BEFORE INDEPENDENT HEARING COMMISSIONERS
IN CHRISTCHURCH

TE MAHERE Ā-ROHE I TŪTOHUA MŌ TE TĀONE O ŌTAUTAHI

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

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STATEMENT OF PRIMARY EVIDENCE OF DR JESSE LEIF DYKSTRA ON BEHALF OF CHRISTCHURCH CITY COUNCIL

GEOTECHNICAL ENGINEERING - SLOPE HAZARD AREAS AND LIQUEFACTION HAZARDS

Dated: 11 August 2023

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EXECUTIVE SUMMARY

1. My full name is **Dr Jesse Leif Dykstra**. I am employed as Principal Geotechnical Advisor in the Technical Services & Design team at the Christchurch City Council (the **Council**).

2. I have prepared this statement of evidence on behalf of the Council in respect of matters related to the liquefaction and slope instability Qualifying Matters (**QMs**) arising from the submissions and further submissions on Plan Change 14 to the Christchurch District Plan (the **District Plan**; **PC14**).

3. In my opinion, the Liquefaction Management Area (**LMA**) in the District Plan are not appropriate QMs for PC14 because the current LMA hazard overlay is not based on the most recent liquefaction vulnerability information and is almost certainly not an accurate representation of the hazard at higher resolutions (i.e. individual neighbourhoods down to a specific site).

4. In my opinion consideration should be given to developing a new hazard overlay based on the current Liquefaction Vulnerability Categories (**LVC**) map along with appropriate planning rules because the LVC contains sufficient data across much of the Urban Christchurch area to differentiate between locations with *"high"* or *"medium"* liquefaction vulnerability, from areas where liquefaction damage is *"possible"*). I do recognise, however, that this would require a significant amount of additional work that cannot be completed as part of PC14.

5. Liquefaction hazard does not preclude multi storey development. However, foundation design in areas of high liquefaction vulnerability for buildings four storeys or over would likely need specifically designed deep ground improvement. The scale of the deep ground improvement may have a greater impact on the surrounding area compared to buildings of three storeys or less.

6. It is my view that the existing Cliff Collapse Management Area 1, Cliff Collapse Management Area 2 and Rockfall Management Area 1 hazard overlays in the District Plan are appropriate QMs for PC14. That is because the current life safety risk within these areas is high, and intensification will increase the aggregate risk. The hazard typically cannot be removed, and even where possible, mitigation works will only temporarily reduce the risk.

7. Further, in my opinion, existing slope hazard mitigation works should not be considered an appropriate basis for an additional Slope Instability Management Area (**SMA**) overlay, as they do not remove the actual hazard.

8. I have considered the submissions and further submissions relating to the LMAs and the SMAs, and I do not recommend that any of the submissions be accepted.

INTRODUCTION

9. My full name is **Dr Jesse Leif Dykstra**, I am employed as a Principal Geotechnical Advisor and Natural Hazards and Risk Management specialist in the Technical Services & Design team at the Council.

10. In preparing this evidence I have:

    (a) Reviewed supporting documentation for the District Plan, particularly evidence presented to the Independent Hearings Panel (**IHP**) with respect to land subject to liquefaction[1] and slope hazards;[2]

    (b) Reviewed the following documents:

        (i) Ministry of Business, Innovation and Employment (**MBIE**) technical guidance *"Repairing and rebuilding houses affected by the Canterbury Earthquakes"* (2012);[3]

        (ii) MBIE Technical Categories Map[4] (Canterbury Maps);

        (iii) Tonkin & Taylor report, "Christchurch Liquefaction Vulnerability Study" (2020) and the related LVC map and interactive viewer (Canterbury Maps).

    (c) Reviewed the Council's section 32 report[5] insofar as it concerns geotechnical matters;

    (d) Reviewed the draft section 42A report prepared by Brittany Ratka insofar as it concerns geotechnical matters; and

    (e) Considered the submissions relevant to my evidence.

