Tonkin+Taylor

Job No: 1013790.1000
8 December 2021

Tararua District Council
PO Box 115, Dannevirke 4942

CONSULTATION DRAFT

Guidance for liquefaction assessment in Tararua District

1 Objective

This guidance note is intended to provide a basic framework for assessing liquefaction for practitioners and council staff, to promote a consistent approach to liquefaction hazard in Building Consent applications in Tararua district. The objective is to provide a pragmatic screening approach for typical individual building projects in Tararua District, with a focus on residential-style buildings, to help find an appropriate balance between the costs involved in detailed liquefaction assessment and the level of precision required for a particular situation.

The precision with which it is possible to determine the vulnerability to liquefaction-induced land damage depends on the level of detail in the information available. Where there is little information (as is currently the case in the Tararua District), there are two options:

- **Detailed site-specific assessment** may be undertaken for every site which allows more accurate and precise determination of liquefaction vulnerability, but at a higher cost, or
- **Simplified screening criteria** can be used to delineate individual sites into likely categories, which provides an efficient and cost-effective approach, but lacks precision (e.g., by applying a generalised approach, it is possible that the liquefaction hazard at a specific site may be under or overestimated).

This guidance note outlines simplified screening criteria which may be of assistance to practitioners applying for Building Consent in Tararua District. If higher levels of precision or certainty are desired (e.g., buildings of higher importance or with greater sensitivity to ground movement) then detailed site-specific assessment should be used.

This guidance note is not intended to be a prescriptive document that captures all possible eventualities. The responsibility for specific engineering design and construction review for land development and building works remains with the designers of those works.

2 Background

In 2021 Tararua District Council (TDC) engaged Tonkin & Taylor Ltd. (T+T) to undertake liquefaction hazard mapping for the district (T+T, 2021[1]) in accordance with the MBIE/MfE (2017) guidance.

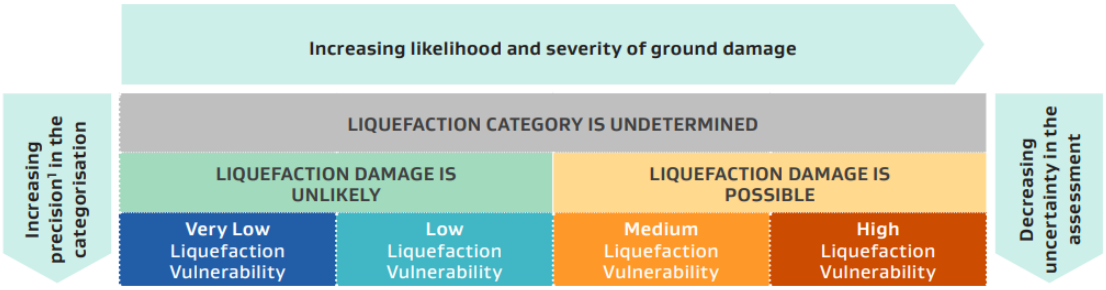
The MBIE/MfE guidance defines a tiered system of liquefaction vulnerability categories, as shown in Figure 1. Much of the land in the district's main residential centres has been assigned the liquefaction vulnerability category of ***Liquefaction Damage is Possible*** (Figure 2). As is typically the case for regional assessments such as this, more precise categorisation (e.g., distinguishing between

[1] Tonkin and Taylor, (2021). *Tararua District Council Liquefaction Vulnerability Study.* Report reference 1013790.v2

Tonkin & Taylor Ltd | Level 3, PwC Centre, 60 Cashel Street, West End, Christchurch, 8013, New Zealand | PO Box 13-055, Christchurch 8141
P +64-3-363 2440 F +64-9-307 0265 E chc@tonkintaylor.co.nz

Medium and ***High*** liquefaction vulnerability categories) was not possible due to a lack of both subsurface geotechnical investigation and detailed groundwater information.

Recognising that in many cases more detailed assessment of liquefaction will be required to support Building Consent applications, TDC has now engaged T+T to develop basic guidance to assist practitioners and TDC Building Control staff. This guidance note focusses on the scope of liquefaction assessment likely to be appropriate for each liquefaction vulnerability category, taking into account the types of development and ground conditions most common across the district.



Note:

1 In this context the 'precision' of the categorisation means how explicitly the level of liquefaction vulnerability is described. The precision is different to the accuracy (ie trueness) of the categorisation.

Figure 1 - Liquefaction classifications from MBIE/MfE (2017).

