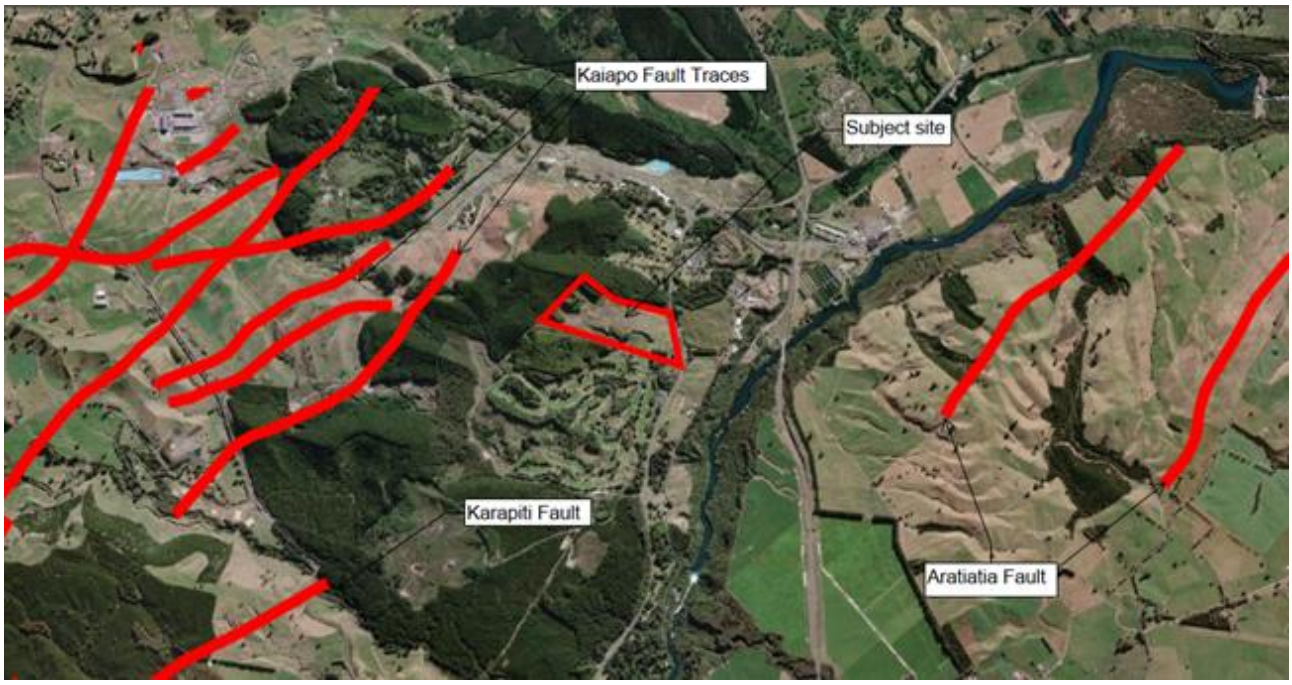

Figure 4-3: Fault Locations

4.5 Published geohazard mapping

Published mapping of natural hazards is available from GNS Science, Waikato Regional Council, and Taupō District Council records. A review of the published geohazard mapping is summarised in Table 4-2.

Table 4-2: Published geohazard mapping summary

Geohazard	Comment
Flooding	The site is not located in a flood hazard zone
Geothermal ground	The site is not located in a mapped hot ground zone but is part of the geothermal rule area
Fault avoidance zone	The site is not located within a fault avoidance zone
Subsidence	The site is located immediately south of the boundary of the Wairakei Subsidence Bowl
Landslides	There are no landslides recorded in the National Landslide Database on the site
Liquefaction	Waikato Regional Council has published a high level liquefaction hazard study in December 2021 that assigns the preliminary category 'Liquefaction Hazard – Unlikely'

5 Geotechnical investigation

5.1 Field program

The investigation program was undertaken from January 11th to 14th 2022 at locations selected by WSP. Service clearance was carried out by Geotech Drilling prior to commencing intrusive investigations. Machine borehole drilling and sCPTu testing were carried out by Geotech Drilling and supervised by a representative of WSP. Downhole seismic shear wave testing was carried out by RDCL.

The three machine boreholes were all completed to target depth with standpipe piezometers installed as planned. The sCPTu tests reached practical refusal at depths ranging from 14.73m below ground level (bgl) to 20.8m bgl due to excessive tip or skin friction resulting in lifting of the CPT truck.

Subsequent to the ground investigation, groundwater monitoring was carried out for a period of three weeks.

5.2 Investigation summary

The soils encountered at the investigation locations essentially comprised pumiceous sands with varying coarseness and varying pumiceous gravel content. The upper 5m to 6m of the soil profile was typically loose while the underlying 14m to 15m was medium dense to dense, based on shear wave velocity (Vs), standard penetration test (SPT), and CPT correlations. Further details of the investigations are presented on the logs in the Appendix.

5.3 Ground model

Based on the published geological maps, historical investigations, and our intrusive site investigation program, the ground model in Table 5-1 is proposed.

Table 5-1: Ground model

Geological unit	Upper Taupō Pumice Alluvium	Lower Taupō Pumice Alluvium
Soil description	Fine to medium sand with fine pumice gravel; moist	Fine to medium sand with fine pumice gravel; moist
Typical depth to top of unit (m bgl)	0	5 – 6
Typical thickness of unit (m)	5 – 6	15
Typical relative density	Loose	Medium dense to dense; typically increasing with depth
Typical Vs (m/s)	132 – 211; average 150	173 – 363; Average 260
Typical SPT N	2 – 9; average 5	11 – 52; average 26
Typical Sleeve friction* (kPa)	5 – 200; average 90	80 – 650; average 260

**Note that sleeve friction is reported rather than tip resistance as it has been shown that pumiceous soils with variable relative densities show differences in sleeve friction but not tip resistance*[2]

5.4 Groundwater conditions

Groundwater measurements were taken upon completion of drilling, and each week for three weeks thereafter. The results are summarised in Table 5-2.

Table 5-2: Groundwater levels

Date	BH1	BH2	BH3
14/01/2022	Dry	Dry	Dry
18/01/2022	Dry	Dry	Dry
28/01/2022	Dry	Dry	Dry
3/02/2022	Dry	Dry	Dry

6 Geotechnical considerations

6.1 Seismicity

Seismicity for the site has been assessed based on the assumption of Importance Level 2 structures. The MBIE has presented design PGA's for Taupo[3] for each importance level, which are:

- 0.09g for 1/25-year earthquake for IL2
- 0.39g for 1/500-year earthquake for IL2

Note that due to limitations in the CLiq and CPeTit software, we have adopted a PGA of 0.1g for the 1/25-year earthquake.

