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 MARIE-CLAUDE HEBERT ON BEHALF OF CHRISTCHURCH CITY COUNCIL

GEOTECHNICAL MATTERS - SPECIFIC PURPOSE ŌTĀKARO AVON RIVER CORRIDOR ZONE

Dated: 11 August 2023

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EXECUTIVE SUMMARY

1. My full name is **Marie-Claude Hébert.** I am employed as a Senior Geotechnical Engineer in the Engineering Services team of the Building Consenting Unit 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 Specific Purpose (Ōtākaro Avon River Corridor) Zone (**SPOARC**) qualifying matter (**QM**) arising from the submissions and further submissions on Plan Change 14 to the Christchurch District Plan (the **District Plan; PC14**).

3. I have previously prepared a memo[1] dated 30 January 2023 advising on the geotechnical suitability of the construction of three-storey structures at 254 – 256 Fitzgerald Ave and 5 Harvey Tce (the **Site**) indicated in **Figure 1** below.

Figure 1 Area of 254 & 256 Fitzgerald Avenue and 5 Harvey Terrace. Note the Avon River located to the west of Fitzgerald Avenue.

4. In my memo I concluded that in my opinion, development up to three storeys would be feasible from a geotechnical perspective so long as there are specifically designed foundations taking into account the liquefaction hazard

[1] Appendix 42 of the Section 32 Report for PC14: PC14-HBC-Notification-Appendix-42-to-Section-32-QM-evaluation-Part-2-Geotechnical-Engineering-Memo.pdf (ccc.govt.nz)

at the Site and there is input from a suitably qualified geotechnical engineer/engineering geologist during the building consent stage.

5. Foundation design for buildings with four to six storeys would likely need specifically designed deep ground improvement, which could have wider implications, including cost, and constructability concerns. 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. There are no PC14 submissions raising issues specifically related to the geotechnical conditions on the three properties within the Site which is the subject of this evidence. I therefore maintain my view as set out above in paragraphs 4 - 5.

INTRODUCTION

7. My full name is **Marie-Claude Hébert**. I am employed as a Senior Geotechnical Engineer in the Engineering Services team of the Building Consenting Unit at the Council. I have been working in the field of geotechnical engineering for over 16 years.

8. In preparing this evidence I have:

   (a) Reviewed publicly available geological and geotechnical information for the Site;

   (b) Reviewed the geotechnical report by Geotech Consulting Ltd dated 23 February 2021 provided with an application for Private Plan Change 11[2] (currently on hold);

   (c) Reviewed information in email format dated 12 December 2022 from Ms Jesse Dykstra, Principal Geotechnical Advisor at the Council who reviewed the geotechnical report by Geotech Consulting Ltd (attached as **Appendix A**);

   (d) Reviewed the proposed provisions in sub-chapter 13.14 of PC14 concerning the SPOARC QM;[3]

[2] Plan Change 11 - https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan/changes-to-the-district-plan/proposed-changes-to-the-district-plan/plan-change-11/
[3] Proposed Housing and Business Choice Plan Change (Plan Change 14) Plan-Change-14-HBC-NOTIFICATION-Sub-chapter-13.14-Specific-Purpose-Otakaro-Avon-River-Corridor.pdf (ccc.govt.nz)

(e) Reviewed section 6.23 in Council's section 32 Qualifying Matters report (Part 2) for PC14 relevant to the SPOARC QM;[4] and

(f) Reviewed the Council's draft 42A report on QMs related to Open Space Zones and the SPORAC and (Cemetery) Zones.

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

QUALIFICATIONS AND EXPERIENCE

10. I hold the qualifications of BSc. (Hons) with a Major in Geology (Earth and Planetary Sciences). My honours thesis was in seismology and physical volcanology and was supervised by Professor John Stix.

11. I have been employed as the senior geotechnical engineer in the Engineering Services team of the Building Consenting Unit since 2021 but I have been conducting building and resource consent reviews of geotechnical reports for commercial and residential developments for the consenting and compliance team since 2013.

12. Prior to joining the Council, I spent 10 years working as a consultant at Golder Associates focusing on geotechnical assessments for the rebuild of Christchurch following the 2010-2011 Canterbury Earthquake Sequence and the Canterbury region following the 2016 Kaikōura Earthquake.