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[1] Natural-Hazards-Part.pdf (ihp.govt.nz)
[2] B310-CCC-Mr-Ian-Wright-Natural-Hazards-13-2-15.pdf (ihp.govt.nz); 310-CCC-Supplementary-Evidence-of-Mark-Yetton-Cliff-Collapse-Certification-22-12-2015.pdf (ihp.govt.nz); 310-CCC-Supplementary-Evidence-of-Ian-Wright-Natural-Hazards-Cliff-Collapse-Certification-22-12-2015.pdf (ihp.govt.nz)
[3] Repairing and rebuilding houses affected by the Canterbury earthquakes | Building Performance
[4] Christchurch Liquefaction Information (canterburymaps.govt.nz), Other Maps, MBIE Technical Categories layer
[5] Plan-Change-14-HBC-NOTIFICATION-Section-32-Qualifying-Matters-Part-2.pdf (ccc.govt.nz)

11. I am authorised to provide this evidence on behalf of the Council.

QUALIFICATIONS AND EXPERIENCE

12. I hold a Ph.D. in Engineering Geology from the University of Canterbury and a B.Sc. (Honours) in Earth & Environmental Sciences from the University of British Columbia. I am a member of Engineering New Zealand, the New Zealand Geotechnical Society and the New Zealand Coastal Society.

13. I have been employed as Principal Geotechnical Advisor by the Council since February 2018. Prior to that I worked as a Senior Engineering Geologist in the geotechnical consultancy sector for AECOM/URS and Golder Associates. My experience includes assessment/testing of geotechnical ground conditions, interpretation of geotechnical testing results and providing advice on site specific geotechnical issues that could influence land use, such as slope stability hazards (including lateral spreading), liquefaction, compressible soils and erosion/flooding.

14. A primary area of specialization for me has been around slope stability hazards and risk assessment. I managed the Council's Slope Stability Engineering Panel (**SSEP**) since joining Council in 2018 through to expiry of the panel agreement in 2021. Following the 2010/2011 Canterbury Earthquake Sequence (**CES**) I was a member of the Port Hills Geotechnical Group, including as a team leader from 2013-2016 when I was with URS/AECOM. I was an active consultant member of the SSEP during that time.

15. I have been trained by MBIE to undertake Rapid Building Assessments under Emergency Management situations. I am an MBIE accredited, and Council authorised Rapid Building Assessor (for geotechnical aspects).

CODE OF CONDUCT

16. While this is a Council hearing, I have read the Code of Conduct for Expert Witnesses (contained in the 2023 Practice Note) and agree to comply with it. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

17. I confirm that, while I am employed by the Council, the Council has agreed to me providing this evidence in accordance with the Code of Conduct.

SCOPE OF EVIDENCE

18. My statement of evidence addresses the following matters:

    (a) Considers whether the proposed Liquefaction Management Area (**LMA**) as provided for in the Liquefaction Hazard Chapter of PC14 (Chapter 5.5) is an appropriate QM;

    (b) Considers whether the proposed Slope Instability Management Areas (**SMAs**) as provided for in the Slope Instability Chapter of PC14 (Chapter 5.6) are appropriate QMs;

    (c) Considers and responds to submissions concerning former "Technical Categories" and/or Liquefaction Hazard;

    (d) Considers and responds to submissions concerning slope instability.

19. I address each of these points in my evidence below.

LIQUEFACTION HAZARD (5.5). IS THE LIQUEFACTION MANAGEMENT AREA (LMA) AN APPROPRIATE QUALIFYING MATTER (QM)?

Background

20. The LMA is a natural hazard overlay in the operative District Plan. The location of the overlay was adopted during the IHP process (2014-2017) that informed the District Plan, which became operative in December 2017.

21. To the best of my knowledge, the location of the current LMA overlay is based primarily on observations of physical land damage due to liquefaction and lateral spreading following the CES, along with available (at the time) ground water and geotechnical information. Observational data includes locations of ground cracking and liquefaction ejecta, and property damage data was also considered. Together, this data informed the technical guidance developed and published by the MBIE to support the repair and rebuild of residential property following the CES. The following paragraphs summarise how this process eventually led to the current LMA overlay in the District Plan.

