Memo

Date	9 June 2020
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CC	Nick Griffiths, Hazards Team Leader, Environment Canterbury Carmel Rowlands, Planning Team Leader, Environment Canterbury Ashlee Robinson, Planner, Environment Canterbury
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Using liquefaction information in the Timaru District Plan review

1. Introduction

Timaru District Council are reviewing their District Plan. I recommend that liquefaction information and provisions are incorporated into the District Plan to reduce the risk of damage from liquefaction and lateral spreading.

Liquefaction is a process whereby soil behaves more like a liquid than a solid during strong earthquake shaking. It is caused by water pressure within the soil becoming so high that the soil particles start to 'float'. This can cause heavy things on the soil (like houses) to tilt or sink, things buried under the soil (like tanks) to float upwards, and can cause sediment to be ejected up to the ground surface to form 'sand boils' or in extreme cases sheets of sand and silt. Soils must be saturated (below the water table) and predominantly sandy or silty to liquefy. Liquefaction usually only occurs in susceptible soils when the earthquake shaking is strong enough to move furniture and make it hard to stand up.

Lateral spreading is where, as a result of liquefaction, the ground moves sideways towards an unsupported edge such as a river bank.

Liquefaction and lateral spreading caused widespread damage to houses and infrastructure in coastal Waimakariri, Christchurch and Selwyn during the 2010/11 Canterbury Earthquake Sequence. It also caused some localised damage in Kaikoura during the 2016 Kaikoura-Hurunui earthquake and minor liquefaction was observed Christchurch during the 1869 Christchurch earthquake and parts of coastal North Canterbury during the 1901 Cheviot and 1922 Motunau earthquakes. There are no known historic occurrences of liquefaction in Timaru District.

The risk of damage from liquefaction can be mitigated with engineering solutions such as ground treatment to reduce the likelihood of liquefaction in an area during strong earthquake shaking, or using more robust foundations or other techniques that make it faster and easier to repair houses or infrastructure if liquefaction does occur. However, in very susceptible areas the cost of mitigating the risk may become uneconomic, and it may be better to avoid the area for development.

Liquefaction risk can be managed through district plan provisions, for example requiring specific liquefaction assessments for subdivisions and mitigation methods such as more

robust foundations if necessary. From November 2021 liquefaction risk will also be managed through the building consent process. The definition of 'good ground' under the Building Code will be amended to explicitly include ground that is not prone to liquefaction and/or lateral spreading for the whole of New Zealand (it currently only applies to Waimakariri and Selwyn districts and Christchurch City). This means that Building Consent Authorities will need to manage the liquefaction risk in areas prone to liquefaction as part of the building consent process by requiring more robust foundations than the standard B1/AS1 solutions.

A note on terminology: Liquefaction *susceptibility* describes how susceptible the ground is to liquefaction during strong earthquake shaking, which depends primarily on the characteristics of the ground and where the water table is. Liquefaction *hazard* is how likely liquefaction is at a particular location is, which depends on the liquefaction susceptibility as well as how likely strong earthquake shaking is, which varies around New Zealand. Liquefaction *risk* is the liquefaction hazard combined with the potential consequences. For example, the liquefaction risk can be reduced in a liquefaction-prone area by increasing lot sizes – this does not change the likelihood of liquefaction occurring but decreases the potential consequences by having less houses exposed to liquefaction damage.

2. Liquefaction susceptibility mapping

Areas of different liquefaction susceptibility were mapped for Timaru District in 2001 by Geotech Consulting Ltd as part of the Timaru District Engineering Lifelines Project Earthquake Hazard Assessment. This mapping was based mainly on 1:250,000 scale geological and soils information, with some groundwater level data, but no geotechnical soil testing.