13. I have expertise in geotechnical investigation methods especially cone penetration testing, and the analysis methods used to assess liquefaction potential. My experience includes managing the geotechnical investigations, analysis and reporting as well as undertaking geotechnical designs for the stabilisation of liquefaction prone soils using a variety of ground improvement methods.

14. I have been trained by the Ministry of Business, Innovation & Employment (**MBIE**) to undertake Rapid Building Assessments under Emergency Management situations. I am an MBIE accredited (2018) and Council authorised Rapid Building Assessor (for geotechnical aspects).

15. I am a member of Engineering New Zealand and New Zealand Geotechnical Society.

[4] Plan Change 14, Section 32 Report: Part 2 – Qualifying Matters (Part 3). Plan-Change-14-HBC-NOTIFICATION-Section-32-Qualifying-Matters-Part-2.pdf (ccc.govt.nz)

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. 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

17. My statement of evidence addresses the following matters:

    (a) Provides a summary of the publicly available geotechnical mapping and information from GNS and the Christchurch Liquefaction Information website[5] for the Site;

    (b) Summarises the results of the geotechnical assessment report provided by Geotech Consulting Ltd[6];

    (c) Comments on the consenting considerations from a geotechnical perspective for one to three storey development (enabled by the Medium Density Residential Zone (**MRZ**) rules proposed by PC14); and

    (d) Comments on the consenting considerations from a geotechnical perspective for four to six storey development (enabled by the High Density Residential Zone (**HRZ**) rules proposed by PC14).

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

19. As noted above, no submissions raising issues specifically related to the subject of my evidence has been received.

OVERVIEW OF SITE GEOLOGY AND GEOTECHNICAL ENVIRONMENT

20. Geological mapping by GNS[7] shows the Site as being located on a fluvial interchannel trough or flat, part of the Yaldhurst member of the Springston Formation with a surface geology typically of alluvial sand and silt. The Site

[5] Christchurch Liquefaction Information (canterburymaps.govt.nz)
[6] Appendix-2-Geotechnical-Report.pdf (ccc.govt.nz)
[7] Begg, J. G., Jones, K. E., & Barrell, D. J. (2015). Geology and geomorphology of urban Christchurch and eastern Canterbury. GNS Science Geological Map 3. Lower Hutt: GNS Science

is located in the former Red Zone with TC3[8] sites to the North and East. The Site is in an area mapped as having "high liquefaction vulnerability", as shown on the Council's liquefaction vulnerability map[9]. EQC extensively mapped the liquefaction and lateral spreading that occurred during the 2010-2011 Canterbury earthquakes. The Site is mapped as having experienced no observed liquefaction damage as a result of the 4 September 2010 earthquake, moderate liquefaction damage as a result of the 22 February and 13 June 2011 earthquakes and minor liquefaction damage as a result of the 23 December 2011 earthquake.

21. A previous desktop assessment of the area by Ms Dykstra (CCC Principal Advisor, internal email dated 12 December 2022 attached as **Appendix A**) has identified that the Site is partially protected from the effects of liquefaction/lateral spreading by the post-earthquake palisade wall along the opposite side of Fitzgerald Avenue.

GEOTECHNICAL REPORT BY GEOTECH CONSULTING

22. A geotechnical assessment report by Geotech Consulting[10] (dated February 2021) has been provided to the Council in support of a private plan change request for the Site (**PC11**). The Geotech Consulting report assesses a proposed subdivision with two-storey residential buildings of light-weight construction at the Site. The assessment was informed by publicly available data from the NZ Geotechnical database and geotechnical investigation data including from boreholes, cone penetration testing, hand-augered boreholes and dynamic cone penetration testing.

Summary of Ground Conditions

23. The Geotech Consulting report summarised the ground conditions on the sites at 254-256 Fitzgerald Avenue/5 Harvey Terrace as shown in **Figure 2**.

