12 August 2022 Our Ref: 50622

Attn: S&P Dennett
270a Pikowai Road
Pikowai
Via email: sue.den.1556@gmail.com; tim@fergussonplanning.co.nz

Dear Sue & Paul

RE: 270A PIKOWAI ROAD, PIKOWAI
GEOTECHNICAL FEASIBILITY STUDY

1.0 INTRODUCTION

Thank you for this opportunity to provide Geotechnical engineering services for your project at 270a Pikowai Rd.

Engineering Design Consultants Ltd (EDC) understands that it is proposed to subdivide your land into two lots as shown on the Fergusson Planning drawing re: 22-046 dated July 2022. Appendix "A" contains the proposed subdivision plan.

Figure 1: Site Location (courtesy of Google Earth)

Figure 2: Site Location (courtesy of Google Earth)

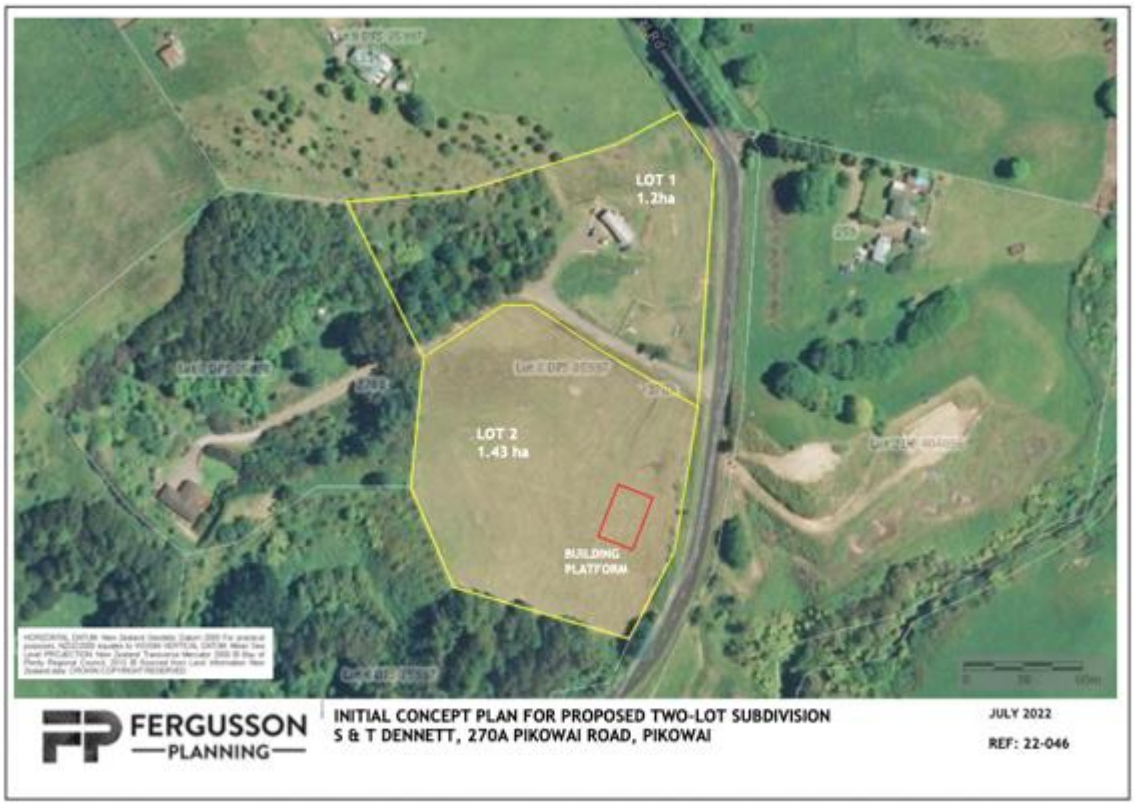


Figure 3: Proposed Subdivision Plan

2.0 OBJECTIVE / SCOPE

The objective of this report is to assess the geotechnical constraints and practicality of proposed plan as well as provide preliminary recommendation on appropriate foundation type(s).

In order to achieve the outlined objectives, our geotechnical investigation shall comprise the following scope:

- A geotechnical desktop study to review geological mapping, geotechnical information resources and review of freely available historical aerial photographs.
- A site walkover.

This report assesses the condition of the land only.

3.0 SITE ASSESSMENT

A senior geotechnical engineer visited the site on the 26th May 2022. The following photograph(s) show views of the site and the possible building platform on the proposed Lot 2 (1.43Ha) at the time of the site visit. The Coordinates of the approx centre of the site are: 39°52'36" S and 176°39'04" E.

Figure 4: View of the Proposed Lot 2 looking Southwest from the access to the existing dwelling on the Proposed Lot 1

Figure 5: View of slope to west of the proposed Building Platform on the proposed Lot 2

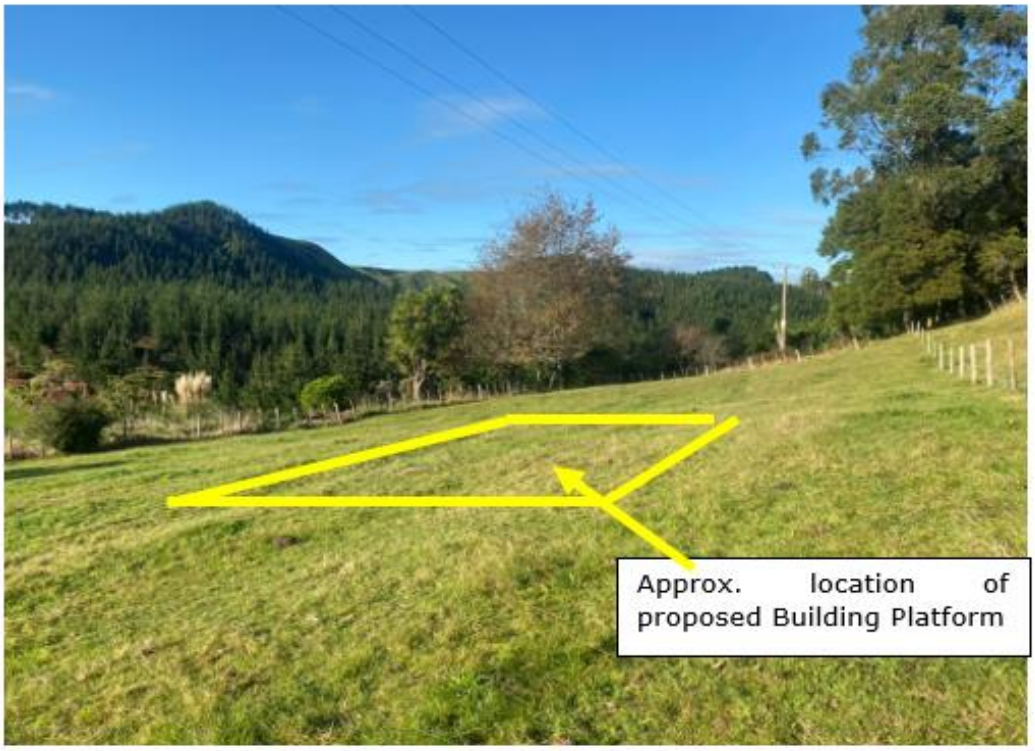


Figure 6: Showing view looking south across the proposed Building Platform on the proposed Lot 2