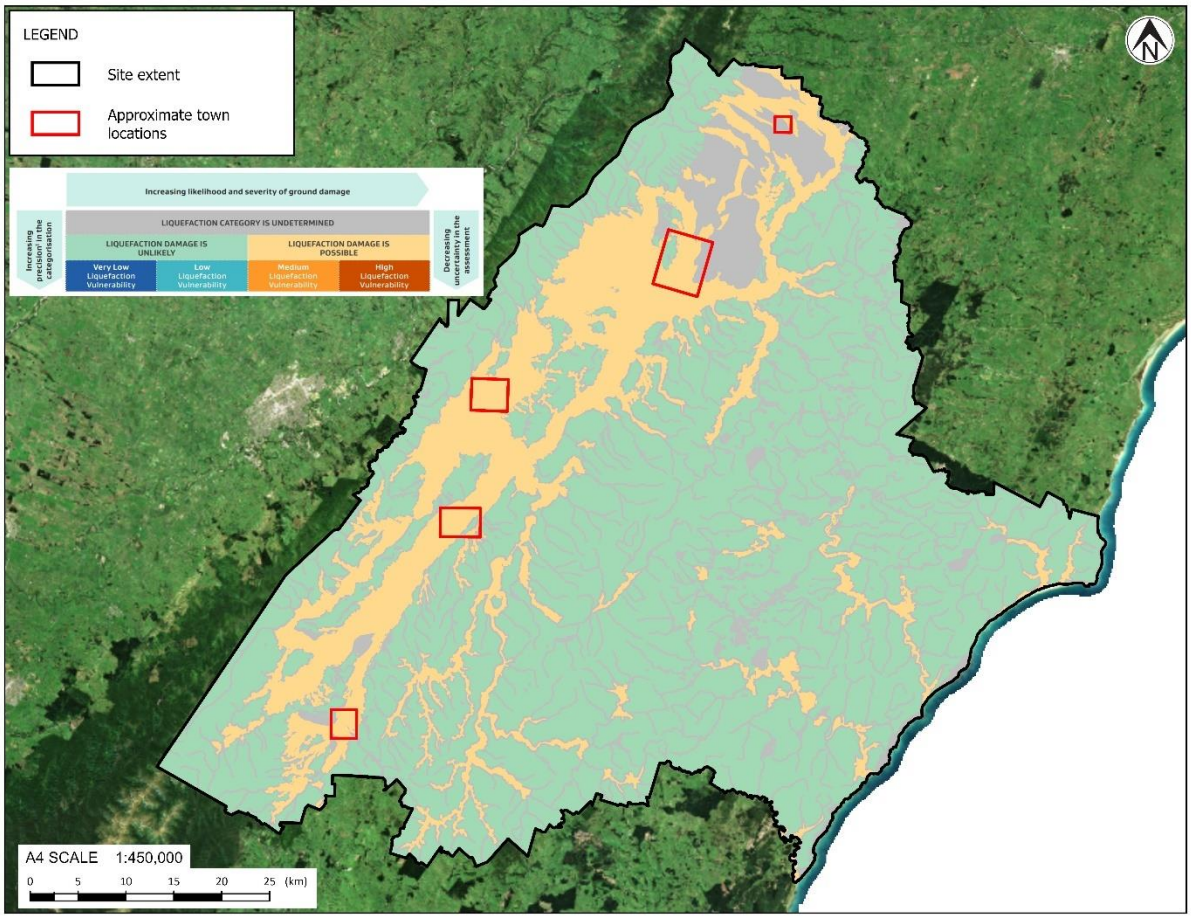


Figure 2 - TDC liquefaction vulnerability categories assigned in T+T (2021).

3 Liquefaction guidance and Building Code compliance

3.1 National-level guidance

In November 2019, the Ministry of Business, Innovation and Employment (MBIE) made changes to the NZ Building Code which limit the application of the B1 Acceptable Solution B1/AS1 so that it may not be used on ground prone to liquefaction or lateral spreading from 29 November 2021 onward[2]. This was implemented by changing the definition of 'Good Ground' to exclude land with the potential for liquefaction and/or lateral spreading.

B1/AS1 is the most commonly used means of compliance for residential buildings. This guidance note is therefore primarily focussed on residential buildings. For other types of buildings (such as commercial and industrial buildings), other compliance pathways may be more appropriate, such as using the MBIE/NZGS modules in conjunction with B1/VM1.

MBIE have issued various guidance documents on assessing and addressing liquefaction hazards. The following guidance documents were issued under Section 175 of the Building Act, so while not Acceptable Solutions or Verification Methods, where appropriate they may be used to demonstrate compliance with the Building Code[3].