[8] Technical Category 3 (TC3) means that moderate to significant land damage from liquefaction is possible in future significant earthquakes. Site-specific geotechnical investigation and specific engineering foundation design is required.
[9] Christchurch Liquefaction Information (canterburymaps.govt.nz)
[10] Geotech Consulting Ltd, Subdivision of 254-256 Fitzgerald Avenue Richmond Christchurch, Geotechnical Assessment Report - https://ccc.govt.nz/assets/Documents/The-Council/Plans-Strategies-Policies-Bylaws/Plans/district-plan/Proposed-changes/2022/PC11/Appendix-2-Geotechnical-Report.pdf

Depth to top surface (m)	Thickness (m)	Description
0	0.4 to 0.8	Historic fill, buried topsoil in places.
0.4 to 0.8	≈ 5 (up to 9m in CPT04)	Interbedded silts and sands – generally loose and soft with some very soft clayey layers
≈ 5	≈ 6	Medium dense sands and silty sands. With some siltier lenses (eg at -4m RL in CPT002)
10 to 12	1.5 to 3	Very soft silts and clayey silts
13 to 15	8 to 10 m	Dense to very dense sands – becoming silty with depth
22.5	0.5	Clayey silts – aquifer capping layer
23	≈ 18	Riccarton gravels aquifer (from Borehole_1740)

Figure 2 Generalised soil profile at the Site. Table taken from Geotech Consulting report.

Results of Liquefaction and Lateral-Spread Assessment

24. The Geotech Consulting report states that the Site has been 'sufficiently tested' to a serviceability limit state (**SLS**[11]) earthquake during the 2010-2011 Canterbury Earthquake Sequence, and the February 2011 earthquake is likely to have produced liquefaction approaching that of an ultimate limit state (**ULS**[12]) event. Due to the Site having been "tested" to an SLS earthquake, the observations of performance during the Canterbury Earthquakes can be relied upon to predict future performance.

25. The Geotech Consulting report assessed the liquefaction potential according to the methodology outlined by MBIE[13]. Estimated liquefaction induced settlements on the site are 20 to 40 mm at a SLS earthquake and 80 to 150 mm at ULS earthquake for the upper 10m, increasing to 30-70 mm SLS and 160 to 210 mm ULS for the full soil profile, which are in line with a TC2[14]/TC3 hybrid[15] category. Lateral stretch risk is assessed as minor at SLS and minor to moderate at ULS, based on records of site performance in the Canterbury Earthquakes and the expectation of improved performance due to the stone column palisade wall built along Fitzgerald Ave at the river bank to the west of the Site.

[11] Serviceability Limit State (SLS), as defined by AS/NZS1170.0 (2002) is a State that correspond to conditions beyond which specified service criteria for a structure or structural element are no longer met. The SLS earthquake loads are determined as outlined in AS/NZS1170.0 (2002) and NZS1170.5 and consider the importance level of the structure.
[12] Ultimate Limit State (ULS) as defined by AS/NZS1170.0 (2002) is a state associated with collapse, or with other similar forms of structural failure. The ULS earthquake loads are determined as outlined in AS/NZS1170.0 (2002) and NZS1170.5 and consider the importance level of the structure.
[13] MBIE. (2012, December). Guidance on repairing and rebuilding houses affected by the Canterbury earthquakes. Ministry of Building Innovation and Employment.
[14] Technical Category 2 (TC2, yellow) means that minor to moderate land damage from liquefaction is possible in future significant earthquakes. You can use standard timber piled foundations for houses with lightweight cladding and roofing and suspended timber floors or enhanced concrete foundations.
[15] A hybrid classification, as per the MBIE guidance for repairing and rebuilding houses affected by the Canterbury earthquakes (2012) refer to some TC3 sites that 'straddle' the liquefaction settlement limits of TC2 and TC3, where the SLS settlements are assessed as being less than 50 mm, but the ULS settlements are assessed at greater than 100 mm.

RMA Section 106 Hazard Assessment

26. The Geotech Consulting report provides an assessment of natural hazards (as summarised in Table 4 of that report and shown in **Figure 3** below), as defined in Section 106 of the Resource Management Act 1991 (**RMA**). The hazard assessment identifies liquefaction as a potential hazard at the Site, however states that the proposed (two storey) development can be considered so long as it mitigates the risk from the liquefaction hazard by following t the MBIE guidance for repairing and rebuilding houses affected by the Canterbury earthquakes (2012). This is appropriate because the MBIE guidance provides recommendations for buildings up to two storeys in areas with liquefaction hazard.