Following the 2010/11 Canterbury Earthquake Sequence, Timaru District Council requested that the 2001 liquefaction susceptibility maps be reviewed, particularly in areas of development pressure in Geraldine and Washdyke. Environment Canterbury commissioned Geotech Consulting Ltd to undertake this work, which involved using updated geological mapping (Aoraki QMap, published by GNS Science in 2007) as well as new borelogs and several test pits and cone penetration tests in Geraldine, Washdyke and Timaru township. The report *Liquefaction Hazard in Timaru District* was completed in 2013, peer reviewed by Golder Associates Ltd, and was provided to Timaru District Council in March 2014. It is available on the Environment Canterbury website at https://api.ecan.govt.nz/TrimPublicAPI/documents/download/1812002, and the accompanying GIS layer is available on Canterbury Maps at https://opendata.canterburymaps.govt.nz/datasets/timaru-liquefaction-susceptibility-2013. The maps were compiled at a scale of 1:25,000 for Timaru township and 1:250,000 for the remainder of the district.

The liquefaction susceptibility areas are shown in Figures 1 and 2. The 2013 report confirmed that most areas in Timaru District have low to no liquefaction susceptibility, because they are underlain by either rock or river sediments comprising mostly non-liquefiable gravels. There are only a few low-lying areas near the coast where there could be significant areas of damaging liquefaction during a moderate or strong earthquake.

Because liquefaction susceptibility can vary significantly over short distances, depending on how the underlying material was deposited, the actual liquefaction potential at individual sites can only be determined by a site-specific investigation. The liquefaction susceptibility areas showed general areas where liquefaction was generally more or less likely during strong earthquake shaking, and therefore where more or less detailed assessments should be undertaken before development. The 2013 report provided detailed information on each susceptibility area, as well as recommended liquefaction assessments and potential mitigation options for each area.