- **MBIE Canterbury Guidance (2012)[4]:** The Canterbury Guidance is intended to provide an approach for investigating and selecting foundation solutions for addressing liquefaction prone land in Christchurch. The guidance and processes contained therein are based on the Technical Category (TC) maps, published in 2011. At the time of the change to B1/AS1, MBIE added the following note to B1/AS1, referring users to the MBIE Canterbury guidance (2018) (emphasis added): "*For houses built in areas that have the potential for liquefaction, the MBIE guidance document "Repairing and rebuilding houses affected by the Canterbury earthquakes" may be appropriate. This guidance provides a range of potential foundation solutions depending on expected ground movement and available bearing capacity. These parameters also determine the required degree of involvement of structural and geotechnical engineers and the extent of specific engineering design."*
- **MBIE/NZGS Modules (2021)[5]:** MBIE/NZGS module 4; Earthquake resistant foundation design, discusses compliance and is primarily intended for buildings which typically require specific engineering design. This approach requires defining settlement limits (both total and differential) for a building to achieve satisfactory performance. Compliance is thereby achieved by defining allowable settlement limits, and specifically designing the foundation and any required earthworks to achieve these limits. This approach is generally not used for routine residential buildings.
- **MBIE/MfE Guidance (2017)[6]:** The primary focus of the MBIE/MfE guidance is on developing a framework for managing liquefaction hazard by appropriate land use planning under the Resource Management Act, however Section 3.8 of the document also briefly addresses compliance with the Building Act. It contemplates that most residential houses not requiring specific engineering design would achieve compliance via B1/AS1 but acknowledges that B1/AS1 currently does not address liquefaction.

[2] November 2019 Building Code update | Building Performance, accessed 25 November 2021
[3] Building Act (2004), Section 19 (2)(b)
[4] MBIE. (2012). *Repairing and rebuilding houses affected by the Canterbury earthquakes. Version 3, published December 2012, updated May 2018.* Wellington: Ministry of Business Innovation and Employment.
[5] NZGS/MBIE. (2021) *Modules 1 - 7 Earthquake geotechnical engineering practice series.* Wellington, NZ
[6] MBIE/MfE (2017) Planning and engineering guidance for potentially liquefaction-prone land, Version 0.1, September 2017, Wellington: Ministry of Business Innovation and Employment.

MBIE subsequently published information on their website on liquefaction[7], in July 2021. This information recommended that designers adopt the MBIE Canterbury Guidance (2012) foundation options, and specified how these relate to the MBIE/MfE (2017) liquefaction vulnerability categories, as show below:

- ***Very Low*** and ***Low*** liquefaction vulnerability = Adopt TC1-type foundations
- ***Medium*** liquefaction vulnerability = Adopt TC2-type foundations
- ***High*** liquefaction vulnerability = Adopt TC3-type foundations

3.2 District-level liquefaction guidance

T+T (2021) classifies the land within Tararua District into one of three liquefaction vulnerability categories: ***Liquefaction Category is Undetermined***, ***Liquefaction Damage is Unlikely*** or ***Liquefaction Damage is Possible***. The currently available information does not support further classification of the land into the other more precise categories of ***Very Low***, ***Low***, ***Medium*** or ***High*** liquefaction vulnerability. Therefore, translating the currently mapped vulnerability categories to Technical Categories is not immediately possible. This outcome is generally expected in a regional-scale study, and it is anticipated that more detailed site-specific assessments to support resource and building consents would follow.

The relevant classifications for the Tararua district are explained below:

- Land that has been categorised as ***Liquefaction Damage is Unlikely*** is not considered to be "prone to liquefaction or lateral spreading" so is not excluded from the B1/AS1 definition of 'Good Ground' on this basis.
- Land that has been categorised as ***Liquefaction Damage is Possible*** is considered to be "prone to liquefaction or lateral spreading" and therefore does not meet the definition of 'Good Ground' as outlined in the Building Code amendments.
- For land that has been categorised as ***Liquefaction Category is Undetermined*** there is currently insufficient information to determine whether it is "prone to liquefaction or lateral spreading" within the context of the definition of 'Good Ground' as outlined in the Building Code amendments. If liquefaction vulnerability assessment at a higher level of detail is undertaken in future (e.g., a site-specific assessment) then this may result in reclassification of the land into a different category and whether it meets the definition of 'Good Ground' should be reconsidered based on that new information.

4 Framework for simplified assessment in Tararua District

For each of the broad liquefaction vulnerability categories mapped across Tararua District, the following guidance provides a framework for liquefaction assessment to enable hazard screening for Building Consent applications for routine individual building projects (primarily residential-style buildings).

4.1 Specific context for the simplified assessment

It is emphasised that these screening criteria have been developed specifically in relation to the local context, so these screening criteria may not be applicable in other locations.

Some factors of particular relevance are summarised in Table 4.1, to provide an overview of how these considerations have influenced the development of the screening criteria.

[7] Ensuring new buildings can withstand liquefaction effects | Building Performance, accessed 26 November 2021. Note that this was not issued as guidance under Section 175 of the Building Act.