6.2 Liquefaction

6.2.1 General

Liquefaction is a result of the tendency of soil to contract under cyclic shear loading. If the soil is saturated with water and the contraction of loose soil is prevented or slowed due to drainage time, excess pore water pressures are generated reducing the effective stress. Liquefaction refers to the loss of strength and stiffness of the soil caused by this excess pore water pressure[4]. Liquefaction can result in settlement of the ground surface, bearing capacity failure, and horizontal movements. Surface manifestations of liquefaction such as sand boils can also occur.

For liquefaction to occur, three key conditions are required[5]:

[2] Wesley, L.D. et al. *Engineering Properties of a Pumice Sand*. Proceedings, 8th Australia New Zealand Conference on Geomechanics, Hobart. 2000.
[3] Ministry of Business, Innovation, & Employment. Earthquake geotechnical engineering practice. Module 1. Overview of the guidelines. November 2021. Appendix A.
[4] Canadian Geotechnical Society. *Canadian Foundation Engineering Manual 4th Edition. (2006).* 99.
[5] Ministry of Business, Innovation and Employment (MBIE). *Planning and Engineering Guidance for Potentially Liquefaction Prone Land. (2017).* 8.

1. The soil must be susceptible to liquefaction (typically loose non-plastic soil that is contractive under cyclic shear loads)
2. The soil must be saturated
3. An earthquake with sufficient duration and intensity to trigger liquefaction must occur

Liquefaction triggering is assessed by comparing the Cyclic Stress Ratio (CSR), which represents the seismic demand caused by the design earthquake with the Cyclic Resistance Ratio (CRR), which represents the capacity of the soil to resist liquefaction. Vertical and lateral movements can then be predicted based on the thickness and Factor of Safety of the liquefied layers.

A key factor when assessing the liquefaction of soils in the Taupō area is that the standard correlations between in-situ test results and CRR were developed for hard-grained soils and several authors (Pender[6], Asadi et al[7], Asadi et al[8], Orense et al[9], Orense et al[10]) have demonstrated that the standard correlations underestimate CRR for crushable pumiceous soils by between 50% up to 200% and thus significantly overpredict the potential for liquefaction triggering and subsequent damage.

6.2.2 Liquefaction Assessment Method

We have used the Vs based method developed by Kayen (2013)[11] along with corrected CRR's presented by Asadi (2019)[12] to assess the potential for liquefaction. A parametric assessment has been carried out for groundwater levels of 10m, 15m and 20m. Calculations were also carried out using the CPT-based procedure of Idriss & Boulanger (2014)[13], and the uncorrected Kayen (2013) procedure for comparison.

6.2.3 Liquefaction Assessment Results

We have completed calculations of liquefaction triggering for the 1/25 year, and 1/500 year earthquakes along with a parametric assessment of groundwater at 10m, 15m, and 20m depth. The results indicate a negligible risk of liquefaction triggering and associated land damage. A detailed summary of the calculations and results is presented in the Appendix.

6.2.4 Implications for development

Based on the currently available information and level of assessment, per the MBIE guidance on liquefaction assessment, it is considered that the site may be classified as having a very low susceptibility to liquefaction. A revised liquefaction vulnerability assessment for the site is presented in Figure 6-1.

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[6] RP Orense, MJ Pender, AS O'Sullivan. EQC Project 10/589. *Liquefaction Characteristics of Pumice Sands. (2012)*
[7] M.B. Asadi, M.S. Asadi, M.J. Pender, R.P. Orense. *Dynamic properties and undrained cyclic behaviour of undisturbed pumiceous soil.* 2016.
[8] M.S. Asadi, M.B. Asadi, R.P. Orense, M.J. Pender, E. Jacobs. *Undrained cyclic and post-liquefaction behaviour of natural pumiceous soils.* 2017.
[9] R.P. Orense, M.B. Asadi, M.E. Stringer, M.J. Pender. *Evaluating Liquefaction Potential of Pumiceous Deposits Through Field Testing: Case Study of the 1987 Edgecumbe Earthquake.* 2020.
[10] R.P. Orense, M. Hyodo, T. Kaneko. *Dynamic deformation characteristics of pumice sand.* 2012.
[11] Kayen, R., Moss R., Thompson E., Seed R., Cetin K.., Der Kiureghian A., Tanaka Y., & Tokimatsu, K. Shear wave velocity-based probabilistic and deterministic assessment of seismic soil liquefaction potential. 2013. J. Geotech. Geoenviron. Eng. 139(3): 407:419.
[12] Asadi et al. Shear wave velocity-based assessment of liquefaction resistance of natural pumiceous sands. Geotechnique Letters. 8(4), 262-267
[13] R.W. Boulanger, I. M. Idriss. *CPT and SPT Based Liquefaction Triggering Procedures.* Report No. UCD/GCM-14/01. April 2014.

Figure 6-1: Preliminary liquefaction vulnerability map

6.3 Slope stability

A slope stability analysis was completed by WSP based on the ground model proposed in this report, soil parameters informed by our investigation results, previous work by WSP in the Taupō area and a critical slope section inferred from elevation data published by TDC.

6.3.1 Method of assessment

Slope stability calculations were carried out using Geostudio Slope/W Ver. 2021.3. All analyses were carried out using the Morgernstern-Price[14] Limit Equilibrium calculation method as implemented in Slope/W's implementation of the General Limit Equilibrium[15] method.

Calculations were carried out for the following cases:

1. Static slope stability assuming dry conditions
2. An elevated groundwater case
3. A ULS seismic case

6.3.2 Input parameters

Input parameters for the slope stability model are described below, with justification where relevant.

- Effective Friction Angle - Phi (**Φ'**) – 35° for the upper pumice and 40° for the lower pumice
    - Based on design values adopted for the Taupō Eastern Arterial Project and historical direct shear testing by WSP in the Taupō, correlations between relative density and friction angle, and the CPT testing results

[14] Morgenstern, N.R. & Price, V .E. (1965). The analysis of the stability of general slip surfaces. Geotechnique, Vol. 15, No. 1, pp 79-93.
[15] Fredlund, D.G. & Krahn, J. (1977). Comparison of slope stability methods of analysis. Canadian Geotechnical Journal, Vol. 14, pp 429-439.