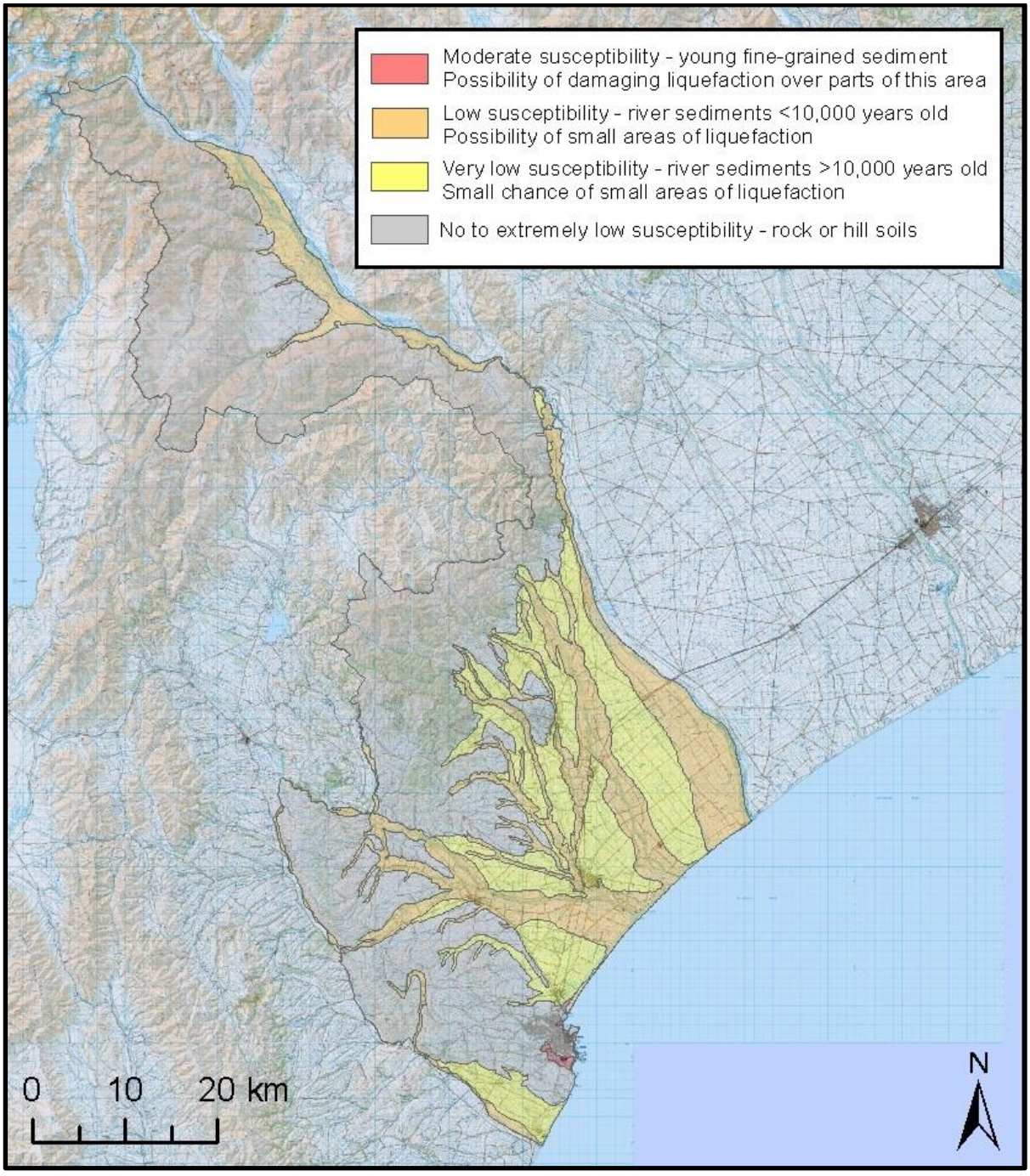


Figure 1: Liquefaction susceptibility areas for Timaru District mapped by Geotech Consulting Ltd in 2013.