Table 4.1: Local context most relevant to development of liquefaction screening criteria for Tararua District

Local context	How this has influenced the screening criteria
A lack of subsurface geotechnical investigations and groundwater monitoring across the district.	A focus on confirming soil types and groundwater levels at each individual site.
There is a relatively small amount of new building activity in the district, and much of this is small-scale and spread out over a large geographical area.	This means that there is a lower density of capital/social investment and lower total exposure to a single event, so a lower level of risk (refer risk matrices in Tables 3.5 to 3.7 of MBIE/MfE 2017 guidance).
Much of the site investigation and building design in the district is currently undertaken by general civil/structural practitioners, following B1/AS1 and NZS3604:2011.	Use the same types of shallow soil testing that have traditionally been used to confirm "good ground", but with enhancements to also allow simplified liquefaction screening. Structure the screening criteria around factors which can reasonably be assessed by general practitioners without specialist geotechnical expertise. Clearly flag the types of situations where specialist geotechnical engineering input is required.
If a specialist geotechnical engineer or deep geotechnical testing is required, these often need to be brought in from elsewhere around the country – adding significant mobilisation cost.	Focus the requirement for specialist engineering input onto larger developments, where the risk profile is greater and the project budget is better able to accommodate costs by sharing across multiple buildings. Where specialised geotechnical testing and assessment is undertaken, this should be collated by council and the factual data made available on the NZ Geotechnical Database to help inform future developments in the area.
Areas mapped as ***Liquefaction Category is Undetermined*** predominantly comprise elevated and geologically older deposits.	In these areas there is a lower likelihood of shallow groundwater and liquefaction-prone soils being present. This means favourable ground conditions are assumed unless a simple site investigation identifies any obvious "red flags".
Areas mapped as ***Liquefaction Damage is Possible*** predominantly comprise river deposits, which are highly variable (both vertically and horizontally). Where high/steep free faces are present, these are typically associated with non-liquefiable gravel river terraces.	While liquefaction-prone soils may be present, there is a lower likelihood of thick, uniform deposits of highly-susceptible soils being present (e.g., as might be the case for marine, estuary or lake deposits). This means that the screening criteria can focus on identifying "red flags" relevant for thinner and less extensive liquefiable soils, and lower free-face heights.
The district is within an area of relatively high seismic hazard (e.g., a 500-year design ground acceleration of 0.55g).	Where susceptible soils are present, consequential liquefaction-induced ground damage could occur at relatively frequent levels of design shaking (e.g. as low as 25 to 100 year return period). This means it is especially important for site-specific subsoil and groundwater assessment to identify where significant thickness of liquefiable soils are present at shallow depth.
The District Plan will be reviewed over the next 2 years, providing opportunity to manage liquefaction-related risk proactively through land use planning. In the meantime, the recent Building Code change regarding "good ground" means this risk will be managed predominantly through the Building Consent process.	This guidance note focusses on managing liquefaction-related risk for individual building projects through the Building Consent process. For larger-scale developments (e.g. larger than 4 lots as outlined in Table 3.6 of the MBIE/MfE 2017 guidance) it is likely a Resource Consent will first be required, providing an opportunity to manage risk through that process (refer Section 6.7.2 of MBIE/MfE 2017 guidance).

4.2 Accepting a balance between cost and accuracy of liquefaction assessment

The simplified screening assessment outlined in this guidance note seeks to strike a pragmatic balance between the cost and accuracy of liquefaction assessment for typical individual building projects in Tararua District, considering the local context described in Section 4.1. This approach to managing uncertainty is discussed in more detail in Appendix J1 of the MBIE/MfE (2017) guidance.

This simplified assessment is not intended to be applied to larger-scale land development projects (e.g. greater than 4 lots), where the risk profile is greater and the efficiency of sharing costs across multiple buildings means that undertaking a more detailed assessment is more practical. In these cases, a site-specific geotechnical assessment should be carried out, following the guidance provided in MBIE/NZGS modules 2 & 3 (2021) and the Canterbury MBIE Guidance (2012) for the assessment of liquefaction hazards.

Because of the balance adopted between cost and accuracy of the liquefaction assessment, there remains residual uncertainty in the accuracy of the results, which needs to be accepted as part of using this simplified screening assessment:

- It is expected that in the majority of cases the screening assessment will determine the correct liquefaction vulnerability category.
- In some cases, the screening assessment will over-predict the liquefaction vulnerability. In these cases it is favouring an approach where money is invested in building a more robust foundation which can handle poorer ground conditions (more than only liquefaction), rather than spending an often-similar amount of money on more detailed liquefaction assessment which might (or might not) show that a less robust foundation would suffice.
- In a smaller number of cases, the screening assessment will under-predict the liquefaction vulnerability. In these cases, it is favouring an approach where a minor increase in damage in localised areas if/when/where an earthquake occurs in future is balanced against the high up-front cost of more detailed assessment and more robust foundations across the entire district.