MBIE "Technical Categories"

22. Following the CES, based on the data described in the previous paragraph, residential areas on flat land were either "red zoned" (i.e., deemed not suitable for residential development) or assigned a "technical category" (**TC**). The MBIE mapping included non-categorised areas (rural, urban non-residential, Port Hills and Banks Peninsula, and unmapped areas) and three technical categories in order of increasing liquefaction susceptibility (**TC1, TC2, TC3**). The TCs were established to support the post-EQ recovery of residential areas, by clarifying repair and reconstruction options based on liquefaction information *available at the time*. The TCs are largely based on a qualitative assessment that considers both the level of liquefaction experienced during the CES, and future performance expectations. The aim of establishing the TCs was to focus geotechnical investigations to where they were most needed following the CES, and to provide guidance on appropriate foundation solutions. The TCs are referred to extensively in the MBIE technical guidance, "Repairing and rebuilding houses affected by the Canterbury Earthquakes" (published December 2012, last updated May 2018).

23. The TCs were intended to help guide repair and rebuilding of residential properties following the CES. It was anticipated in the development of the MBIE guidance, that over time the TCs would become less relevant/useful as additional data from more detailed ground investigations and liquefaction assessments became available. The liquefaction hazard in the Christchurch urban area is now covered by the LVC map which is based on much more, and more accurate data. The "MBIE Technical Categories" map on 'Canterbury Maps' notes that the many more detailed subsurface investigations that have been completed (since the TCs were established) *enables appropriate foundations to be designed for future new building work without necessarily using the technical categories as a starting point.* Much of this newer data is available at the New Zealand Geotechnical Database (**NZGD**).

24. Based on the limited (and qualitative) data that went into developing the TCs and the guidance around their application, the TCs are not an up to date hazard map. Nevertheless, the MBIE guidance provides useful information on how to manage the liquefaction hazard on residential land, and the TCs provide a high-level indication of where there may be soils that are susceptible to liquefaction, based on the information that was available

at the time (i.e., prior to about 2012). TCs are still used as a starting point for determining residential foundation requirements (in conjunction with the published MBIE guidance) on specific parcels of land. TCs are still used during detailed design and are still referenced in geotechnical reports provided to the Council as part of consent applications. The recommendations provided in the MBIE technical guidance (2012) regarding investigation methods, liquefaction assessment and associated design recommendations are still relevant. However, it is my opinion that the TCs should not be used as a liquefaction hazard map. There is now much more relevant information incorporated into the LVC map.

University of Canterbury "Liquefaction Resistance Index"

25. The same general information that informed the TCs was further assessed by University of Canterbury researchers, who developed a map of "Liquefaction Resistance Index" (**LRI**) zones. The LRI is a semi-quantitative assessment of ground susceptibility to liquefaction, based on liquefaction observations following the CES, and ground water depth information. The results of this study were published by the University of Canterbury (Cubrinovski & Hughes, 2014), and included mapping of five representative zones of LRI throughout the Christchurch urban area (i.e., not just residential areas as per the TCs). The LRI map was included in the referenced paper as Appendix 8.

26. The LRI was referenced in several chapters in the previous version of the Infrastructure Design Standard (**IDS**), as it facilitated a basic assessment of soil resistance to liquefaction based on specific location. This was a useful planning and design tool for high-level assessment of the likely impacts of soil conditions on public infrastructure projects. However, the LRI has now been superseded by the LVCs mapping that is now available via Canterbury Maps. The current IDS references the LVCs (not the LRI). See below for more information on the LVCs.

The LMA hazard overlay in the District Plan

27. The liquefaction observation data that informed the TC and LRI mapping also appears to have formed the basis (supplemented with some additional "ground truthing") for the Liquefaction Assessment Areas 1 & 2, (**LAA1**, **LAA2**) that were originally considered during the IHP. During the IHP process LAA2 was considered to not require a hazard overlay, and only the LAA1 was included in the District Plan. The LAA1 included in the District

Plan now forms the LMA that is being proposed under PC14. This effectively means that the LMA is not based on the most recent or accurate liquefaction information (see discussion on LVC below).