4.0 PUBLISHED GEOLOGY & HYDROGEOLOGY

EDC has reviewed the following resources as part of the geological and hydrogeological desk-based study:

- New Zealand Geotechnical Database (NZGD)
- GNS 1:250,000 online QMap
- EDC's Geological and Geotechnical Database
- GNS NZ Active Fault Map

4.1 Geological mapping

The published Geology is complex in this area, it appears that in some places the Matahina Formation overlies the Tauranga Group Deposits but is absent in places. Both of these geologically young deposits are underlain by the Waipapa (composite) Terrane.

The Institute of Geological & Nuclear Sciences Ltd map titled "Geological Map: Geology of The Rotorua Area 1:250 000" describes the Matahina Formation (Q9z) as being "Predominantly Pink- to purplish-grey, columnar jointed, welded, locally eutaxitic rhyolite ignimbrite; non-welded and soft in some areas; minor fall deposits".

The exact thickness of the alluvial deposits is unknown to EDC but local topography suggests it has variable thickness.

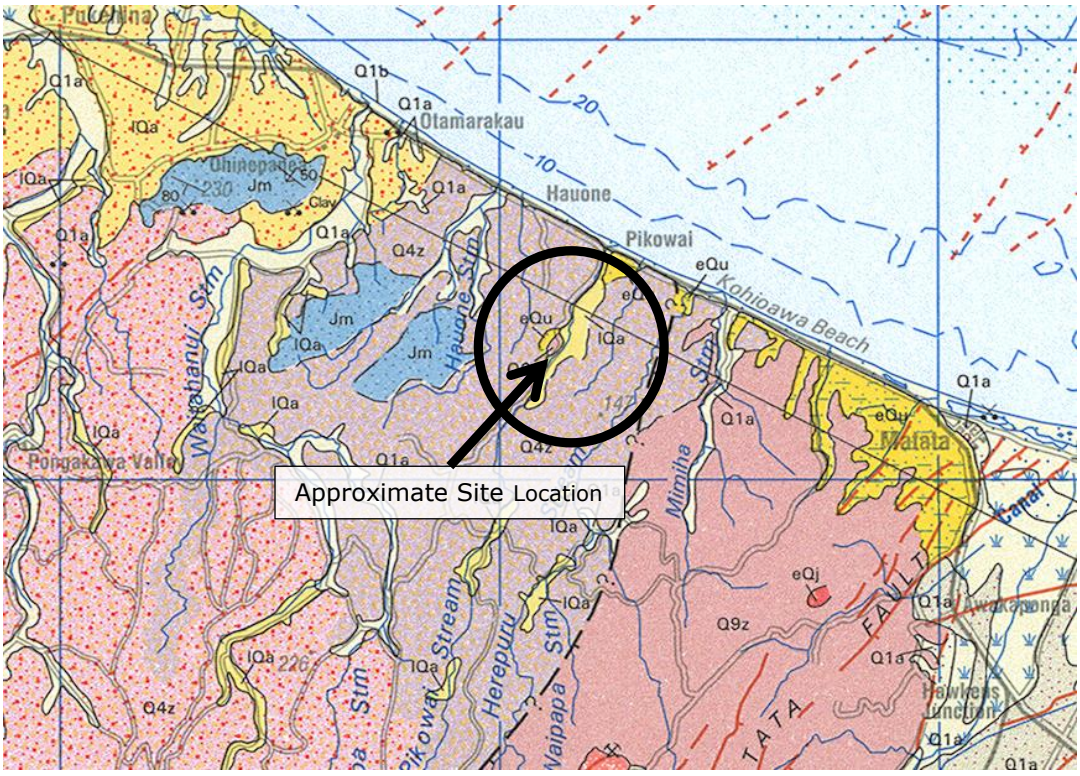


Figure 7: GNS 1:250,000 Qmap Rotorua

Q4z Rotoiti Formation – non-welded ignimbrite

Q9z Matahina Formation – non-welded ignimbrite

Qvd Manawahe Formation – dacite lavas

Q12z Okataina group - rhyolite lavas

IQa Tauranga Group – Alluvium

Q1a Taupo Pumice Alluvium

eQu Tauranga Group Alluvium

Jm Waipapa Composite Terrane -Manaia Hill Group

4.2 Faults

Information contained on the Geological Mapping & GNS Active Fault database in relation to the local faults is included below:

Figure 8: GNS Active Fault Map

Some local faulting is identified on the Rotorua Area Map approx 1km east of the site, however as can be seen on Figure 8 (above), there are no active faults in the vicinity of the site.