4.3 Areas mapped as *Liquefaction Damage is Unlikely* in Tararua District

4.3.1 Typical ground conditions

Most of these areas in Tararua District have been geomorphologically mapped as 'Hills and Ranges'. This comprises elevated landforms characterised by highly dissected hills with many gullies and valleys, as well as hills that are more rolling in nature, ultimately depending on the underlying geology. The ground conditions vary from exposed rock at the surface to thick deposits of residual soils. Based on the available information, it is likely that this area predominantly comprises some cohesive (plastic) residual soils and rocks that are not considered to be susceptible to liquefaction.

4.3.2 Simplified liquefaction screening assessment

These areas are not prone to significant liquefaction-induced land damage, so are not excluded from the definition of 'Good Ground' on this basis. Further liquefaction assessment is not required for these sites, unless greater certainty about the liquefaction vulnerability is required (e.g., buildings of higher importance or with greater sensitivity to ground movement).

There may be other reasons why the definition of 'Good Ground' is not satisfied at a particular site (e.g., the presence of compressible/expansive soils, uncontrolled fill or slope instability) and the person assessing the site and specifying the foundation solution will need to undertake their own assessment for these factors.

The investigation of shallow soil conditions should generally follow the normal procedures outlined in NZS3604:2011. It is recommended that, where practical, hand augers for the examination of soil

materials extend to between 3 and 4 m below ground level – noting that shallow refusal on rock or dense soils could occur on many sites, and this is consistent with the expected ground conditions and the mapped ***Liquefaction Damage is Unlikely*** category. If loose, granular soils or shallow groundwater are discovered within this depth, the site should be categorised as ***Liquefaction Damage is Possible*** and the process outlined in Section 4.5 should be followed. For all other sites, it can be assumed that the mapped category of ***Liquefaction Damage is Unlikely*** is correct, and a suitable foundation option selected accordingly (e.g. a TC1-type foundation from the MBIE Canterbury Guidance). As discussed further in Section 4.8, consideration could be given to the benefits of adopting a foundation which is more robust than these minimum requirements.

4.4 Areas mapped as *Liquefaction Category is Undetermined* in Tararua District

4.4.1 Typical ground conditions

Most of these areas in Tararua District have been geomorphologically mapped as 'elevated alluvial terraces'. These terraced areas were uplifted, folded and faulted during the Quaternary period, relating to the rising of the axial ranges in the east of the district.

For these areas, there is currently insufficient information to classify the liquefaction hazard. This terrain comprises sediments deposited in both high energy and low energy environments, which are likely to have both plastic and non-plastic behaviours. However, the older age of these sediments means that they are less likely to contain liquefaction-susceptible soils than the more recent alluvial terrain forming the main valley where the main townships are located.

4.4.2 Simplified liquefaction screening assessment

The nature of the expected ground conditions means that if more detailed site-specific assessment was undertaken in the future, then this would probably indicate ***Liquefaction Damage is Unlikely***. For future assessments, it is likely that undertaking simple shallow hand auger boreholes and confirming soil properties and/or groundwater depths would be sufficient to efficiently determine whether ***Liquefaction Damage is Unlikely*** or ***Liquefaction Damage is Possible***. The appropriate process for the updated category should then be followed.

The investigation of shallow soil conditions should generally follow the normal procedures outlined in NZS3604:2011 but it is recommended that where practical, hand augers for the examination of soil materials extend to between 3 and 4 m below ground level. If loose, granular soils or shallow groundwater are discovered within this depth, the site should be categorised as ***Liquefaction Damage is Possible*** and the process outlined in Section 4.5 should be followed. For all other sites, it can be assumed that ***Liquefaction Damage is Unlikely*** and the process outlined in Section 4.3 followed.

4.5 Areas mapped as *Liquefaction Damage is Possible* in Tararua District

4.5.1 Typical ground conditions

In Tararua District this area corresponds to the geomorphic terrain 'Alluvial channels and plains'. Typically, soils found in this terrain are geologically young (Holocene-aged) and deposited in low to high energy environments forming a variety of soils, including loose and soft strata. The characteristics of the soils comprising these terrains are highly variable in nature and vary spatially across the landscape. Alluvial sediments typically range from granular gravels, sands and silts to fine grained soil deposits (clay and silt) with plastic-type behaviours. These soils typically contain materials that are susceptible to liquefaction.

The depth to groundwater is also likely to be shallow (< 4 m) within this terrain because it is generally associated with active and historic river and stream systems, as well as water bodies such

as lakes. The MBIE/MfE (2017) guidance typically associates these alluvial terrains as being susceptible to liquefaction. Some areas could have variable groundwater levels due to variation in ground elevation, where groundwater typically becomes deeper at higher elevations.