Christchurch City Council "Liquefaction Vulnerability Category" map (LVC)

28. In July 2020, Tonkin & Taylor completed the (Council commissioned) . This report forms the basis for the current and interactive viewer that is available on Canterbury Maps. Derivation of the LVC map follows the most recent (2017), utilising a standardised assessment methodology, and based upon all the relevant geotechnical data available at the time, including:

    (a) Ground investigation data from the NZGD;

    (b) Land damage observations following the CES;

    (c) The latest scientific understanding of liquefaction processes;and

    (d) The latest geology and groundwater mapping.

    In addition to the post-EQ observational data that the TCs were based on, the LVC assessment also incorporates data from thousands of ground investigations (primarily Cone Penetration Testing (**CPTs**)). The assessment that underpins the LVC map is a quantitative liquefaction analysis of all available geotechnical investigation data (CPTs) and their spatial distribution. The LVC map represents a probabilistic distribution of liquefaction vulnerability across the entire Christchurch urban area. The results are combined into six categories, depending on likelihood of liquefaction, as well as model precision (generally areas with less data points have lower certainty compared to areas with more data points). The LVC map is the most up-to-date liquefaction hazard map and is based on the latest data available (as of publication date). However, it does not interpret the data for any specific purpose (e.g. planning, consenting, IDS), and is therefore not suitable to supersede the TCs or replace the LMA hazard overlay in the District Plan.

Assessment of appropriateness of LMA proposed in PC14:

29. In my opinion, the TCs are not an accurate hazard map because they are not based on the most recent liquefaction vulnerability information. They are not therefore a suitable basis for strategic land-use decisions.

30. The LMA hazard overlay is not based on the most recent liquefaction vulnerability information and is almost certainly not an accurate representation of the hazard at higher resolutions (i.e., individual neighbourhoods down to specific sites). For these higher resolution liquefaction hazards, the LMA has now largely been superseded by the LVC map.

31. The LVC map is strictly a hazard map, therefore in isolation it does not provide any context for planning purposes.

32. Because of these factors, none of the LMA hazard overlay, TCs or the LVC map are appropriate planning tools, and are not therefore appropriate QMs to be included as part of PC14.

Recommendations

33. In light of my conclusions set out above, in my opinion, the current LMA hazard overlay in the District Plan which is proposed to be carried over into PC14 should be updated/replaced to reflect the latest understanding of the liquefaction hazard. Consideration should be given to updating the District Plan to reflect the LVC assessment, which currently contains enough data across much of the Urban Christchurch area to differentiate between locations with “high” or “medium” liquefaction vulnerability, from areas where there is less certainty due to lower density of data (i.e., where liquefaction damage is “possible”). In other words, a revised LMA overlay could potentially include three hazard levels (***high, medium and possible***) with appropriate planning rules for each hazard level. This would be similar to the current slope hazard overlays (e.g., Mass Movement Areas 1, 2 and 3) in the District Plan.

Conclusions

34. In my opinion there are currently no appropriate liquefaction-related QMs in the District Plan that are appropriate to pull over into PC14. If the current LMA hazard overlay was updated as described above, then it is *possible* that the new hazard overlay, where it reflects a “high” liquefaction vulnerability would be an appropriate QM. However, determining whether this is the case would require significant testing to determine if areas that are within the “high” vulnerability area are in fact generally not suitable for intensification. In my opinion the amount of additional geotechnical

assessment required to test this sufficiently is substantial and would probably take several months or more to complete.

35. Liquefaction hazard does not preclude multi storey development. However, foundation design in areas of high liquefaction vulnerability for buildings four storeys or over would likely need specifically designed deep ground improvement. This could have wider implications, including cost, planning considerations and constructability concerns which may render the development unfeasible. The scale of the deep ground improvement may have a greater impact on the surrounding area compared to buildings of three storeys or less.

SLOPE INSTABILITY (5.6) – ARE THE SLOPE INSTABILITY MANAGEMENT AREAS APPROPRIATE QMS?

Current Slope Instability Management Areas

36. I note that the proposed QM for Slope Instability Management Areas (**SMAs**) includes only Cliff Collapse Management Area1 (**CCMA1**), Cliff Collapse Management Area 2 (**CCMA2**) and Rockfall Management Area 1 (**RMA1**).