Hazard	Current assessment	Post development assessment
Erosion	The site is close to the Avon River but is separated from the main channel by Fitzgerald Ave. As a major city thoroughfare we anticipate that Council will ensure that the river bank does not erode in this location	No change in risk.
Falling debris	The site is flat with no source area for falling debris.	No change
Subsidence	There is a liquefaction risk at the site which is likely to result in some subsidence in a future earthquake.	Building in accordance with the recommendations of MBIE for liquefaction prone sites will mitigate this risk.
Slippage	There is a risk of lateral spread associated with liquefaction and proximity to the Avon River, in a ULS earthquake	Development does not change this risk but building in accordance with the recommendations of MBIE for liquefaction prone sites will protect life in the event that some slippage takes place.
Inundation	The site is not in the CCC Flood Management Area	No change in risk

Figure 3 Assessment of RMA Section 106. Table 4 taken from Geotech Consulting report

Preliminary Foundation Recommendations

27. The Geotech Consulting report concludes that the only significant geotechnical hazard on the Site is related to liquefaction but that the Site can be considered as having TC2 /TC3 hybrid classification. Shallow ground improvement and shallow foundation systems are recommended for the two-storey development.

28. The Geotech Consulting report was reviewed by a Council Principal Geotechnical Advisor for the purpose of assessing completeness of information provided with PC11. The reviewing geotechnical advisor

generally agreed with the assessment that any of the site-specific geotechnical hazards should be able to be dealt with by appropriate foundation design and perhaps ground improvement where necessary, while acknowledging that the report assessed the Site's suitability for a lightweight two storey development proposal.

29. I also reviewed this report and consider that the methodologies were robust and in line with good engineering practice and the findings are therefore reliable.

30. Given the robustness of this report (as explained above) I agree with this conclusion.

ONE TO THREE-STOREY DEVELOPMENT

31. The Geotech Consulting report concludes that the Site is suitable for the two-storey light weight development that the PC11 applicant proposed.

32. In my memo I assessed the Geotech Consulting report and considered the potential residential development of up to three-storeys (as per the MRZ rules), discussed in more detail below.

33. In my opinion, the Geotech Consulting report's findings concerning the Site are robust and I consider that it can be relied on for informing the suitability of the Site for three-storey development and more detail is provided on this point in paragraph 35 below.

34. It is my view, based on the information provided in the Geotech Consulting report and the assessed ground conditions, that both two and three-storey development is feasible at the Site. However, Site specific geotechnical design aspects will need to be considered in detail at the consenting and detailed design stages.

35. In terms of a three-storey development, from a consenting point of view, I would require a similar geotechnical assessment report provided for the two-storey PC11 development proposal to be provided for three-storey development, however an additional matter must be considered. The liquefaction analysis must consider the potential effects of liquefaction beyond 10 m depth. This is because the MBIE guidance for repairing and rebuilding houses affected by the Canterbury earthquakes (2012) suggests a cut-off of 10 m depth in liquefaction analysis, and this guidance applies to single or two-storey dwellings only.

36. Further, for a three-storey development, the foundation designer would have to consider the serviceability and relevelability of the building following a SLS earthquake. This consideration may limit the size or complexity of the proposed building footprints, but this is typical for any residential development at sites with medium to high liquefaction severity.

37. In my opinion, development up to three storeys would be feasible in this area, so long as input from a suitably qualified geotechnical engineer/engineering geologist during the building consent stage is secured. In my view, specifically designed foundations taking into consideration the liquefaction hazard are required. Although additional considerations are required in the liquefaction analysis for three-storey buildings, specifically designed foundations in-line with the recommendations in the MBIE guidance (2012) are likely appropriate. I recommend that applicants request a pre-application meeting before lodging their building consent application for any complex geotechnical design or if they have concerns.

FOUR TO SIX-STOREY DEVELOPMENT

38. In my memo I also assessed the Geotech Consulting report and considered the potential residential development of up to and up to six storeys (as enabled by HRZ rules).

39. In my opinion, the Geotech Consulting report findings concerning the Site are robust and I consider that it can be relied on for informing the suitability of the Site for six-storey development. It should be noted, that additional geotechnical input would be required for specific design of foundations for development of buildings of four to six-storeys, as described in paragraph 40 below.