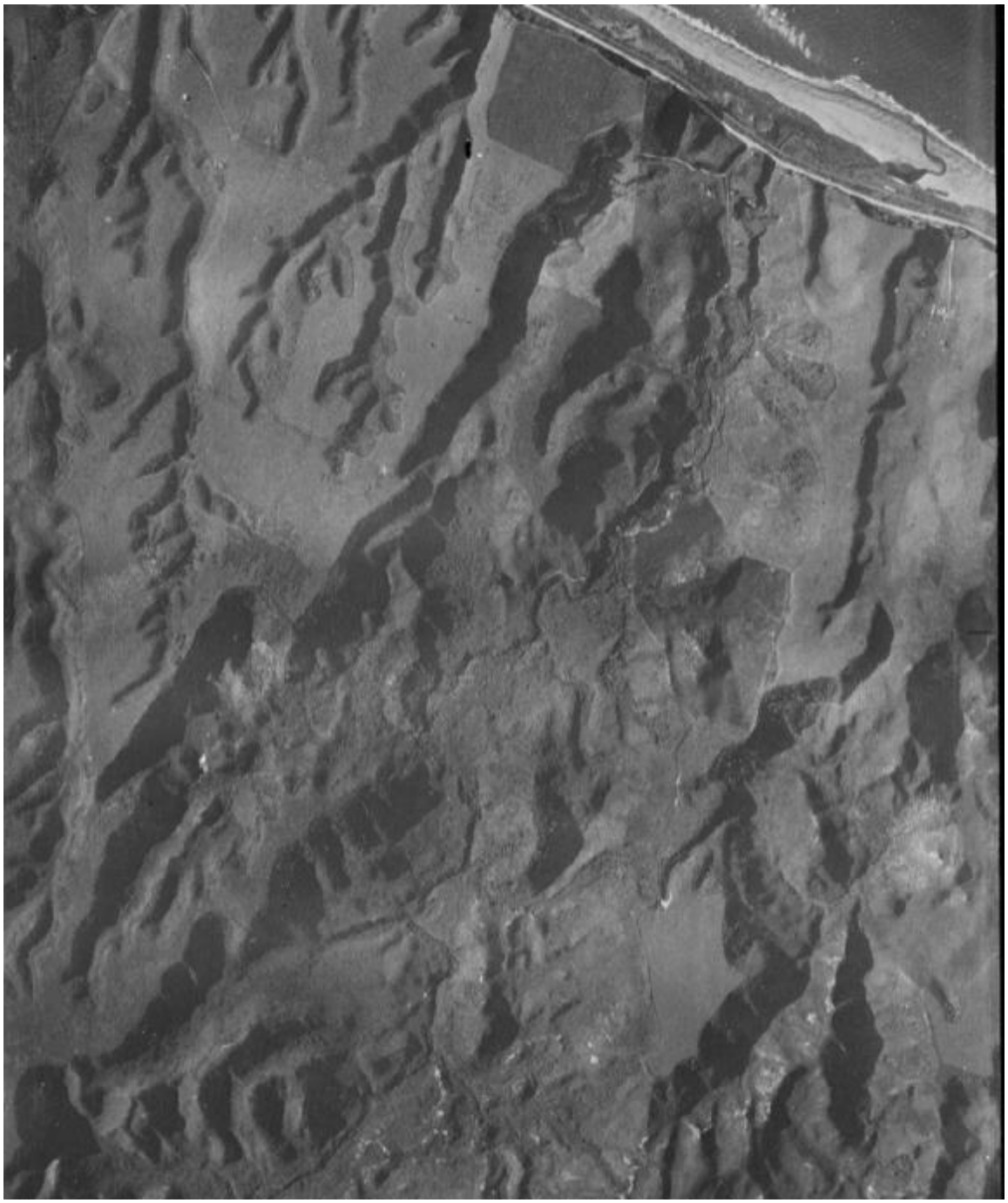
The topography of the local area suggests the presence of a number of other faults (not shown on the maps mentioned above). These are not considered 'Active' but it is possible that they could be re-activated during a suitably large seismic event.