37. The SMAs in the District Plan are based on "area-wide" Annual Individual Fatality Risk (**AIFR**) mapping completed by GNS Science and supplemented with ground truthing and observations by the Port Hills Geotechnical Group (**PHGG**). This area-wide (sometimes also referred to as "suburb level) risk mapping is based on several assumptions, including the likelihood of the hazard, which is influenced by:

    (a) area-wide rockfall/debris production rates observed during the CES;

    (b) modelled energy and runout distance based on "averaged" values for the representative slope (i.e., not site specific);

    (c) the amount of time spent exposed to the hazard and probability of a person being in the path of the hazard during an event; and

    (d) vulnerability (probability of death) of a person who is impacted by the hazard (i.e., rockfall, cliff collapse or mass movement).

38. The CCMA1 and CCMA2 overlays represents areas of very high AIFR, at least two orders of magnitude and one order of magnitude (respectively) greater than the maximum acceptable risk threshold adopted in the current

District Plan (i.e., AIFR <10^{-4}). The RMA1 overlay is also reflective of a relatively high level of risk, based on the GNS methodology (AIFR >10^{-4} at 67% occupancy rate). During the IHP process, there was broad agreement amongst experts thatarea-wide risk assessment and associated ground truthing would not be as effective as site-specific ground truthing. It was resolved that it would be beneficial to leave a route available to individual landowners to have their site-specific AIFR re-assessed, with the potential outcome that their land could be certified as at a lower risk and able to be relieved of associated subdivision, land use and development restrictions (i.e., via AIFR Certification, see next paragraph).

AIFR Certification

39. AIFR Certification is a process in the District Plan (5.6.1.2 Exceptions to Rule 5.6.1.1), that is only available within the "lower risk" slope hazard areas; these are Rockfall Management Area 1 (**RMA1**), Rockfall Management Area 2 (**RMA2**) and Cliff Collapse Management Area 2 (**CCMA2**).

40. The purpose of certification is to provide a pathway for individual landowners to be able to recalculate rockfall or cliff collapse risk on a site-specific basis through an independent and peer-reviewed risk assessment that shows that their land is subject to lower slope hazard risk compared to the area-wide AIFR that the current District Plan hazard overlays are based on. I note that in isolation, AIFR Certification is not sufficient to change the current hazard overlays (this would require a plan change), and that certification is temporary (AIFR Certificates are valid for 2 years).

41. The current hazard overlays are based on area-wide AIFR assessments with several underlying assumptions, including rockfall production rates and runout distances. These area-wide risk models are representative of general slope conditions and precedent performance (during the CES) of a number of larger slopes around the Port Hills and Lyttelton area, *but they do not take into account site specific conditions* such as:

   (a) topographic forcing or natural barriers that aren't accounted for in the area-wide risk model;

   (b) less credible hazard source areas (e.g., borderline steep i.e., ~35-40° slopes); and

(c) lower rockfall/debris production rates compared to the area-wide risk model.

42. Given that site specific hazard conditions are not necessarily accounted for the area-wide AIFR calculations, there will be uncertainties in the area-wide AIFR values for any specific site.

Existing Hazard Mitigation Works

43. AIFR Certification was established as a pathway to incorporate site specific hazard conditions into the risk assessment for an individual property, without necessarily requiring resource consent. Certification was not intended to consider existing hazard mitigation works, because while those can (at least temporarily) reduce the risk, they do not remove the hazard itself.

44. Some landowners in the Port Hills have previously sought the removal of slope hazard overlays (from the District Plan planning maps) where they affect certain properties. Reasons cited for removal include the presence of existing rockfall protection structures or other mitigation (including the presence of vegetation as potential mitigation against rockfall hazards).

45. Some slope hazards can be completely *removed* (***hazard removal***); for example, a small rock outcrop source area may be able to be cut back to the same angle as the overall (stable) slope so that there is no credible source area for rockfall. Situations where this is possible are relatively rare, however, I can think of two locations where this has been done successfully (in the Avoca Valley and Bowenvale Valley). In these specific locations hazard removal was possible because there were limited source area outcrops (rather than continuous or semi-continuous bluffs as are typical on steeper and/or higher slopes).