- Effective Cohesion (c') – 5 kPa
    - Typical value adopted for pumice soils to account for apparent cohesion
- Slope geometry
    - 1.5H:1.0V slope with a 5H:1V back slope which we infer to be the worst case section
- Seismic coefficient
    - 0.39g[16] PGA applied as a pseudo-static seismic coefficient of PGA * 0.5 as recommended by the NHRCP for Limit-Equilibrium Pseudo-Static Slope Stability Assessments[17]
    - Note that this method implies accepting up to 25-50mm of permanent deformation after the ULS earthquake.
- Porewater pressure
    - Dry for static and seismic conditions
    - Elevated groundwater case with Ru = 0.2 applied to the top 5m of the soil profile

6.3.3 Results

Calculated Factors of Safety are presented in Table 6-1. A recommended setback distance from the slope crest was determined by finding the distance behind the crest where the minimum factor of safety for all cases increases to at least 1.5. On this basis we have calculated a recommended setback distance of 10m from the slope crest.

Table 6-1: Slope stability assessment results

	Static Case	Seismic Case	Elevated Groundwater
Calculated Factor of Safety	1.5	1.04	1.17
Required Factory of Safety	1.5	1.2	1.1

6.3.4 Proposed cut and fill slopes

It is proposed that the development will consist of level sections involving minor cut to fill earthworks, providing 'benched' platforms for buildings. This will involve the creation of cuts into the uphill areas of the Lots using the cut materials as fill over the lower sections to create a level building platform. At this preliminary stage, based on the type of soils that are inferred to be present on site, it is envisaged that cut and fill slopes of up 1.5m in height could be created with side slopes of 1H:1V formed from the pumice materials on site or from imported fill. Slopes would be required to be vegetated and may potentially incorporate a 'geocell' to provide stabilisation and prevention of erosion of near surface soil materials. Alternatively, retaining structures may be used to support cut/ fill slopes. This could include short timber pole walls, timber crib walls or segmental block walls with geogrid reinforcement. If higher cut or fill slopes are to be used then

[16] MBIE. Earthquake geotechnical engineering practice – Module 1. Overview of the guidelines. Appendix A. Table A1: Peak Ground Acceleration (a_{max}) and earthquake magnitude (M) values recommended for Geotechnical Assessment, for Site Classes A, B, C, D, and E, for level ground conditions. 2021.
[17] National Cooperative Highway Research Program. NHRCP Report 611 – Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments. 2008. Section 8.3.1 Slopes and Embankments - Limit Equilibrium Approach. p101.

a slope stability assessment will be required to be undertaken by a geotechnical engineer or engineering geologist.

6.3.5 Gully erosion

A key geohazard impacting the site is the risk of gully erosion and regression. At this stage, it is understood that it is proposed to use the gully as a flow path for the management of surface water run-off. Therefore, it is anticipated that gully management including planting of vegetation along the side slopes and gully floor, and installation of baffles or check dams within the gully, would be required to mitigate any risk of erosion.

6.4 Foundations and good ground

It has been requested to carry out a high level assessment of the suitability of the site for typical foundations and the likelihood of achieving 'Good Ground' under NZS3604. The good ground assessment in NZS 3604 essentially has four criteria:

- Ultimate bearing capacity of at least 300 kPa;
- The soil must not be expansive, where expansive is defined as a liquid limit of more than 50% and a linear shrinkage of more than 15%;
- The soil must not foreseeably experience movement of more than 25 mm for any reason including soft compressible soils, land instability, ground creep, subsidence, seasonal swelling and shrinkage, frost heave, changing groundwater level, erosion, dissolution of soil in water, and effects of tree roots; and,
- The soil must not be liquefaction prone.

A discussion of these requirements in the context of the available information about the site is presented in Table 6-2.

Table 6-2: Foundations and 'Good Ground' Assessment

Criteria	Commentary	Good Ground
Ultimate Bearing Capacity > 300 kPa	Some building sites would meet the criteria for 'Good Ground' as defined within NZS 3604 whilst others may not, requiring Specific Engineer Designed (SED) foundations	Case by case. Some building sites will likely meet this criteria and others will not. Standard practices such as undercutting and replacement of loose soils, re-compaction, and the use of raft slab foundations are likely to be suitable.
Expansive soils	Expansive soils typically comprise clays and silts near the ground surface. Expansive soils were not encountered at our investigation locations and are unlikely to be present elsewhere at the site.	Good ground
Ground movement	At this stage we do not have enough information to make an assessment of whether settlement caused by the Wairakei Settlement Bowl is possible and what likely future settlements would be.	Further information is required on land subsidence to make a determination. Provided that settlements within the site are predominantly uniform, they may be accommodated with Specific Engineer Designed (SED) foundations

Criteria	Commentary	Good Ground
Liquefaction	Based on our investigation and testing we consider that the site has a very low liquefaction vulnerability as defined by MBIE[18]	Good ground

It should be noted that if criteria for 'Good Ground' is not met this does not preclude development of the site. Subject to further ground investigation and geotechnical assessment of sites, 'Specific Engineer Designed' (SED) foundations may be provided that would accommodate potential subsidence or seismic risks. Typically these may include the adoption of 'rib-raft' or 'waffle slab' type foundations located on a gravel pad. Alternatively ground improvement may be undertaken which could comprise the excavation and replacement of unsuitable ground or densification of underlying soils by vibro-compaction or vibro- replacement.

6.5 Location of infiltration pits and on site wastewater disposal

It is proposed that 'infiltration' (soakage) pits be used within the development for the disposal of stormwater along with on-site discharge fields for wastewater disposal. The use of soakage pits and on-site discharge fields will be dependent upon the ground conditions present beneath individual lots, the form of construction of the building platforms, the feasibility of providing soakage within fill platforms and the impact this may have on the stability of slopes nearby.

At this preliminary stage, it is recommended that 'on lot' soakage pits (or similar) be no closer than 10m from the slope crest. Additionally, where soakage devices are to be placed within fill material platforms, it is recommended that provision be made in their design to carry the water down to underlying in-situ soils. A minimum separation of 5m between soakage devices is recommended. Further ground investigation to include permeability testing of existing soils will be required for the detailed design of soakage systems on each site.