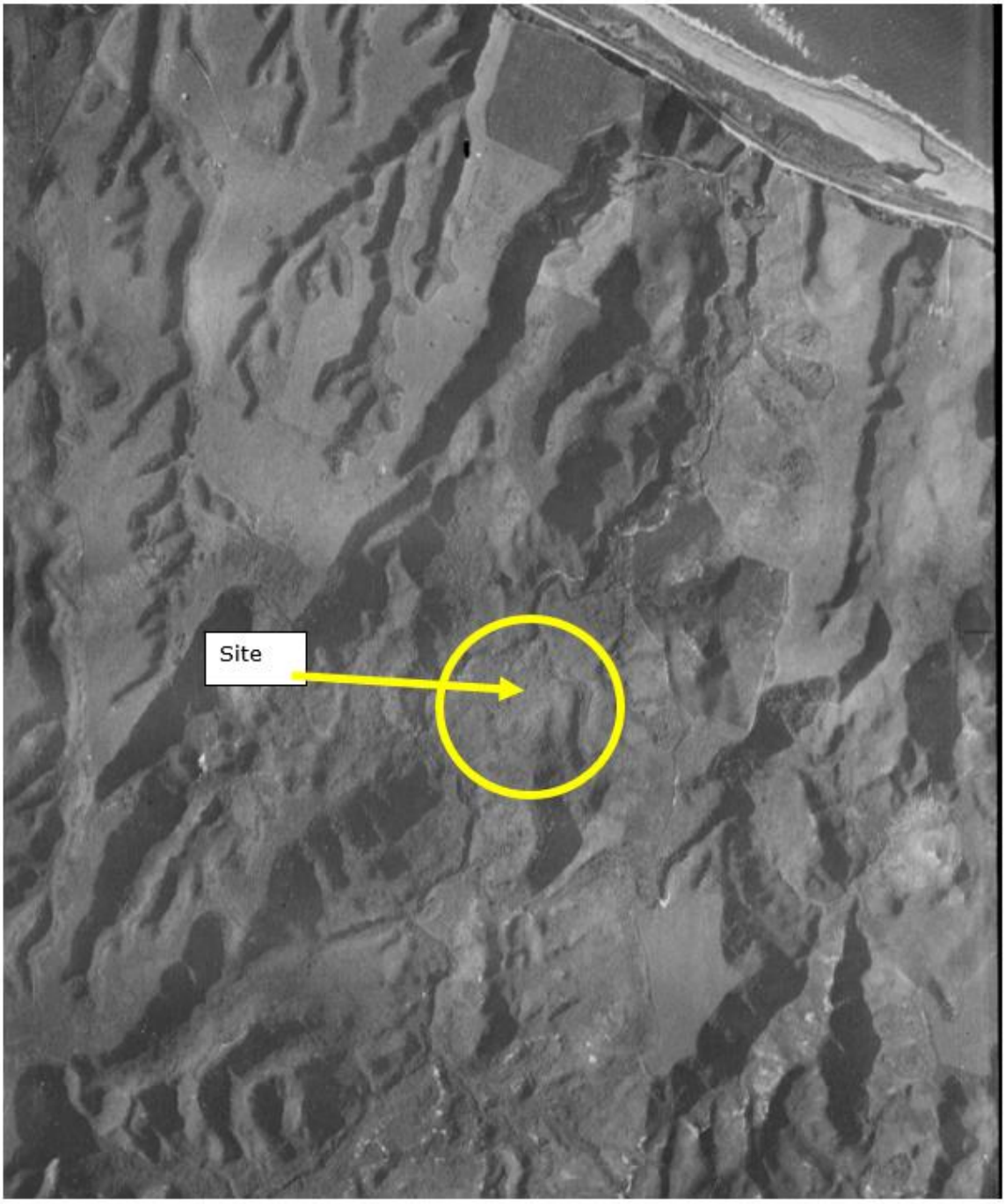
5.0 GEOHAZARDS DESK-BASED INFORMATION

5.1 Site History

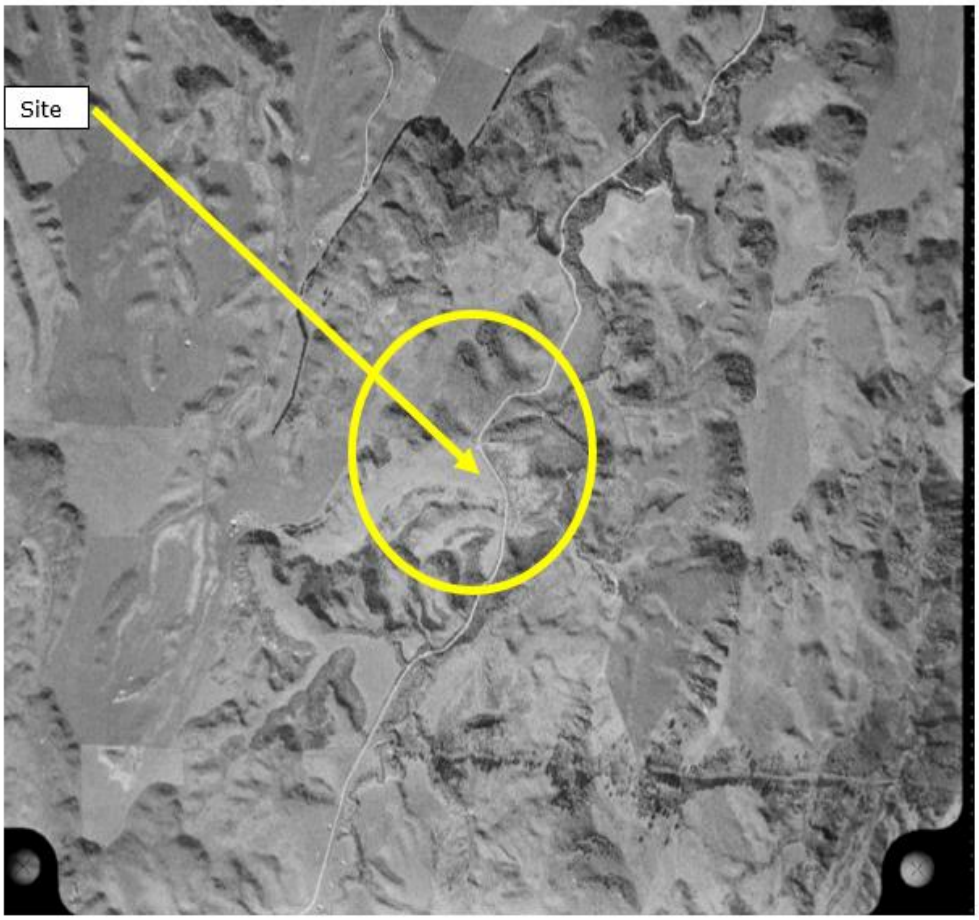
5.1.1 Historical Aerial Photographs

EDC has reviewed historical aerial photographs available on RetroLens from 1944 (earliest available aerial photograph on the Retrolens site), through to 2022. This review indicated that:

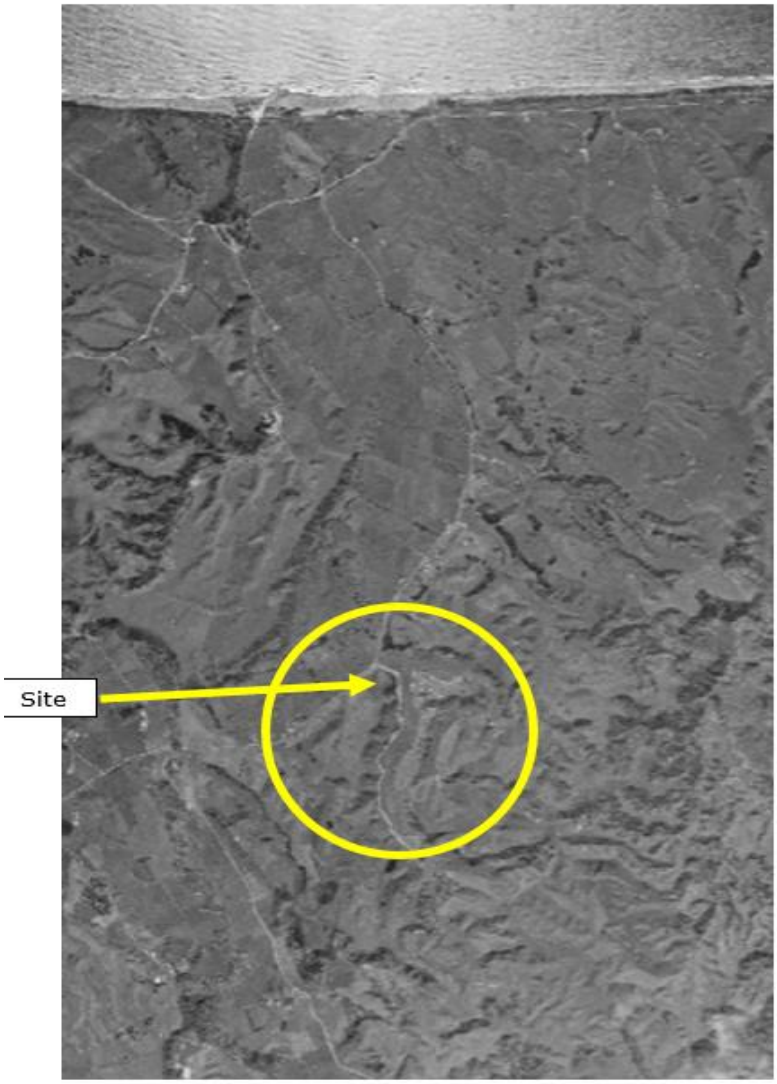




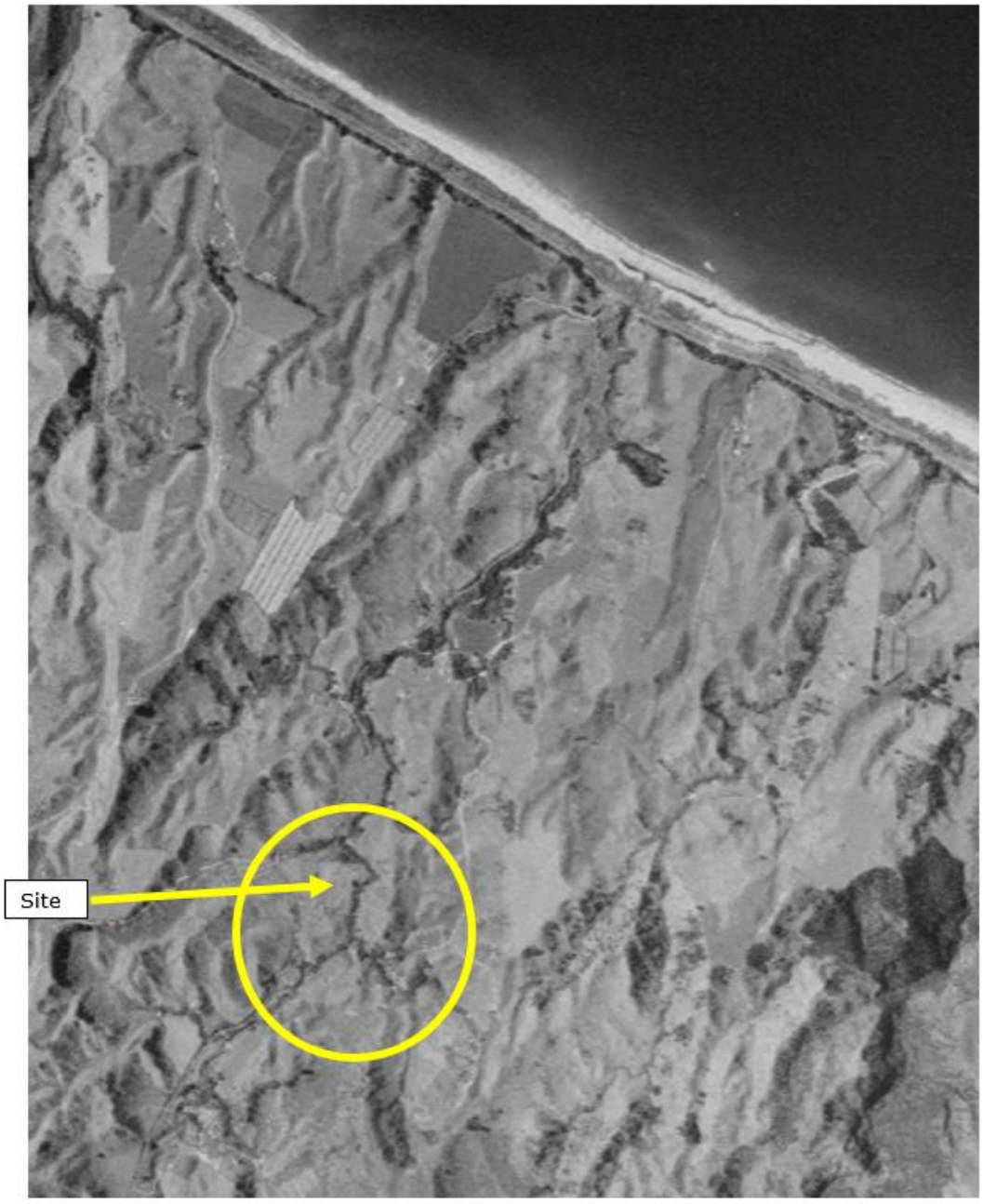
1943



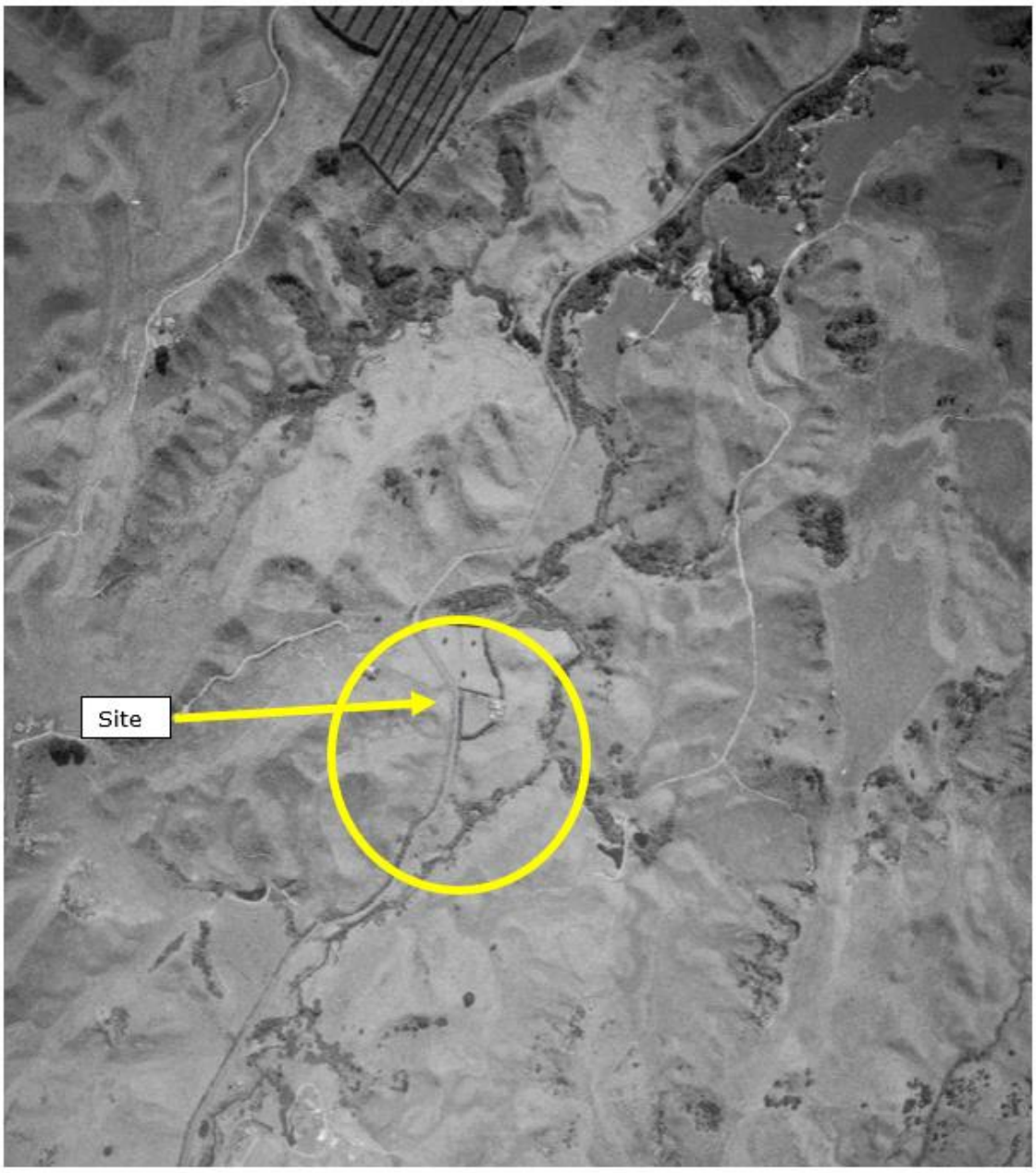
1962



1969



1982



1987

No obvious topographic changes between 1943 and 1987. The existing house on what is the proposed Lot 1, was built post-1987. Apart from the house, the land appears to have been used for pasture for this whole period.

6.0 SITE SUBSOIL CLASS

There is insufficient desktop data to confirm the local soil class. Based on the available desktop information EDC considers that a seismic site subsoil classification "Class C – Shallow Soil Site", as defined in NZS:1170.5 should be appropriate for this site, in the absence of any site-specific information and our knowledge of the geological formation.

Deep geotechnical investigation (machine boreholes) and/ or geophysical techniques such as Horizontal to Vertical Spectral Ratio Analysis (HVSR) or Multichannel Channel

Analysis of Surface Wave (MASW) would be required to confirm the soil site class in detail.

7.0 LIQUEFACTION POTENTIAL

Based on the data available on the Bay of Plenty Regional Council's GIS, the site is within 'Undetermined' Liquefaction Vulnerability Category. The area of the site has been placed in this category due to the 'unknown' nature of the soils in the area and according to GIS the site is located within the 'Hills and ranges' terrain.

Given the nature of the soils anticipated, the likely depth to groundwater, we consider that the risk of liquefaction during a 'design' earthquake event is low.

If any of the faults in the local vicinity were to be activated due to an earthquake, then shaking damage is more likely than liquefaction.

8.0 SUMMARY OF GROUND CONDITIONS

Based on our knowledge of soils in the vicinity of the site, our site walkover, desk study and the geotechnical map, we anticipate the following:

8.1 Topsoil

Any topsoil is likely to be of limited depth.

8.2 Residual Soils

The residual soils are likely to be an interbedded sequence of pumiceous silts and sands with a variable content of clay. These soils are likely to supply a minimum UBC of 200kPa, with most providing 300kPa. There could be a number of cobbles and/or boulders of rock within the residual soils.

9.0 CONCLUSIONS

9.1 Further Investigation

A full geotechnical investigation will be required to confirm the conclusions made in this feasibility assessment. The geotechnical report will need to investigate the subsoils and assess slope stability for the building platform that will be close to the rear (western) slope.

9.2 NZS 3604 "Good Ground" Assessment

In accordance with NZS 3604: 2011 "Good Ground" is defined as *"Any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300kPa (i.e. an allowable bearing pressure of 100kPa using a factor of safety 3.0)".* It excludes expansive soils, topsoil or organic rich soils, uncompacted loose gravel and any ground likely to experience ground movements of 25mm or more.

The soils at the site are unlikely to meet the NZS 3604 definition of 'Good Ground' due to probable geotechnical UBC's of 200 to 300kPa. A Specific Engineered Designed (SED) foundation would be required.