40. It is my view, based on the information provided in the Geotech Consulting report and considering the ground conditions at the Site, that development of up to six storeys at the Site may be feasible so long as detailed geotechnical analysis and design information is provided at the consent[16] stage. Foundation design for buildings with four to six storeys would likely need specifically designed deep ground improvement, which could have wider implications and constructability concerns. The scale of the deep ground improvement may have a greater impact on the surrounding area compared to buildings of three storeys or less. These impacts, including noise and

[16] Building Consent and potentially Resource Consent, if required under the District Plan rules.

vibration, large equipment on site, traffic disruptions, safety concerns, and dust and debris, must be defined at the consent stage. It is crucial for the design team to demonstrate the feasibility of the foundation solution and show that they will take necessary measures to minimize the impact of the construction activities before applying for building consent for buildings with four or more stories.

41. Four to six-storey buildings will have added structural considerations and may increase the complexity of the foundation design, potentially adding cost to the project and rendering it unfeasible. It is recommended to determine the potential cost implications early in the project. For buildings of four storeys or more in areas with liquefaction hazard, we would require a geotechnical peer review (PS2) to be provided at building consent. We would strongly advise a pre-application meeting for buildings over three storeys, especially in areas of high liquefaction vulnerability.

ANALYSIS OF SUBMISSIONS AND FURTHER SUBMISSIONS

42. There are no PC14 submissions referring to geotechnical conditions on the three properties within the Site that are relevant to the subject of this evidence.

CONCLUSION

43. In my opinion, based on available geotechnical information, the PC11 proposal to allow the construction of two storey buildings and any associated ground improvement at the Site is unlikely to have any adverse geotechnical impacts on the Site or the surrounding sites. Site specific geotechnical design aspects must be considered in detail at the consenting and detailed design stages.

44. Three storey buildings would be feasible on the Site, with specifically designed foundations taking into account the liquefaction hazard at the Site and with input from a suitably qualified geotechnical engineer/engineering geologist during the building consent stage.

45. Foundation design for buildings with four to six storeys would likely need specifically designed deep ground improvement, which could have wider implications, including cost, and constructability concerns. The scale of the deep ground improvement may have a greater impact on the surrounding area compared to buildings of three storeys or less.

Dated: 11 August 2023

Marie-Claude Hébert

APPENDIX A

From: Dykstra, Jesse <Jesse.Dykstra@ccc.govt.nz>
Sent: Monday, 12 December 2022 10:57 pm
To: Kleynbos, Ike <Ike.Kleynbos@ccc.govt.nz>
Subject: Risks of six storey development on Fitzgerald Ave_Geotech Review_JDykstra

Hi Ike,

I have completed my broad-brush assessment of the suitability of 20m high (6 storey) development within 3 privately-owned sites in the former "red zone" area in the Fitzgerald Ave/Harvey Tce and River Rd area (see map of site locations below).

For the purposes of this assessment, I have made the following assumptions:

- Site 1 (western end of Harvey Ave) is likely to be the most suitable (geotechnically) of the three sites for high density residential development; this is because Site 1 is a) partially protected from liquefaction/lateral spreading by the post-EQ-construction of the palisade wall along the west/opposite side of Fitzgerald Ave, and b) closest to the existing residential/red zone boundary.
    - These factors imply that the existing ground conditions at Site 1 may be significantly better (for residential development) compared to the other two sites,
    - This does not necessarily mean that Site 1 is actually suitable for high density residential development, at least without major ground improvement and/or enhanced foundation works (see comments below).
- If Site 1 is geotechnically "not suitable" for high density residential development (i.e. buildings up to 20m high) then the other two sites are unlikely to be suitable for same.

As you're aware, the assessment of "**very low life hazard risk**" (from liquefaction/lateral spreading) is based on geotechnical expert evidence provided by Clive Anderson during the independent hearings panel (IHP) process that informed the RDP:

7.25 In terms of liquefaction, on the basis of the evidence of Clive Anderson, it is my understanding that:

(a) liquefaction, including lateral spread/stretch, is a very low life hazard risk;

(b) there is land in the Recovery Zone that has similar liquefaction susceptibility to Green Zone land outside the zone ; and

(c) in a number of cases there are likely to be engineering solutions to deal with liquefaction issues on a site by site basis.

I agree with this assessment as it was completed at the time – i.e. considering the pre-EQ land use and zoning. However, I wonder whether Clive Andersons's conclusion would have been similar if he were considering up to 20m high buildings in the same location. I don't know for sure, but assume that he was not considering anything higher than two storey light-weight structures at the time. It may be worth following up with him on this.