6.6 Assessment of geotechnical effects

A significant geotechnical factor impacting the development of the site and land stability relates to the management of surface water and groundwater flows. At this stage, based on limited available information on the proposed development and the ground conditions present at the site, a high level review of the management of surface water and groundwater flows may be made, as follows:

- Regarding the effect of the development on infiltration:
    - Development of the land will lead to an increase in the impermeable area across the development, increasing runoff and decreasing natural infiltration.
    - Watering of lawns may increase infiltration during times of year when infiltration would otherwise not have occurred.
    - The impact of the above two changes is driven by the effects they will have on the current groundwater table and changes that may occur. We consider that the overall effect on groundwater levels will be minor, and settlement would likely also be minor. Any Increase in infiltration during summer due to watering of lawns would also be less than normal winter infiltration. It is therefore considered unlikely that this will have any impact on slope stability.
    - Based on observations of the golf course land to the south of the site, there has been no discernible adverse impact on the land due to infiltration from watering

[18] MBIE. Planning and engineering guidance for potentially liquefaction-prone land. Resource Management Act and Building Act aspects. 2017.

activities nor within those sections where there has been an increase in impermeable areas.

- Regarding the effect of soakage pits and the stormwater ponds
    - On site soakage pits have the effect of concentrating infiltration into a small area, which could result in localised instability. The proposed setbacks detailed in Section 6.5 will limit this risk.
    - On site stormwater ponds will concentrate a large volume of water into a small area during storm events. This could result in the formation of tomos driven by seepage from the pond and also potentially slope instability caused by raising of the groundwater table beneath the pond. It is considered that further ground investigations and appropriate engineered design for stormwater ponds will mitigate these risks.
    - Based on observations of the golf course land to the south of the site, there has been no discernible adverse impact resulting from the concentration of water in on site ponds.

7 Conclusions

From the available information recorded within the area, it is considered that the site is suitable for the proposed development based on our desk study, the intrusive investigations carried out, and our analysis of the results. General conclusions are presented in Table 7-1.

Table 7-1: Summary of findings

Item	Summary and Uncertainty
Ground model	The soil conditions predominantly consist of a 5-6m thick layer loose of pumiceous sand with some fine pumiceous gravels underlain by medium dense to dense pumiceous sand with fine pumiceous gravels extending to at least 20m depth. There is low uncertainty in the ground model. **Refer to Section 5.3 for more information**
Groundwater	Groundwater monitoring from wells installed within the site for a period of three weeks indicate a static groundwater table located at least 20m below ground level. **Refer to Section 5.4 more information**
Seismicity	Based on the available information the site is assessed as being of 'Seismic Class C'. Assuming that buildings within the proposed development will have an Importance Level IL2, design PGAs of 0.1g SLS and 0.39g ULS have been determined. **Refer to Section 6.1 for more information**
Liquefaction	Based on our assessment the site has a very low liquefaction susceptibility and a negligible risk of liquefaction related land damage. **Refer to Section 6.2 for more information**

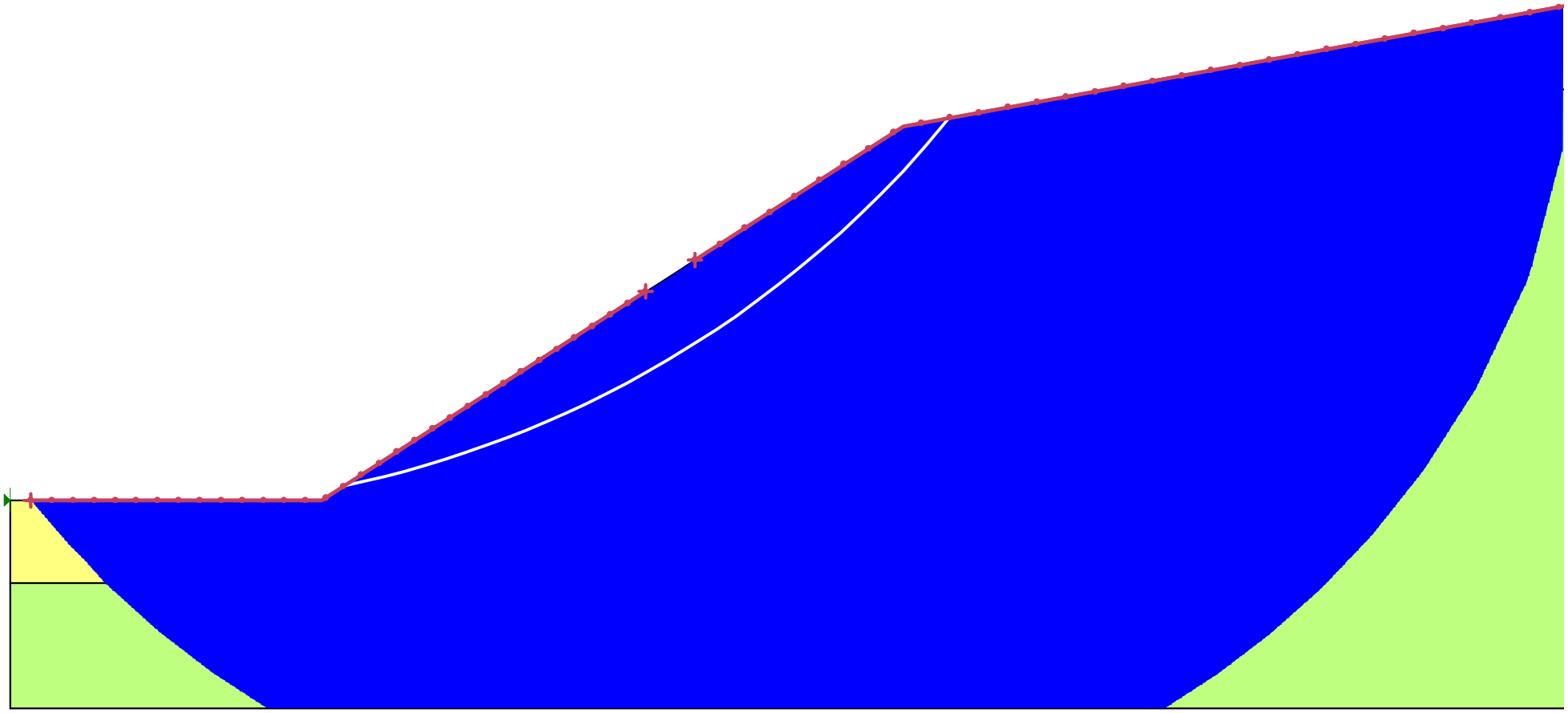
Item	Summary and Uncertainty
Slope Stability	It is considered that there is a low risk of slope stability issues impacting the site. Based on a preliminary assessment, building setbacks of 10m or 0.5x the slope height are recommended for natural, cut and fill slopes. Refer to Section 6.3 for more information
Foundations and 'Good Ground'	Ultimate bearing capacity will vary across the site. For the type of ground conditions inferred to be present, it can be expected that some areas indicating the presence of 'Good Ground' (bearing capacity >300kPa), permitting the adoption of standard NZS 3604 foundations, will be present whilst other areas will require SED foundations It is unlikely that expansive soils will be present. Settlements of more than 25mm are possible due to the Wairakei settlement bowl and seismic effects. Standard foundations such as a reinforced concrete raft or 'waffle slab' on a compacted gravel layer are likely to be suitable for residential dwellings. Refer to Section 6.4 for more information
Gully Erosion	Management of the gully with additional vegetation and baffles / check dams is recommended to minimise erosion risks. Refer to Section 6.3.5 for more information
Assessment of geotechnical effects	Changes to on-lot infiltration patterns are likely to have negligible effects provided good practice is followed regarding location of on site soakage devices. The on site stormwater pond is likely to have negligible effects provided that an engineered design is prepared with suitable mitigations to minimize the risk of erosion and tomo formation. Refer to Section 6.6 for more information
Further investigations	Further investigations are recommended at the engineering design stage for residential dwellings and stormwater ponds.