9.3 Foundation Options

We consider the following foundation options are likely to be suitable for residential development on the proposed lots:

- Waffle-Slab type foundations;
- Slab-on-grade with deepened edge beams;
- Traditional strips and pads (spread foundations);
- Edge ringbeam, with suspended floor;
- Piled foundations.

Other forms of foundation could be an option, but are likely to require more detailed geotechnical investigation and collaboration between the architect, geotechnical and structural engineer.

9.4 Settlement

The natural silts and sands will in our opinion exhibit only low compressibility under the relatively light foundation loads associated with residential development undertaken in accordance with the requirements of NZS 3604:2011.

Consequently, a shallow foundation solution could be adopted and settlement of foundations in this material should be within accepted limits providing the inspection and design of foundations are carried out as would be expected under normal circumstances in accordance with the requirements of NZS 3604:2011, and providing that the recommendations made in the geotechnical report are adopted.

9.5 Erosion Control

We anticipate:

- Stormwater from land runoff, roofs and the hard paved area should be collected and disposed of in a council approved manner to prevent slope instability or erosion of lower lying areas.
- Stormwater flow paths should be designed to ensure water is diverted appropriately.
- The advice of a competent engineer should be sought if any erosion features are encountered during construction.
- It is vital that a good level of vegetation is maintained in the area by the land depression during and post-development.

9.6 Liquefaction

In accordance with the 'Planning and engineering guidance for potentially liquefaction-prone land' (MBIE/MfE, 2017), we have undertaken a risk-based liquefaction risk assessment. Please refer to Appendix "A" for the assessment matrix and further information.

Based on the desk-based information, shallow site investigation and EDC's knowledge of the area we make the following assessment of the site using Table 3.7 of the MBIE/MfE Guidance:

- The site will fall within the 'Rural-residential setting category;
- Ground damage is expected to be 'none to minor' under SLS conditions (25-year return period earthquake);
- It is acknowledged in the MBIE Guidance that there are acceptable levels of residual uncertainty in this assessment.

  In this case the liquefaction vulnerability category is considered to be ' very Low' - "There is a probability of more than 85 percent, that liquefaction-induced ground damage will be: None to Minor for 500-year shaking

Based on this we recommend either an NZS3604 or TC2 foundation system (Ministry of Business, Innovation and Employment, 2021). Should significant ground damage occur in a future ULS earthquake event, the above foundation system is not considered to be susceptible to catastrophic collapse, in accordance with the NZ building code.