Free faces are associated with this terrain in the form of riverbanks, stop banks, streams and drainage ditches, all of which are visible on aerial photography and LiDAR imagery. The MBIE/MfE (2017) guidance notes that in the presence of liquefaction-susceptible soils, lateral spreading is more likely to be possible within 200 m of free faces more than 2 m high.

4.5.2 Simplified liquefaction screening assessment

The variability of ground and groundwater conditions in this geomorphic terrain means that if more detailed site-specific assessment was undertaken in the future, classifications of ***Low***, ***Medium*** and ***High*** liquefaction vulnerability are all possible outcomes.

An option for simplified further liquefaction assessment in this category is to screen out sites that have the greatest potential for ***High Liquefaction Vulnerability***, and flag these areas for more detailed assessment. All other sites can be considered likely to have no worse than ***Medium Liquefaction Vulnerability***, and a suitable foundation option selected accordingly.

High Liquefaction Vulnerability sites are typically likely to be subject to more substantial lateral spreading and/or ground settlement damage. The potential for these effects can be estimated by assessing free face height and distance, and non-liquefiable crust thickness, respectively. Simplified screening procedures for these effects are presented in Table 4.2:

- If this screening indicates ***Liquefaction Damage is Unlikely***, the process outlined in Section 4.3 should be followed.
- If this screening indicates ***Medium Liquefaction Vulnerability***, a suitable foundation option should be selected accordingly (e.g. a TC2-type foundation from the MBIE Canterbury Guidance). As discussed further in Section 4.8, consideration could be given to the benefits of adopting a foundation which is more robust than these minimum requirements.
- If this screening indicates ***High Liquefaction Vulnerability***, the process outlined in Section 4.7 should be followed.

Table 4.2: Simplified liquefaction vulnerability screening criteria for areas mapped as *Liquefaction Damage is Possible* in Tararua District.

	Background rationale	**Evaluation criteria** *(check from top to bottom, stopping when a liquefaction category match is found)*
Criteria 1: Non-liquefiable crust thickness	A thick non-liquefiable crust will help to supress the surface manifestations of liquefaction, reducing ground damage and settlement. Where this crust is sufficiently thick, a site is unlikely to have ***High Liquefaction Vulnerability***. For the purposes of this simplified screening, the crust thickness (**CT**) is measured as the depth to the first liquefaction-susceptible soil layer (e.g. non-plastic silt, sand or loose gravel) which is below the expected long-term average groundwater level.	• If CT > 4 m, assume ***Liquefaction Damage is Unlikely.*** • If CT < 3 m, assume ***High Liquefaction Vulnerability.*** • Otherwise, go to Criteria 2.
Criteria 2: Lateral spread	Where a site is sufficiently distant from a free face, the lateral spread hazard can be considered likely to be minor. MBIE/MfE (2017) indicate that as a starting point for simplified lateral spreading screening, particular attention should be given to liquefaction-susceptible land that is within 200 m of a free-face greater than 2 m high; or within 100 m of a free-face less than 2 m high. The free face height (**H_{ff}**) is measured as the difference in height between the lowest point (e.g, bottom of riverbed or base of terrace) and the highest point (e.g., top of riverbank/terrace). For the purposes of this simplified screening, the lateral spread hazard can be considered likely to be minor if the free face height is less than 0.5 m. The distance to the free face (**L**) is measured as the distance between the top of the bank/terrace and the closest part of the proposed building. The ratio between the distance to and height of free face (L/H_{ff}) is used as a normalised parameter to evaluate the relative proximity of the site to the free face.	• If L > 200 m, assume ***Medium Liquefaction Vulnerability.*** • If H_{ff} < 0.5 m, assume ***Medium Liquefaction Vulnerability.*** • If L/H_{ff} > 50, assume ***Medium Liquefaction Vulnerability.*** • Otherwise, assume ***High Liquefaction Vulnerability***

4.6 Site assessment and ground investigations for simplified liquefaction screening

To assess the screening criteria outlined above, various techniques may be utilised. Examples of potential site assessment and ground investigation options are discussed below. Other investigations may be required to assess other aspects of the site (e.g., the presence of compressible/expansive soils, uncontrolled fill or slope instability) and the person assessing the site and specifying the foundation solution will need to undertake their own assessment for these factors.

Lateral spread assessment: This could be undertaken based on a desktop study but should be calibrated by a site visit and visual assessment of the site and its surrounds, noting any channels or free faces present in the vicinity of the site.