The following is noted on page 11 of the DRAFT QM analysis attached to you original email:

The threshold for natural hazard risk in s77O(a) is based on s6 matters, with s6(s) specifying this as "significant risks from natural hazards". As concluded in RDP evidence, the three aforementioned privately owned sites within the Policy 3(c) walking catchment are unlikely to be exposed to any significant natural hazard risk captured in the RDP, and therefore could not be considered as a qualifying matter for natural hazard risks.

Based on my understanding of the first sentence in the paragraph above, **I don't think that s6(s) matters are referring to life safety risk only** – rather it appears to be referring to a more general definition of risk, which would presumably **include risk to property** (e.g. buildings) due to natural hazards. I could be wrong on this, but that is my current interpretation – perhaps someone could clarify this?

If that is the case, that would imply that although life safety risk was the main consideration for the IHP review, risk to buildings/property may be an *additional consideration* for s6(s). Which then wouldn't be in agreement with the yellow-highlighted text above – **in other words Clive Anderson concluded that there was "very low life hazard risk", but his assessment did not include a consideration of risk to property, nor did it consider that future development on the land could consist of structures up to 20m high.**

From a geotechnical perspective, the main risks usually associated with liquefiable soils in low density residential areas are around property and infrastructure damage. For example, within the former "red-zone" there may be a high risk of private property damage associated with lateral spreading, but there isn't necessarily a high life safety risk because the damage is unlikely to be catastrophic for low density residential housing (i.e. these buildings are unlikely to fully collapse). Something to consider when contemplating suitability of land for high density residential development, is that the life safety risk associated with a single-storey building being pulled apart by lateral spreading, could be much lower compared to that of a 6-storey building under similar seismic loading. Foundation failure in the former is not usually a major life safety risk, but would be an important consideration for designing much taller/heavier structures.

Note that I previously completed a high-level review of available geotechnical information for PC11 (i.e. Site 1), including the geotechnical assessment report (TRIM file 22/246600) provided by the applicant's geotechnical consultant (Geotech Consulting Ltd.). My comments included:

"I generally agree with the Geotech report assessment, that any of the site specific geotechnical hazards should be able to be dealt with by appropriate foundation design and perhaps ground improvement where necessary.

In my view geotechnical hazards aren't necessarily a reason to reject the plan change proposal. There may be existing legislation that requires CCC to take a negative view of any proposed plan change that would increase population density in areas that are currently subject to existing natural hazards? Certainly there is plenty of evidence that the area was subject to significant liquefaction and experienced quite a bit of lateral spreading during the CES, but the new (repaired) Fitzgerald Ave now provides an "engineered" buffer between the Avon and the proposed development. But technically, mitigating the geotechnical hazards at the site is quite feasible."

Note that this earlier assessment was based on the proposal at the time, which was for "new two-storey apartment blocks". If the proposal were for a 6-storey residential development, I almost certainly would have taken a different view – at least to the extent that additional geotechnical investigations (particularly deep investigations that confirm the presence of high-bearing-capacity strata) would be required. The NZGD does include some records in the vicinity of Fitzgerald Ave/ Harvey Tce, including a borehole to ~29m depth – this record indicates that dense gravels and sands (i.e. non-liquefiable material with good bearing capacity) were encountered below approximately 17m depth. This suggests that ground improvement and/or engineered foundations (including the option of a piled raft foundation) may be feasible in the general area, but much more detailed investigation would be required to confirm this, as well as what methods (if any) would be appropriate.

Conclusion:

In my opinion, existing ground conditions at Sites 1, 2 and 3 are not suitable for residential development up to 20m high – significant liquefaction effects (including lateral spreading) occurred during the CES in the area, due to the presence of liquefiable strata (typically loose silty sand) in the upper 10-20m of the ground profile and the proximity of the Otakaro/Avon River channel. Significant ground improvement and engineered foundations would likely be required to support future residential development, especially so for structures that are more than 2 stories high. Further detailed assessment of existing ground conditions would be required before an appropriate methodology can be designed. There isn't currently enough deep investigation data available to determine what ground improvement/foundation methods may or may not be suitable, or even feasible given a potential 6-storey building height.

I trust this information is useful – please let me know if you have any questions.

Jesse Dykstra | PhD, BSc (Hons)
Principal Geotechnical Advisor
Architectural & Structural Team
Technical Services & Design

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