46. Most rockfall hazards cannot be permanently removed, but the associated risk may be effectively mitigated with engineered structures like bunds, catch benches, rockfall fences, mesh drapes or other barriers. These are commonly referred to as *passive* rockfall protection – that is they allow rockfall to occur in a controlled manner. There are also *active* rockfall protection measures that prevent rockfall from occurring in the first place – these may include scaling or direct bolting and/or meshing of source areas.

47. The problem with relying on any of these hazard mitigation measures for *long-term* risk reduction is that they do not remove the hazard itself, they

just mitigate the consequences. They also have a finite lifespan where they are effective, and over longer periods of time the risk may vary due to a range of factors, including:

(a) Changing seismic activity (the AIFR is typically based on the long-term average);

(b) Changing weather conditions (for example due to climate change), or other environmental changes (e.g., fire leading to loss of trees and/or increased slope instability);

(c) Changes to the local groundwater flow regime, perhaps due to new upstream development/infrastructure or natural changes;

(d) Physical mitigation works typically have a limited effective lifespan due to such factors as:

    (i) Corrosion of bolts, cables, mesh etc.; and

    (ii) Loss of capacity of a structure to capture material (e.g., a catchment area partially fills up with debris, or a barrier is subject to high energy impact).

48. This means that hazard mitigation works cannot be relied upon to reduce the associated life safety risk over medium-to-long periods of time (decades or longer) without detailed engineering design, certification and ongoing maintenance – in my experience the maintenance of these structures is commonly neglected to the point where they are no longer effective.

Conclusions on slope instability

49. For the reasons detailed above, it is my opinion that existing slope hazard mitigation works should not be considered an appropriate basis for creating an additional slope SMA overlay. They do not remove the actual hazard.

50. It is also my opinion that the existing SMA overlays (CCMA1, CCMA2 and RMA1 only) are appropriate QMs for PC14, for the following reasons:

(a) The CCMA1, CCMA2 and RMA1 hazard overlays represent areas that are subject to high levels of risk (i.e., AIFR significantly greater than 10^{-4}), based on the GNS methodology,

(b) Any intensification within these already high-risk locations would only increase the risk that someone could be injured or killed by rockfall or cliff collapse in the future,

(c) The hazards are generally not able to be removed. Hazard mitigation works (where possible) may temporarily reduce the risk, but will not remove the hazard.

51. Therefore, I consider that sites within these overlays are not suitable for intensification.

CONSIDERATION OF EVIDENCE FROM SUBMITTERS - FORMER "TECHNICAL CATEGORIES" AND/OR LIQUEFACTION HAZARD

52. With respect to liquefaction hazards (including associated land damage like lateral spreading) as potential QM controls, there are three main groups of submissions:

(a) Consideration of liquefaction risk as a QM;

(b) Requirement of additional geotechnical investigations as a QM control; and

(c) Consideration of earthquake risk as a QM in areas prone to liquefaction.

53. Individual submissions under each of these three categories are discussed briefly in the following paragraphs and I provide my response accordingly.

Consideration of liquefaction risk as a QM:

54. Submissions raising concerns in relation to this issue include:

(a) S54.2, S54.8 – Shirley van Essen seeks that TC3 land remain zoned Residential Suburban, due to "high liquefaction risk".

(b) S246.4 – Robert Black seeks that TC3 land is included as a QM.

(c) S255.5, S255.6 – William Bennett seeks that TC3 land is included as a QM.

(d) S440.5 – Sandi Singh seeks that both TC2 and TC3 land are considered.

(e) S779.1 – Glenda Duffell seeks that medium-density development is not progressed on TC2 or TC3 land.

(f) S868.3 – Maureen Kerr seeks that liquefaction risk is addressed.

(g) S898.2 – Denis McMurtrie seeks to retain the Residential Suburban zone in South and East Harewood Road and Main North Road around Paparoa Street Strowan due to peaty soils and concerns with sinking land and poor drainage.

(h) S902.7 – Waipuna Halswell-Hornby-Riccarton Community board seek that land stability and the height of the water table are considered.