Appendix A

Slope stability sections

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Ru
	Lower Pumice	Mohr-Coulomb	14	5	40	0
	Upper Pumice	Mohr-Coulomb	14	5	35	0

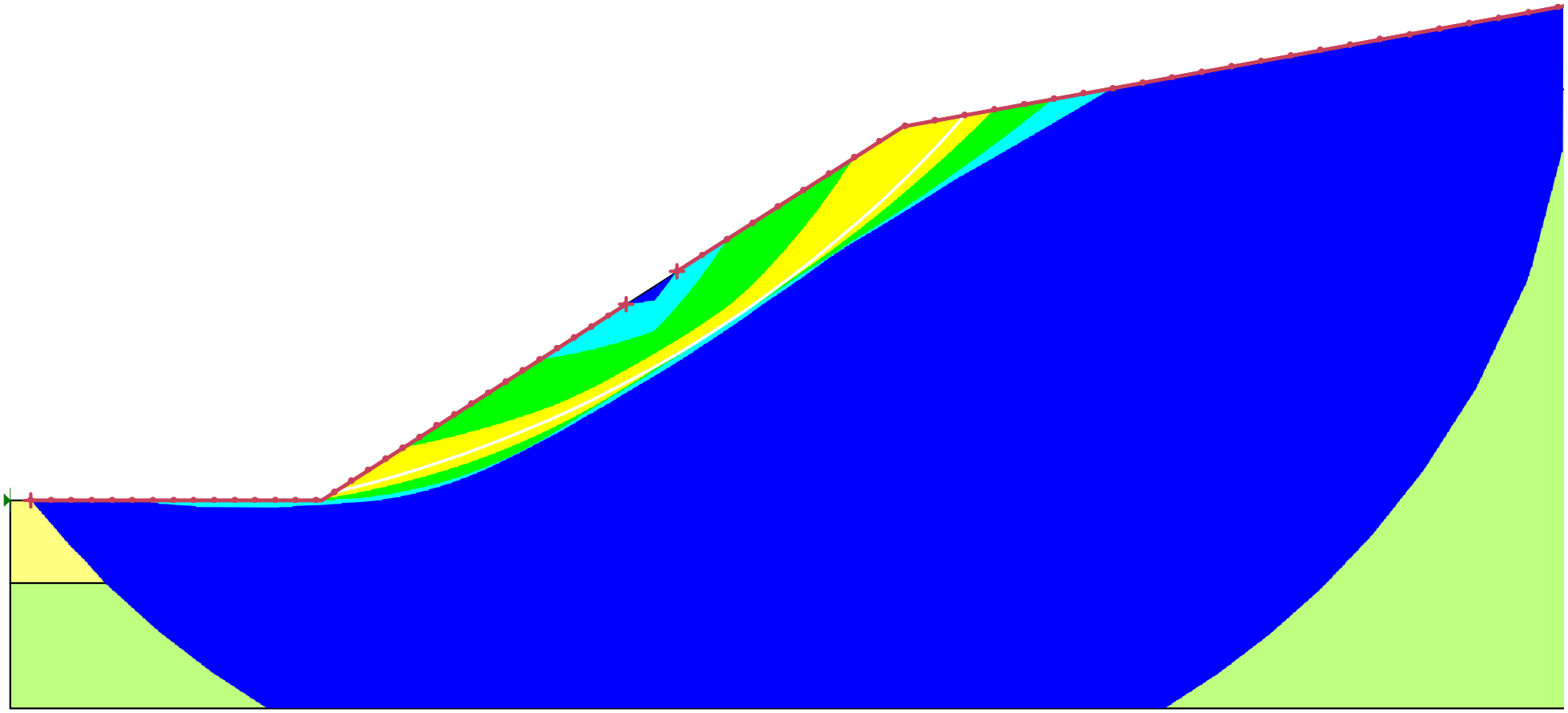
1.489



Project:	Wairakei Golf Course Residential				Method	Morgenstern-Price
Analysis:	Static				Scale	1:292
					PGA	0g
Modelled By:	Preston, Johnathon	Checked By: Name	Analysis Type: SLOPE/W	Date: 14/02/2022	FOS	1.489

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Ru
	Lower Pumice	Mohr-Coulomb	14	5	40	0
	Upper Pumice	Mohr-Coulomb	14	5	35	0.2