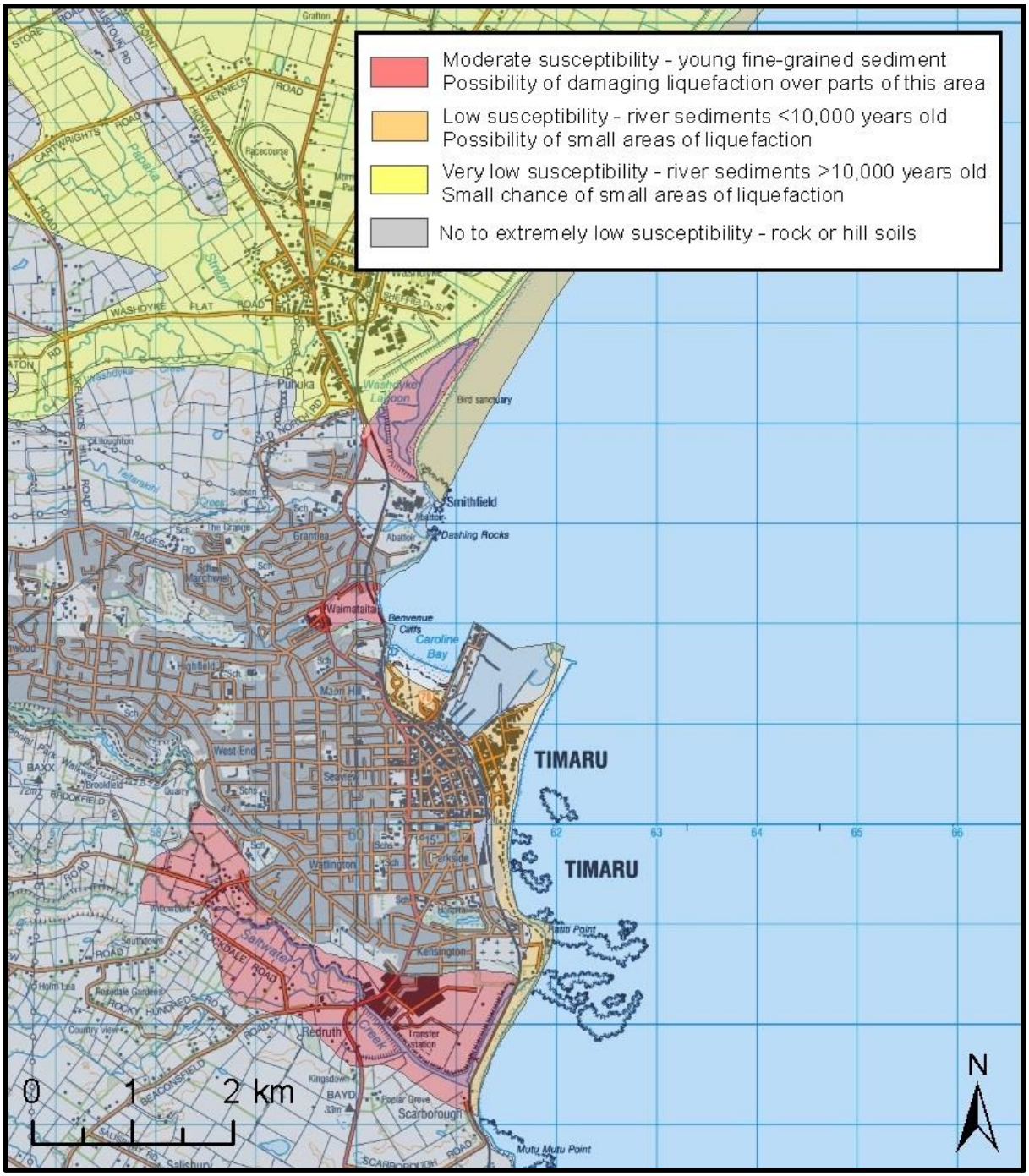
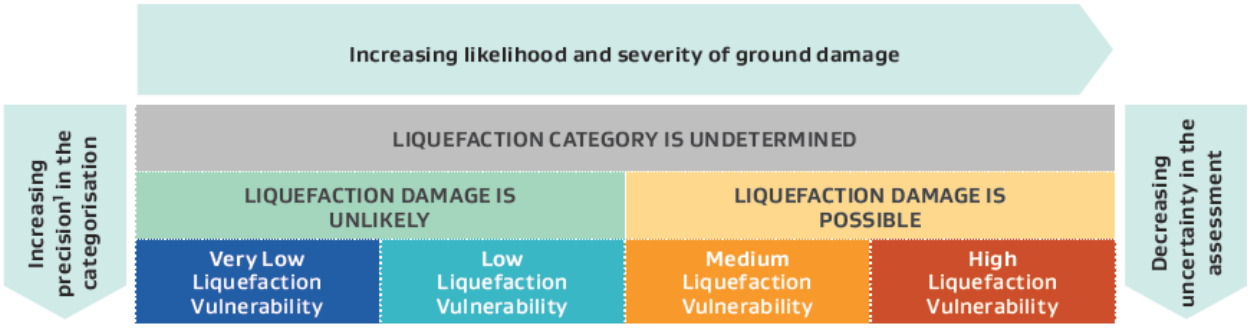


Figure 2: Liquefaction susceptibility areas for Timaru township mapped by Geotech Consulting Ltd in 2013.

3. Repurposing the 2013 liquefaction susceptibility areas using 2017 MBIE guidance framework

The Ministry of Business, Innovation and Employment released *Planning and engineering guidance for potentially liquefaction-prone land* in 2017. The guidance recommends classifying land into vulnerability categories based on the degree of damage that could be expected to occur in an area during strong earthquake shaking. It then adopts a risk-based approach whereby different levels of geotechnical investigation are recommended to determine the liquefaction hazard depending on the vulnerability category and the scope of

the proposed development, and it provides guidance on using district plan provisions and building consent processes to mitigate the liquefaction risk. MBIE's vulnerability categories are given in Table 1 below.



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.

Table 1: Ministry of Building, Innovation and Employment's liquefaction vulnerability categories (Table 1.1 of the MBIE guidance)

I have had advice from Ian McCahon at Geotech Consulting Ltd, who developed the 2001 and 2013 liquefaction susceptibility areas, that the information used to determine those areas means that liquefaction vulnerability can only be divided into 'liquefaction damage is unlikely' or 'liquefaction damage is possible'. There is not enough geotechnical data to further refine areas into the four 'very low', 'low', 'medium' or 'high' liquefaction vulnerability categories with certainty (although it can be said with some confidence that the 'extremely low to no' liquefaction susceptibility equates to the 'very low' liquefaction vulnerability, as these are areas underlain by rock or hill soils). However, it would be useful to delineate the categories a little further than just the unlikely/possible division so that consent requirements, for individual building consents in particular, are not too onerous given the relatively low likelihood of liquefaction in most of the district.