55. The rationale for seeking these changes to PC14 is that intensification may not be appropriate in areas where the ground is subject to liquefaction damage. For sites where ground conditions are poor, building taller than two stories or significantly increased site coverage (e.g. due to additional dwellings) may increase the risk of building damage during a liquefaction-inducing earthquake. The MBIE TC areas are based on liquefaction observations following the CES, with TC2 and TC3 land considered to be subject to the highest liquefaction risk based on information available at the time.

56. In my opinion, liquefaction risk is not currently defined well enough in the District Plan to be use as a QM. As described in more detail in my evidence above, none of the current LMA hazard overlay, TCs or the LVC map are appropriate QMs for PC14. A new hazard overlay based on the LVC map could possibly be added to the District Plan, along with appropriate planning rules.

Requirement of additional geotechnical investigations as a QM control:

57. Submissions raising concerns in relation to this issue include:

(a) S707.2 – Isobel Foyle seeks that council commission a "study of how suitable the land in Christchurch actually is for housing higher than two stories".

(b) S763.1 – Christina Stachurski seeks that geotechnical investigation reports are undertaken for all suburbs before PC14 takes effect.

(c) S902.5 - Waipuna Halswell-Hornby-Riccarton Community board seek that technical assessments are undertaken on “citywide geotechnical stability”.

58. The rationale for seeking these changes to PC14 is that there may be areas within Christchurch where intensification is not appropriate due to unsuitable ground conditions, and that additional geotechnical assessments are required to better understand existing ground conditions.

59. In my opinion, a requirement for new geotechnical investigations as a QM control is not practical, or necessary. The ground conditions beneath much of urban Christchurch have previously been investigated to a fairly high level. As described in more detail above, the new LVC map is based on a large amount of recent geotechnical investigation data, which together with post-CES observations of land damage and new investigations (where required) can be used to generate reasonably accurate ground stability models that are sufficient for most planning purposes.

Consideration of earthquake risk as a QM in areas prone to liquefaction:

60. Submissions raising concerns in relation to this issue include:

(a) S778.1, S778.2, S778.3 – Mary O’Connor seeks to include earthquake risk as a QM.

(b) S794.2, S794.3, S794.8 – Greg Partridge seeks that a QM is applied to South Richmond due to earthquake risk.

(c) S867.1 – Robina Dobbie seeks to include a QM in the CBD and other vulnerable areas for managing natural hazards due to earthquakes, especially the Alpine Fault.

(d) S902.3, S902.4 - Waipuna Halswell-Hornby-Riccarton Community board seek that the effects of the Canterbury Earthquake Sequence (CES) be regarded as a QM for the whole city, or at least TC3 land.

(e) S1086.1 – Christian Jordan is opposed to increased height limit of buildings given that Christchurch is on an “aquifer flood plain” and subject to earthquakes.

61. The rationale for seeking these changes to PC14 is that intensification may not be appropriate in areas that experienced land damage following the CES. This is similar to the rationale for including liquefaction risk as a QM),

except that the specific type of land damage is not limited to liquefaction. I note that earthquake-related land damage could include slope instability such as rockfall, cliff collapse and landslides (even on gentler slopes). Therefore, a QM related to general earthquake risk would have to include areas outside of the LMA in the current District Plan.

62. In my opinion, consideration of "earthquake risk" as a QM for "flat" land (i.e. outside of the SMAs in the current District Plan) is effectively the same as consideration of liquefaction/lateral spreading risk. For most "flat" land (unless directly over a fault rupture) it is the liquefaction/lateral spreading that is the actual hazard associated with an earthquake event. Therefore, the same comments apply as above.

63. For consideration of slope instability risk as a QM for areas within SMAs in the current District Plan, refer to my evidence in Sections B and D.

CONSIDERATION OF EVIDENCE FROM SUBMITTERS – SMA QMS

64. With respect to the proposed SMA QMs, submissions generally fall into two categories:

(a) Consideration of creating an additional hazard overlay to account for existing hazard mitigation works, and

(b) Consideration of erosion risk as a QM. Individual submissions under each category are discussed briefly in the following paragraphs.