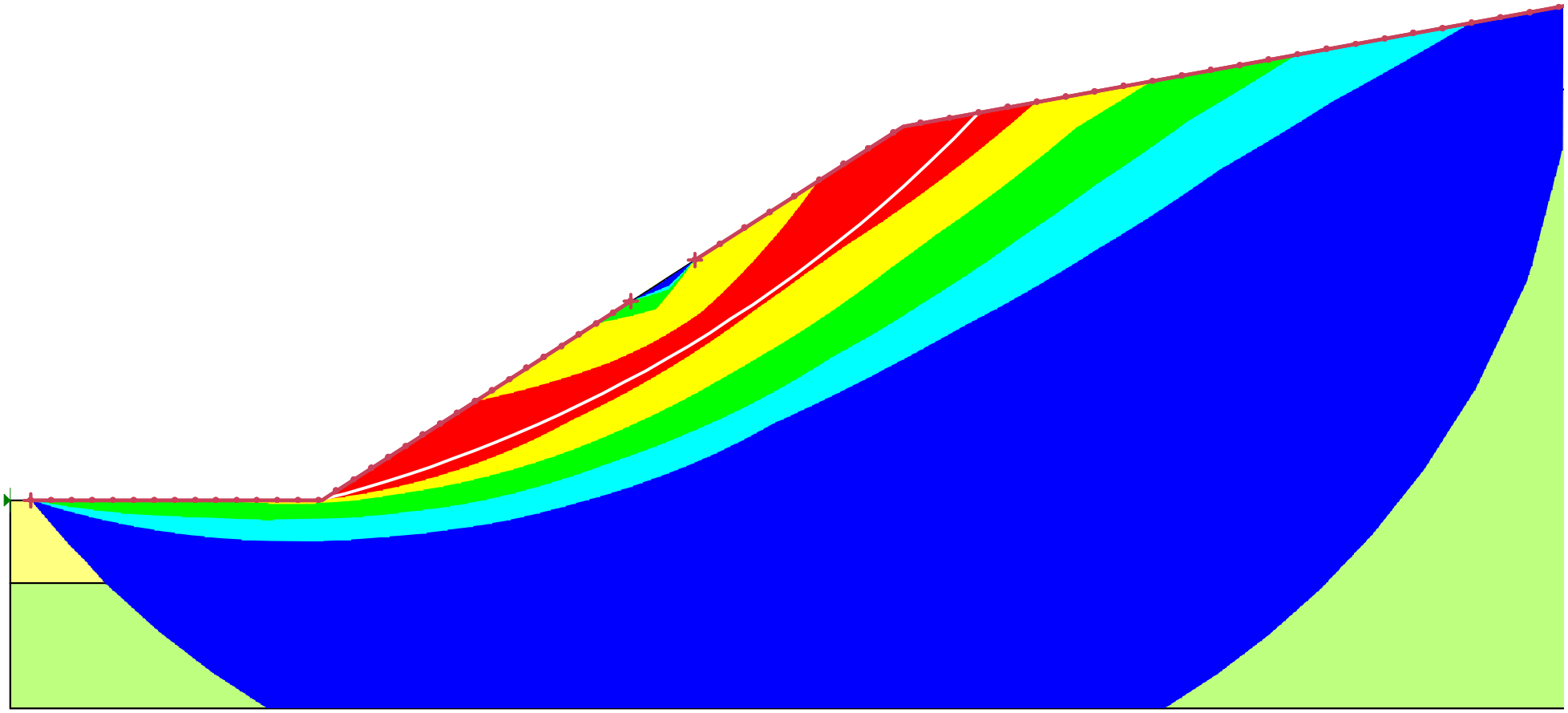
1.168



Project:	Wairakei Golf Course Residential			Method	Morgenstern-Price
Analysis:	Elevated Groundwater			Scale	1:292
				PGA	0g
Modelled By: Preston, Johnathon	Checked By: Name	Analysis Type: SLOPE/W	Date: 14/02/2022	FOS	1.168

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Ru
	Lower Pumice	Mohr-Coulomb	14	5	40	0
	Upper Pumice	Mohr-Coulomb	14	5	35	0

1.038



Project:	Wairakei Golf Course Residential			Method	Morgenstern-Price
Analysis:	Seismic			Scale	1:292
				PGA	0.195g
Modelled By: Preston, Johnathon	Checked By: Name	Analysis Type: SLOPE/W	Date: 14/02/2022	FOS	1.038

Appendix B

Logs

Borehole No. BH01

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established		
Client:	T W Group	*Ref. Grid:*	n/a	*Depth:*	19.95 m
Project No.:	2-37928.00	*R.L.:*	Not established	*Inclination:*	Vertical
Location:	Wairakei, Taupo	*Datum:*			

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	SANDY SILT Top Soil with trace pumice gravel and rootlets; Dark brown. Moist; dense.												
	Fine SAND with fine to medium pumice gravel; Dark brown. Moist; medium dense.												
	Fine to medium pumiceous SAND; whitish brown. Moist; loose.												
	Fine SAND; grey. Moist; dense.												
	Fine SAND with fine pumice gravel; grey. Moist; dense.		1										
	Fine SAND with fine to medium pumice gravel; brown. Moist; medium dense.												
	Fine SAND with fine to medium pumice gravel; dark brown. Moist; medium dense.												
	Fine SAND with fine pumice gravel; brown. Moist; dense.				5	3// 1/2/1/1							
	Fine SAND with fine pumice gravel; brown. Moist; dense.		2										
	Fine to medium pumiceous GRAVEL; whitish brown. Moist; loose.												
	Core loss												
	Fine to medium SAND with fine pumice gravel; brown. Moist; dense.												
	Fine SAND with fine pumice gravel; whitish brown. Moist to wet; dense.		3		6	1// 1/2/2/1							
	Core loss												
	Fine to medium sand with fine to medium pumiceous GRAVEL; whitish brown. Moist; loose.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		4										
					9	4// 3/1/2/3			Rotary cored				
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		5										
			6		11	4// 3/2/3/3							
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		7										
	Core loss				20	6// 4/5/5/6							
	Fine to medium SAND with fine pumice gravel; whitish blackish brown. Moist; medium dense.		8										
	Fine to medium SAND; brown. Moist; medium dense.		9		18	6// 4/5/4/5							
	Fine to medium SAND with trace pumice gravel; brown. Moist to wet; medium dense.												

Notes:

Started:	12/01/2022	*Finished:*	13/01/2022
Drilling Co.:	Geotech Drilling	*Drilling Rig:*	
Logged by:	RC	*Checked by:*	

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH01

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established		
Client:	T W Group	*Ref. Grid:*	n/a	*Depth:*	19.95 m
Project No.:	2-37928.00	*R.L.:*	Not established	*Inclination:*	Vertical
Location:	Wairakei, Taupo	*Datum:*			