Ian McCahon suggests aligning the 2013 liquefaction susceptibility areas with the MBIE guidance as follows in Table 2. The suggested levels of liquefaction assessment are based on Tables 3.6 and 3.7 in the 2017 MBIE guidance as well as Ian's local knowledge of Timaru's geology, soils, groundwater conditions and seismic hazard.

Note that while the suggested liquefaction assessments will apply for most sites within each category, a higher level of liquefaction assessment may be needed where desktop assessments and/or site testing indicates that a liquefaction hazard may be present, which needs to be determined by suitably qualified and experienced professionals on a case by case basis. A site being in the 'liquefaction unlikely' category should not be a hard and fast reason for the liquefaction potential to be ignored in the face of other evidence.

2013 liquefaction susceptibility area	Geology/ geomorphology	2017 MBIE vulnerability category	Suggested liquefaction assessment
Moderate	Fine-grained, mostly estuarine sediment younger than 10,000 years	Liquefaction damage is possible	Detailed assessment including deep geotechnical testing (MBIE Level C assessment) is recommended for subdivisions to determine liquefaction hazard. Detailed site-specific assessment including deep geotechnical assessment (MBIE Level D assessment) is recommended for building consents and important infrastructure to determine liquefaction hazard. Liquefaction risk should be mitigated through methods such as minimum lot sizes to reduce potential consequences (subdivisions), foundation design (buildings), or other methods (buried infrastructure, etc). It is likely that new residential buildings in this category will require technical category TC2- or TC3-equivalent foundations.
Low	River sediment younger than 10,000 years (active riverbeds and floodplains) and beaches; predominantly gravel	Liquefaction damage is possible	Desktop assessment with shallow testing (MBIE Level B assessment) is recommended for subdivisions, infrastructure and building consents (in addition to the standard investigation procedure outlined in NZS3604) to determine liquefaction hazard. Deep testing (MBIE level C assessment) should be undertaken if initial shallow testing is inconclusive or indicates potentially susceptible soil, or if the value or importance of the development warrants more certainty (e.g. for a large subdivision or important infrastructure). Liquefaction risk should be mitigated through methods such as minimum lot sizes to reduce potential consequences (subdivisions), foundation design (buildings), or other methods (buried infrastructure, etc), if necessary.
Very low	River sediment older than 10,000 years; predominantly gravel	Liquefaction damage is unlikely	A desktop assessment (MBIE Level A assessment) is recommended for subdivisions, infrastructure and building consents (in addition to the standard investigation procedure outlined in NZS3604) to confirm that liquefaction damage is unlikely.
Extremely low to no	Rock or hillslopes	Liquefaction damage is unlikely (Very low liquefaction vulnerability)	No specific liquefaction assessment required for subdivisions or infrastructure. Standard investigation procedure as outlined in NZS3604 for building consents is appropriate and no specific liquefaction assessment is required, unless site conditions suggest otherwise.

Table 2: Suggested liquefaction vulnerability categories and liquefaction assessments for Timaru District

I have supplied an updated GIS dataset with added attribute fields containing the information in Table 2 with this memo. I have also slightly adjusted some of the category boundaries outside of Timaru township so that they better reflect the local geomorphology (the original mapping was taken from the 1:250,000 scale geological map, and in some places this is slightly out of line with obvious geomorphic boundaries such as terrace edges).

Land Information Memoranda (LIMs)

I recommend that the liquefaction vulnerability categories be included in the District Plan *and* on Land Information Memoranda for information so that people are aware of the potential liquefaction hazard.

New Zealand Geotechnical Database

I recommend that Timaru District Council make it a requirement of any liquefaction assessment undertaken for a resource or building consent that the geotechnical data is uploaded to the New Zealand Geotechnical Database.