65. I note that the first category (additional overlay for hazard mitigation works) is possibly outside the scope of PC14 but defer to Council planners on that matter.

Seek additional overlay in the District Plan slope instability management areas to account for hazard mitigation works (e.g. rockfall protection structures):

66. Submissions raising concerns in relation to this issue include:

(a) S231.1 – Phil Elmey seeks that council adopt the Building Code guidance document for design of passive protection structures as an acceptable method of reducing rockfall hazard on a site-specific basis.

67. S231.1 appears to refer to the document published as Rockfall: Design considerations for passive protection structures. While a useful design guidance for passive rockfall protection structures (and currently referenced in the IDS), in my opinion adopting the document is not an acceptable method for reducing site-specific rockfall hazard. As described in more detail in previous sections of my evidence, passive rockfall protection may reduce the short-term risk, but the actual hazard remains.

68. Submission S240.1 – Ruth Dyson seeks an additional slope hazard overlay that identifies specific homes that have had rockfall protection structures constructed.

69. As described in previous sections of my evidence, existing hazard mitigation works (including rockfall protection structures) are not an appropriate basis for an additional slope hazard overlay, because the hazard itself remains.

70. Submission S368.1 – Karen Theobald seeks removal of Point 7, Clause 5.6.1.2 of the District Plan, and suggest replacing it with a new hazard overlay that identifies properties (or parts of properties) where the rockfall risk has been mitigated.

71. I note that "Point 7" is the reference at the end of paragraph *5.6.1.2 a.i., Exceptions to Rule 5.6.1.1 – AIFR Certificate.*

Point 7 states:

> *"The calculation shall not take account of hazard mitigation works."*

This refers to the calculation required to support the AIFR Certification process.

72. My previous response on Ruth Dyson's submission (S240.1) is equally applicable here. For the reasons discussed above, a new hazard overlay is not appropriate because the hazard itself is not removed.

73. In my opinion, Point 7 should not be removed from 5.6.1.2 because AIFR Certification, by design, is intended to consider only the long-term risk (i.e., without mitigation measures).

Consideration of erosion risk as a QM:

74. Submissions, S689.75, S689.76 and S689.77 – Environment Canterbury (**ECan**) seeks new QMs for SMAs, that take into account Trangmar's erosion classes and exclude "severe" erosion class land from further subdivision and development.

75. In my opinion, intensification of hillside land that is subject to "severe" erosion hazard may not be appropriate (at least not without significant erosion mitigation measures). There is a clear link between slopes that are subject to instability (e.g., landslides or rockfall) and high levels of erosion, and I would consider hillside erosion to be a form of "slope instability." I note that landslides and other forms of slope instability tend to cause high levels of soil erosion and sedimentation, and that slopes that are subject to erosion are more likely to experience other forms of instability (landslips, rockfall etc).

76. Consequently, I do not think that the suggested new QM (i.e., severe erosion class areas within current SMAs) is necessary given that current District Plan policies (e.g., 5.2.2.1.1, 5.2.2.1.2, 5.2.2.1.4) that would apply around the existing SMAs should be sufficient to avoid any potential increase in risk due to slope instability (including erosion). In other words, Chapter 5 – Natural Hazards would tend to restrict any subdivision or development where there is likely to be increased risk, or transfer of risk due to hillside erosion.

77. Submissions S154.1 and S154.2 - Ōpāwaho Heathcote River Network (OHRN) seek to include a High Soil Erosion Risk area QM as indicated in the Land and Water Regional Plan.

78. While erosion on hillside land is relevant to my evidence (see my comments above) high erosion risk on non-hillside land is beyond the scope of my evidence.

CONCLUSION

79. In my opinion, there are no appropriate liquefaction-related QMs for PC14 in the current District Plan. Consideration should be given to developing a new hazard overlay based on the current LVC map.

80. I also consider that the SMA-related QMs for PC14 are appropriate, because the life safety risk within CCMA1, CCMA2 and RMA1 is currently unacceptably high, and the hazards cannot be removed.

Date: 11 August 2023

Dr. Jesse Leif Dykstra