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Fine to medium SAND; brown to dark brown. Moist to dry; medium dense.*(continued)*												
	Fine to medium SAND; dark brown. Moist; medium dense.		11		32	9// 9/7/7/8							
			12		32	11// 7/7/9/9							
	Fine to medium SAND; dark brown. Moist; loose.		13		25	7// 6/5/7/7							
	Fine SAND; brown. Moist; medium dense.		14		23	11// 5/6/6/6			Rotary cored				
	Core loss - Material washed through due to being very loose.		15										
	Fine SAND with some fine to medium pumice gravel; brown. Moist; dense.		16		30	12// 6/7/8/9							
	Fine to medium SAND; dark brown. Moist to wet; loose.		17										
	Fine SAND; dark brown. Moist; medium dense.												
	Fine to medium SAND with fine pumice gravel; brown. moist; medium dense.		18		8	2// 2/2/2/2							
	Fine to medium SAND with fine to medium pumice gravel; brown. moist; medium dense.		19										
	Fine to medium SAND with fine pumice gravel and some volcanics ; brown. Moist; medium dense.				28	8// 5/5/6/7							
	END OF BOREHOLE AT 19.95m - Target Depth Reached												

Notes:

Started:	12/01/2022	*Finished:*	13/01/2022
Drilling Co.:	Geotech Drilling	*Drilling Rig:*	
Logged by:	RC	*Checked by:*	

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH02

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established
Client:	T W Group	*Ref. Grid:*	n/a
Project No.:	2-37928.00	*R.L.:*	Not established
Location:	Wairakei, Taupo	*Datum:*	

Depth: 19.95 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Top Soil - SANDY SILT with trace pumice gravel and rootlets; dark brown. Moist to wet; medium dense.												
	Fine to medium SAND with fine to medium gravel; brown. Moist to wet; medium dense.						RC	100					
	SAND with silt with fine pumice gravel; light brown. moist to wet; dense.												
	SAND with silt; light brown. moist to wet; dense.		1				RC	100					
	COBBLE with fine to medium sand; redish brown. Wet; loose.												
	Fine to medium SAND with fine to medium volcanics; dark brown. Wet; loose.												
	Fine SAND with fine to medium pumice gravel; brown. Moist, medium dense.				7	3// 1/2/2/2	SPT	100					
	Fine to medium pumiceous SAND; White. Moist to wet; loose.		2										
	Fine SAND with fine pumice gravel; brown. Moist; medium dense.						RC	100					
	Fine to medium SAND with fine pumice gravel; brown. Moist; loose.												
	Fine SAND with fine pumice gravel; brown. Moist; dense.												
	Fine to medium SAND with fine to medium pumice gravel; light brown. Moist; loose.												
	Fine SAND with fine pumice gravel; light brown. Moist; medium dense.		3		2	2// 1/0/1/0	SPT	100					
	Fine to medium SAND with fine pumice gravel; brown. Moist; dense.												
	Fine SAND; brown. Moist; dense.												
	Fine pumiceous SAND; brown. Moist; loose to medium dense.		4				RC	100					
	Fine to medium pumiceous SAND; whitish brown. Moist; medium dense.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; loose to medium dense.				3	1// 0/1/1/1	SPT	100	Rotary cored				
	Fine SAND; brown. Moist to dry; dense.		5										
	Fine to medium SAND with fine pumice gravel; brown. moist to dry; medium dense.						RC	100					
	Fine to medium SAND with some fine gravel; brown. Moist; medium dense.		6		7	3// 2/1/2/2	SPT	100					
							RC	100					
			7				SPT	100					
	Fine to medium SAND with fine to medium pumice gravel; brown. Moist; medium dense.				11	4// 3/2/2/4							
			8				RC	70					
	Core loss.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		9		16	7// 4/3/4/5	SPT	100					
							RC	100					
	Fine to medium SAND; blackish brown. Wet; loose to medium dense.						RC	100					

Notes:

Started: 12/01/2022 *Finished:* 12/02/2022
Drilling Co.: Geotech Drilling *Drilling Rig:*
Logged by: RC *Checked by:*

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH02

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established
Client:	T W Group	*Ref. Grid:*	n/a
Project No.:	2-37928.00	*R.L.:*	Not established
Location:	Wairakei, Taupo	*Datum:*	

Depth: 19.95 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Top Soil - SANDY SILT with trace pumice gravel and rootlets; dark brown. Moist to wet; medium dense.												
	Fine to medium SAND with fine to medium gravel; brown. Moist to wet; medium dense.						RC	100					
	SAND with silt with fine pumice gravel; light brown. moist to wet; dense.												
	SAND with silt; light brown. moist to wet; dense.		1				RC	100					
	COBBLE with fine to medium sand; redish brown. Wet; loose.												
	Fine to medium SAND with fine to medium volcanics; dark brown. Wet; loose.												
	Fine SAND with fine to medium pumice gravel; brown. Moist, medium dense.				7	3// 1/2/2/2	SPT	100					
	Fine to medium pumiceous SAND; White. Moist to wet; loose.		2										
	Fine SAND with fine pumice gravel; brown. Moist; medium dense.						RC	100					
	Fine to medium SAND with fine pumice gravel; brown. Moist; loose.												
	Fine SAND with fine pumice gravel; brown. Moist; dense.												
	Fine to medium SAND with fine to medium pumice gravel; light brown. Moist; loose.												
	Fine SAND with fine pumice gravel; light brown. Moist; medium dense.		3		2	2// 1/0/1/0	SPT	100					
	Fine to medium SAND with fine pumice gravel; brown. Moist; dense.												
	Fine SAND; brown. Moist; dense.												
	Fine pumiceous SAND; brown. Moist; loose to medium dense.		4				RC	100					
	Fine to medium pumiceous SAND; whitish brown. Moist; medium dense.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; loose to medium dense.				3	1// 0/1/1/1	SPT	100	Rotary cored				
	Fine SAND; brown. Moist to dry; dense.		5										
	Fine to medium SAND with fine pumice gravel; brown. moist to dry; medium dense.						RC	100					
	Fine to medium SAND with some fine gravel; brown. Moist; medium dense.		6		7	3// 2/1/2/2	SPT	100					
							RC	100					
			7				SPT	100					
	Fine to medium SAND with fine to medium pumice gravel; brown. Moist; medium dense.				11	4// 3/2/2/4							
			8				RC	70					
	Core loss.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		9		16	7// 4/3/4/5	SPT	100					
							RC	100					
	Fine to medium SAND; blackish brown. Wet; loose to medium dense.						RC	100					

Notes:

Started: 12/01/2022 *Finished:* 12/02/2022
Drilling Co.: Geotech Drilling *Drilling Rig:*
Logged by: RC *Checked by:*

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH02

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established		
Client:	T W Group	*Ref. Grid:*	n/a	*Depth:*	19.95 m
Project No.:	2-37928.00	*R.L.:*	Not established	*Inclination:*	Vertical
Location:	Wairakei, Taupo	*Datum:*			