Groundwater assessment: This assessment may be undertaken using either direct investigation methods (such as hand augers or excavation to 3 to 4 m depth), or by comparison with known, nearby sources of groundwater data such as nearby waterbodies with known water levels, or nearby investigations such as boreholes or excavations where groundwater was recorded. Seasonal groundwater fluctuations should be considered.

Soil conditions: The investigation of shallow soil conditions should generally follow the procedures outlined in NZS3604:2011 but it is recommended that where practical, hand augers for the examination of soil materials extend to between 3 and 4 m below ground level. Alternatively, test pits, boreholes or Cone Penetration Tests (CPT) may be used to assess soil conditions. Where sufficient nearby data is available to demonstrate ground conditions, this may also be relied upon, in conjunction with investigations on the site in question. Soils should be logged in accordance with the NZGS field guide for description of soil and rock[8].

We note that very little data exists in the New Zealand Geotechnical Database (NZGD) for the Tararua District. Advocating the uploading of geotechnical investigations onto the NZGD as part of the process of evaluating resource and building consent applications would progressively increase the amount of geotechnical data available. This would inform future investigations, allow refinement of existing liquefaction hazard mapping and provide valuable information to support future land-use planning and site assessments.

4.7 Further assessment required for potential *High Liquefaction Vulnerability* sites

For sites where the initial screening indicates the potential for ***High Liquefaction Vulnerability***, design of buildings will require further liquefaction assessment to more precisely characterise the hazard and inform the foundation design. These investigations should follow the guidance provided in MBIE/NZGS modules 2 & 3 (2021) and the Canterbury MBIE Guidance (2012) for the assessment of liquefaction hazards. This will generally involve carrying out deeper investigations such as boreholes or CPTs and carrying out liquefaction analysis. This analysis should consider groundwater depths (including likely seasonal fluctuations), soil conditions, and local seismicity.

Following this analysis, a classification of ***Medium*** or ***High*** liquefaction vulnerability is likely to be able to be assigned, and a suitable foundation option selected accordingly (e.g. a TC2-type or TC3-type foundation respectively). As discussed further in Section 4.8, consideration could be given to the benefits of adopting a foundation which is more robust than these minimum requirements.

[8] Field description of soil and rock – field sheet – New Zealand Geotechnical Society (nzgs.org) accessed 29 November 2021

4.8 Option to adopt a foundation which is more robust than the minimum requirements

The screening assessment presented above is intended to provide an efficient and cost-effective approach to estimate the likely liquefaction vulnerability at an individual site. It is expected that in the majority of cases the screening assessment will determine the correct liquefaction vulnerability category, however there remains a residual risk that the actual liquefaction vulnerability may be greater than assumed.

To help manage this uncertainty (as well as a range of other potential risks), consideration could be given to the benefits of adopting a foundation option which is more robust than the "Building Code minimum requirements" for the assumed liquefaction vulnerability category. For example:

- The cost of a TC2-type waffle slab is often only marginally greater than a NZS3604:2011 slab, however it can offer significantly improved resilience to ground deformations (which could occur for various other reasons in addition to liquefaction), improved flooding freeboard, improved insulation and the ability to accommodate poorer ground with low bearing capacity. This means there could be benefits in adopting a TC2-type waffle slab even in areas where it is assumed that ***Liquefaction Damage is Unlikely***.
- There are some TC3-type foundations which are only modestly more expensive than similar TC2-type options, but offer some specific advantages which may be relevant for particular situations. For example, a TC3 Type 1 surface structure offers improved foundation stiffness, the ability to raise floors levels a metre or more above ground to provide flood freeboard, and is able to accommodate poorer ground with low bearing capacity. A TC2/TC3 hybrid geogrid-reinforced gravel raft with overlying slab can offer additional resilience and accommodate very poor surface ground conditions, and could be a cost-effective upgrade if fill is already required to raise a site or undercut unsuitable surface soils. In these kinds of situations, there could be benefits in adopting a TC3-type foundation even in areas where ***Medium Liquefaction Vulnerability*** is assumed.
- There are particular design details which can make a building more or less resilient to ground deformations (either caused by liquefaction, or other geotechnical issues such as soft or expansive soils). Example design principles are presented in Section 11.2 of the MBIE Canterbury Guidance (2012), such as preferring regular structural plan shapes, stiff tied-together foundation elements, and considering ease of repair of the structure and services. There could be benefits in considering these kinds of careful design details for all sites, regardless of the liquefaction vulnerability category.

4.9 Option for detailed site-specific assessment

As outlined in Section 4.2, the simplified screening assessment outlined above seeks to strike a pragmatic balance between the cost and accuracy of liquefaction assessment for typical building projects in Tararua District. However, there could be some situations where this approach might not strike the optimum balance for a particular project.