9.7 On-Site disposal of Stormwater

It is anticipated that stormwater from roofs will be collected for domestic purposes. Any stormwater overflow from tanks plus any stormwater collected from impermeable surfaces or from behind any retaining walls should be piped (via sealed pipes) to an appropriate discharge point well away from the building platform and disposed of in accordance with Council regulations. No point discharges of stormwater shall be allowed, especially on any slope below the building platform.

9.8 On-Site disposal of wastewater

New dwelling will require an on-site wastewater treatment system. We recommend that a secondary treatment system is used however, other options might be appropriate. We consider that a suitable system can be developed in accordance with AS/NZS 1547:2012 and any local/regional Council requirements.

We anticipate that a BoPRC schedule 5 assessment will be required.

9.9 Retaining Walls

Any retaining walls required, shall be specifically designed for actual retained heights and any surcharge load (e.g. additional loads from building, slopes, vehicular loadings etc).

10.0 HEALTH & SAFETY

We recommend that 'Safety in Design' principles are included during the design of the proposed development. It should be noted that all parties involved in construction, including the client have responsibilities under the current 'Health and Safety at Work Act 2015'. This includes ensuring that the chosen contractor is both competent and suitably qualified/experienced to undertake the commissioned works.

EDC would be happy to provide geotechnical/geoenvironmental advice in relation to these issues at any workshops or design meetings for this project. In addition, our Structural and Fire Safety Design Engineers can provide advice as appropriate.

11.0 REFERENCES

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Yours sincerely

Gareth B Williams
MSc(Eng) CPEng CMEngNZ IntPE(NZ) MInstD MEIANZ

Geotechnical Engineer, Director

Encl. Appendix A

12.0 LIMITATIONS

Except where required by law, the findings presented as part of this report are for the sole use of our client, as noted above. The findings are not intended for use by other parties, and may not contain sufficient information for the purposes of other parties or other uses. No third party (excluding the local authority) may use or rely upon this report unless authorised by EDC in writing.

To the extent permitted by law, EDC expressly disclaims and excludes liability for any loss, damage, cost or expense suffered by any third party relating to or resulting from the use of, or reliance upon any information contained in this report. It is the responsibility of third parties to independently make enquiries or seek advice in relation to their particular requirements.

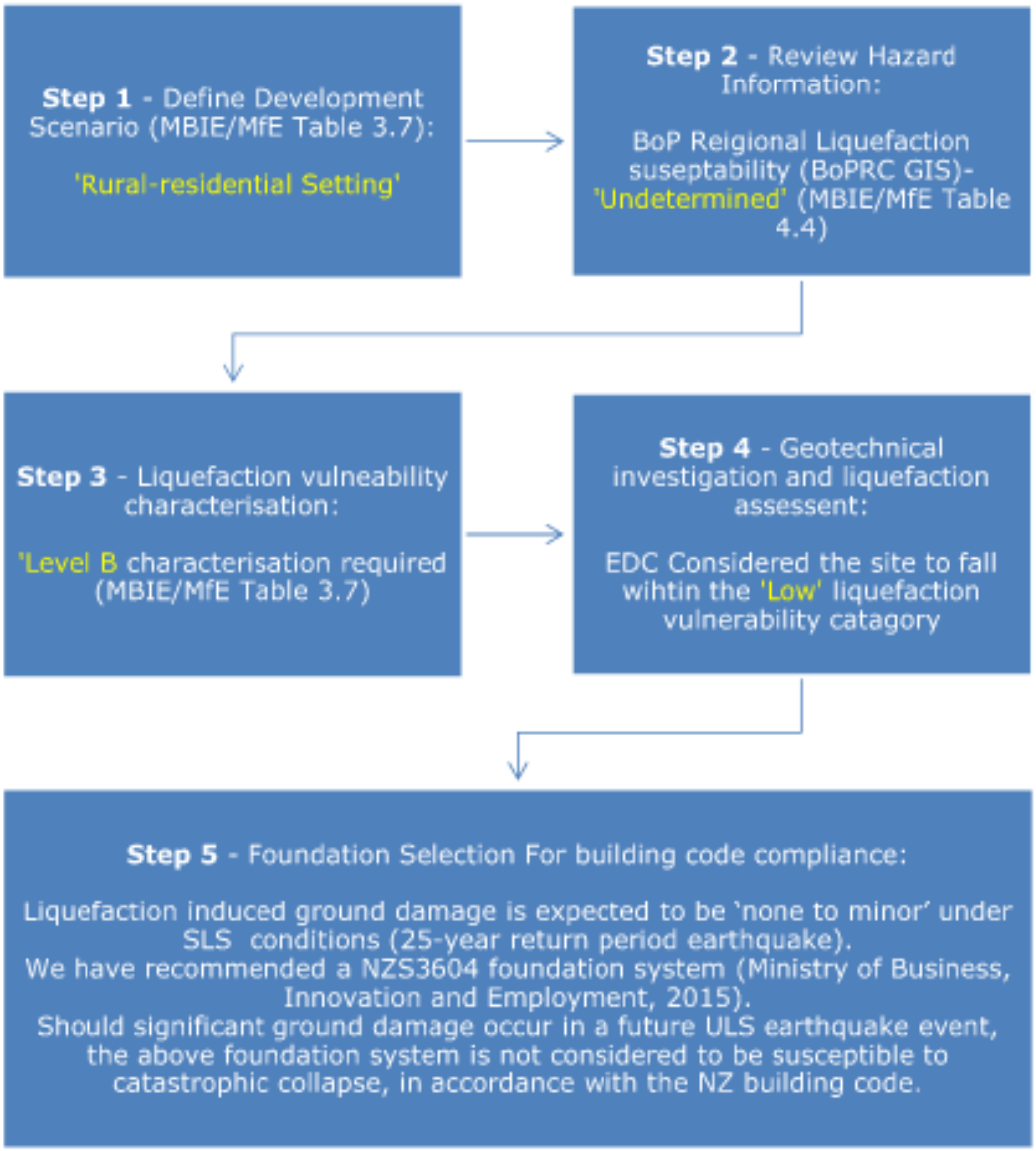
Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report, in regard to its accuracy or completeness.

Our opinions and recommendations are based on our comprehension of the current regulatory standards and must not be considered legal opinions. For legal advice, please consult your solicitor. This opinion is not intended to be advice that is covered by the Financial Advisors Act 2010.

The recommendations and opinions contained in this report are based on our visual reconnaissance of the site, information from geological maps and upon data from the field investigation as well as the results of in situ testing of soil. Inferences are made about the nature and continuity of subsoils away from and beyond the exploratory holes which cannot be guaranteed. The descriptions detailed on the exploratory hole logs are based on the field descriptions of the soils encountered.