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Fine SAND with fine pumice gravel; brown. Moist; dense.*(continued)*						RC	100					
	Fine to course SAND; blackish brown. Moist; medium dense.				22	7// 6/5/5/6	SPT	100					
	Fine to medium SAND with trace pumice gravel; brown. Wet; medium dense.		11				RC	100					
	Fine to medium SAND with some fine pumice gravel; Brown. Moist to wet; medium dense.						RC	100					
	Fine to course SAND; blackish brown. Moist; medium dense.		12		24	6// 6/6/6/6	SPT	100					
	Fine to medium SAND with some fine gravel; brown. Moist; medium dense.						RC	100					
	Fine to medium SAND with fine pumice gravel; brown. moist; dense.		13		25	8// 6/6/6/7	SPT	100					
			14				RC	100	Rotary cored				
	Fine SAND with fine to course pumice gravel and some fine to medium volcanics; brown. Moist; loose.												
	Fine SAND with fine pumice gravel; brown. Moist; dense.		15		45	17// 11/11/12/11	SPT	100					
	Fine to medium SAND with fine to course pumice gravel; brown. Moist; medium dense.						RC	100					
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		16										
	Fine to medium SAND with fine to medium pumice gravel; brown. Moist; dense.				42	15// 9/10/11/12	SPT	100					
	Fine to medium SAND; blackish brown. Moist; medium dense.		17				RC	100					
	Fine to medium SAND; dark brown. Moist; loose.		18		39	15// 9/10/10/10	SPT	100					
	Fine to medium SAND with fine to medium pumice gravel; blackish brown. Moist; medium dense.						RC	100					
			19										
	Fine to medium SAND with fine to medium pumice gravel; brown. Moist; dense.				42	16// 10/12/10/10	SPT	100					
	END OF BOREHOLE AT 19.95m - Target Depth Reached												

Notes:

Started:	12/01/2022	*Finished:*	12/02/2022
Drilling Co.:	Geotech Drilling	*Drilling Rig:*	
Logged by:	RC	*Checked by:*	

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH03

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established		
Client:	T W Group	*Ref. Grid:*	n/a	*Depth:*	19.95 m
Project No.:	2-37928.00	*R.L.:*	Not established	*Inclination:*	Vertical
Location:	Wairakei, Taupo	*Datum:*			

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Top Soil - SANDY SILT with trace pumice gravel; rootlets, dark brown. Moist to wet.												
	Core loss.						RC	75					
	SILTY SAND; brown to light brown. Moist to wet; medium dense.												
	SAND; light brown. fine to medium becoming Medium to course.												
	Sandy medium to course pumiceous GRAVEL; Light grey. Wet, loose.		1										
	Fine SAND; grey. Moist; dense.						RC	100					
	Fine SAND with fine pumice gravel; brown. Moist; medium dense.												
	Fine SAND with fine to medium pumice gravel; brown. Moist; medium dense.												
	Sandy Fine pumice GRAVEL; lightish brown. Moist; loose.												
	Fine to medium SAND with fine pumice gravel; brown. Moist; loose to medium dense.				5	2// 2/1/1/1							
	Fine SAND; brown. Moist; medium dense.		2										
	Fine SAND with fine to medium pumice gravel; brown. Moist; dense.												
	Core loss												
	Fine SAND; brown. Moist to dry; dense.												
	Fine SAND with fine pumice gravel; brown. Moist to dry; dense.		3		2	1// 1/0/1/0							
			4										
	Fine SAND with fine pumice gravel; brown. Moist; dense.				5	2// 1/1/1/2			Rotary cored				
			5										
	Core loss												
	Fine to medium SAND with fine pumice gravel; brown. Moist; medium dense.		6		12	6// 3/3/3/3							
	Core loss		7										
	Fine SAND; brown. Moist; dense.				14	6// 3/3/4/4							
			8										
			9		16	7// 4/4/4/4							
	Core loss												
	Fine SAND; brown. Moist; dense.												

Notes:

Started:	11/01/2022	*Finished:*	11/01/2022
Drilling Co.:	Geotech Drilling	*Drilling Rig:*	
Logged by:	RC	*Checked by:*	

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH03

Project:	Wairakei Golf Course Subdivision - Geotech	*Coordinates:*	Not established		
Client:	T W Group	*Ref. Grid:*	n/a	*Depth:*	19.95 m
Project No.:	2-37928.00	*R.L.:*	Not established	*Inclination:*	Vertical
Location:	Wairakei, Taupo	*Datum:*			

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: CORE TYPE	CORE: TOTAL CORE RECOVERY (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	NOTES / OTHER TESTS	INSTALLATION DETAILS
	Fine SAND; brown. Moist; dense.*(continued)*												
	Fine SAND with fine pumice gravel; brown. Moist; dense.												
	Medium to course SAND with trace pumice gravel; Blackish brown. Moist to wet; medium dense.				20	12// 5/5/6/4							
	Fine to medium SAND with fine to course gravel, volcanics and pumice; brown. Moist to wet; medium dense.		11										
	Fine to medium SAND with fine to medium gravel, volcanics and pumice; brown. Moist to wet; medium dense.												
			12		22	12// 6/5/6/5							
	Fine to medium SAND with fine to course gravel, volcanics and pumice; brown. Moist to wet; medium dense.												
	Core loss.		13										
	Medium SAND with fine pumice gravel; brown. Moist to wet; loose to medium dense.				31	10// 7/9/8/7							
	Sandy fine to medium GRAVEL; brown. Wet; Loose		14										
	Fine to medium SAND with fine gravel; brown. Moist to wet; medium to loose.												
	COBBLE; Red. Moist to wet.												
	Core loss												
	Fine to medium SAND with fine gravel; brown. Moist to wet; Loose.		15		33	12// 7/8/9/9			Rotary cored				
	Fine to medium SAND with fine gravel; Brown. Moist to wet; loose to medium dense.		16										
					32	14// 7/9/8/8							
	Fine to medium SAND with fine gravel; Brown. Moist to wet; loose to medium dense.		17										
	Core loss												
	Fine SAND with fine pumice gravel; brown. Moist; medium dense.		18		48	20// 12/12/14/10							
	Fine SAND with fine pumice gravel; brown. Moist to dry; Dense.												
			19										
					52	17// 9/10/11/12							
	END OF BOREHOLE AT 19.95m - Target Depth Reached												

Notes:

Started:	11/01/2022	*Finished:*	11/01/2022
Drilling Co.:	Geotech Drilling	*Drilling Rig:*	
Logged by:	RC	*Checked by:*	

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

wsp

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