For example, if there was a preference to use standard NZS3604:2011 foundations then this would require 'good ground' to be proven. Or if there was a preference for particular architectural or structural details which are beyond the scope of the standard TC2-type foundation limitations or are more sensitive to ground deformation, this might require specific engineering design based on more a detailed understanding of the site characteristics.

In these types of situations it may be beneficial to undertake a detailed site-specific assessment of liquefaction vulnerability. This assessment should be undertaken by a suitably competent geotechnical professional and generally follow the guidance provided in MBIE/NZGS Modules 2 & 3 (2021) and MBIE/MfE (2017). Shallow investigations as described in NZS3604:2011 are unlikely to be sufficient for sites where a more detailed understanding of liquefaction or lateral spreading are required.

4.10 Resource Consent for subdivision

The liquefaction screening assessment presented above is primarily intended to help identify suitable foundation options and support Building Consent for individual residential-style buildings. However, in cases with a lower risk profile a similar approach may also be appropriate to inform Resource Consent for subdivision. For example, the screening approach could be suitable where only small-scale development is proposed, such as creating up to 4 new residential lots, or subdivision of an existing residential lot for infill housing.

Where larger developments are proposed, the risk profile is greater. In these cases, the larger scale means that undertaking a more detailed liquefaction assessment is more practical, is likely to be more cost effective, and is necessary due to the higher risk profile. Therefore, the screening assessment above should not be used, and a detailed site-specific geotechnical assessment should be carried out. This assessment should follow the guidance provided in MBIE/NZGS modules 2 & 3 (2021) and the Canterbury MBIE Guidance (2012) for the assessment of liquefaction hazards. This will generally involve carrying out deeper investigations such as boreholes or CPTs and carrying out liquefaction analysis. This analysis should consider groundwater depths (including likely seasonal fluctuations), soil conditions, and local seismicity, as well as likely variability of soil conditions throughout the proposed development area.

Once the liquefaction vulnerability category for the site is determined (using a screening assessment or detailed site-specific assessment as appropriate), the Subdivision Consent application should address how any identified liquefaction hazard will be managed. Section 6.7.2 of MBIE/MfE (2017) discusses how this can be incorporated as part of the information required to support the consent application, and how conditions on consents can be used to avoid or mitigate adverse effects. In addition to liquefaction, all other potential geotechnical issues and natural hazards should also be considered as part of the Resource Consent application.

The Resource Consent process will need to consider a wide range of factors as they apply to each specific site, so there are no fixed criteria about how the hazard should be managed for each liquefaction vulnerability category. However, for routine development of the type currently most common in Tararua District, on sites where ***Liquefaction Damage is Unlikely*** or with ***Very Low***, ***Low*** or ***Medium*** liquefaction vulnerability, it may be appropriate for the hazard to be managed through the normal engineering design process for siteworks, buildings and infrastructure, without the need for specific mitigation measures at Resource Consent stage. For sites with ***High Liquefaction Vulnerability***, more careful assessment is likely to be required at Resource Consent stage, and this may indicate a need to avoid development in particular areas or to require measures to mitigate the adverse effects of liquefaction.

5 Document status and limitations

This guidance note is intended to assist parties to comply with their obligations under the Building Act 2004 and the Resource Management Act 1991. It is not mandatory to follow this guidance, but if followed:

- It does not relieve any person of the obligation to consider any matter to which that information relates according to the circumstances of the particular case.
- The consent authority may have regard to the guidance, but is not bound to accept the guidance as demonstrating compliance.
- All users should satisfy themselves as to the applicability of the content and should not act on the basis of any matter contained in this document without considering, and if necessary, taking appropriate professional advice.

The simplified screening assessment presented in this guidance is intended to help inform Building and Resource Consent applications for typical individual building projects in Tararua District, with a focus on residential-style buildings. This simplified assessment is not intended to be applied to larger-scale land development projects (e.g. greater than 4 lots). For other types of buildings (such as commercial and industrial buildings), other compliance pathways may be more appropriate, such as using the MBIE/NZGS modules in conjunction with B1/VM1.

This report has been prepared for the exclusive use of our client Tararua District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement. We understand and agree that this report will inform general guidance about liquefaction assessment provided by Tararua District Council to consent applicants and their designers, on the basis that any use or reliance on this guidance is at that party's sole risk.

While T+T has taken care in preparing this document, it is only a guide and professional judgment is required for each individual site. T+T is not liable for any reliance on this guidance. The responsibility for specific engineering design and construction review for land development and building works remains with the designers of the works.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

Authorised for Tonkin & Taylor Ltd by:

.....

Eric Bird
Senior Engineering Geologist

.....

Mike Jacka
Project Director

8-Dec-21
\\ttgroup.local\corporate\hamilton\projects\1013790\1013790.1000\issueddocuments\2021-12-08 guidance for liquefaction assessment in tararua district.docx