This report includes Appendices. These appendices should be read in conjunction with the main part of the report and this report should not be considered complete without them.

MBIE/MFE SITE SPECIFIC LIQUEFACTION ASSESSMENT FLOW CHART, ASSESSMENT MATRIX & DEFINITIONS



STEP 1 – Define development scenario (refer to Table 3.7 of MBIE/MfE Guidence (2017)

Increasing likelihood and severity of ground damage

Increasing new capital investment and total exposure to a single event

DEVELOPMENT SCENARIO[2]	LIQUEFACTION VULNERABILITY CATEGORY			
	LIQUEFACTION CATEGORY IS UNDETERMINED			
	LIQUEFACTION DAMAGE IS UNLIKELY		LIQUEFACTION DAMAGE IS POSSIBLE	
	Very Low	Low	Medium	High
Sparsely populated rural area (lot size more than 4 Ha) eg A new farm building	Level A	Level A	Level A	Level A
Rural-residential setting (lot size of 1 to 4 Ha) eg A 'lifestyle' property	Level A	Level B	Level B	Level B
Small-scale urban infill (original lot size less than 2500 m2) eg Demolish old house and replace with four townhouses	Level B	Level B	Level B	Level D
Commercial or industrial development[1] eg A warehouse building in an industrial park	Level B	Level B	Level C	Level D
Urban residential development (lot size less than 1 Ha; typically <1000 m2) eg Home in a new subdivision	Level B	Level C	Level C	Level D

Table 4.4: Performance criteria for determining the liquefaction vulnerability category

LIQUEFACTION CATEGORY IS UNDETERMINED

A liquefaction vulnerability category has not been assigned at this stage, either because a liquefaction assessment has not been undertaken for this area, or there is not enough information to determine the appropriate category with the required level of confidence.

LIQUEFACTION DAMAGE IS UNLIKELY

There is a probability of more than 85 percent that liquefaction-induced ground damage will be ***None to Minor*** for 500-year shaking.

At this stage there is not enough information to distinguish between ***Very Low*** and ***Low***. More detailed assessment would be required to assign a more specific liquefaction category.

LIQUEFACTION DAMAGE IS POSSIBLE

There is a probability of more than 15 percent that liquefaction-induced ground damage will be ***Minor to Moderate*** (or more) for 500-year shaking.

At this stage there is not enough information to distinguish between ***Medium*** and ***High***. More detailed assessment would be required to assign a more specific liquefaction category.

Very Low Liquefaction Vulnerability

There is a probability of more than 99 percent that liquefaction-induced ground damage will be ***None to Minor*** for 500-year shaking.

Low Liquefaction Vulnerability

There is a probability of more than 85 percent that liquefaction-induced ground damage will be ***None to Minor*** for 500-year shaking.

Medium Liquefaction Vulnerability

There is a probability of more than 50 percent that liquefaction-induced ground damage will be:

Minor to Moderate (or less) for 500-year shaking; and

None to Minor for 100-year shaking.

High Liquefaction Vulnerability

There is a probability of more than 50 percent that liquefaction-induced ground damage will be:

Moderate to Severe for 500-year shaking; and/or

Minor to Moderate (or more) for 100-year shaking.

Table 3.1: Levels of detail for liquefaction assessment studies, and the key defining features

LEVEL OF DETAIL	KEY FEATURES
Level A Basic desktop assessment	Considers only the most basic information about geology, groundwater and seismic hazard to assess the potential for liquefaction to occur. This can typically be completed as a simple 'desktop study', based on existing information (eg geological and topographic maps) and local knowledge. **Residual uncertainty:** The primary focus is identifying land where there is a ***High*** degree of certainty that ***Liquefaction Damage is Unlikely*** (so it can be 'taken off the table' without further assessment). For other areas, substantial uncertainty will likely remain regarding the level of risk.
Level B Calibrated desktop assessment	Includes high-level 'calibration' of geological/geomorphic maps. Qualitative (or possibly quantitative) assessment of a small number of subsurface investigations provides a better understanding of liquefaction susceptibility and triggering for the mapped deposits and underlying ground profile. For example, the calibration might indicate the ground performance within a broad area is likely to fall within a particular range. It may be possible to extrapolate the calibration results to other nearby areas of similar geology and geomorphology, however care should be taken not to over-extrapolate (particularly in highly variable ground such as alluvial deposits), and the associated uncertainties (and potential consequences) should be clearly communicated. Targeted collection of new information may be very useful in areas where existing information is sparse and reducing the uncertainty could have a significant impact on objectives and decision-making. **Residual uncertainty:** Because of the limited amount of subsurface ground information, significant uncertainty is likely to remain regarding the level of liquefaction-related risk, how it varies across each mapped area, and the delineation of boundaries between different areas.
Level C Detailed area-wide assessment	Includes quantitative assessment based on a moderate density of subsurface investigations, with other information (eg geomorphology and groundwater) also assessed in finer detail. May require significant investment in additional ground investigations and more complex engineering analysis. **Residual uncertainty:** The information analysed is sufficient to determine with a moderate degree of confidence the typical range of liquefaction-related risk within an area and delineation of boundaries between areas, but is insufficient to confidently determine the risk more precisely at a specific location.
Level D Site-specific assessment	Draws on a high density of subsurface investigations (eg on or very close to the site being assessed), and takes into account the specific details of the proposed site development (eg location, size and foundation type of building). **Residual uncertainty:** The information and analysis is sufficient to determine with a ***High*** degree of confidence the level of liquefaction-related risk at a specific location. However, the scientific understanding of liquefaction and seismic hazard is imperfect, so there remains a risk that actual land performance could differ from expectations even with a high level of site-specific detail in the assessment.

Increasing level of detail and decreasing degree of uncertainty

Application of the vulnerability categories is at the discretion of the site engineer/reviewer, and should be taken into account, alongside all other site risks. The following table should be used as a **basic guide only**:

EDC Assessment	Structure Importance Level	Very Low	Low	Medium	High
Level B/C	1	NZS3604	NZS3604	NZS3604	MBIE TC2
	2		NZS3604 or TC2*	MBIE TC2 or TC2/TC3 Hybrid*	Detailed Assessment
Level D	1		NZS3604	NZS3604	MBIE TC2
	2			MBIE TC2	MBIE TC3

Table 1: Indicative foundation requirements based on liquefaction susceptibility and level of assessment

*Based on engineering judgement following assessment of risk.