**BEFORE INDEPENDENT HEARING COMMISSIONERS APPOINTED BY THE WAIMAKARIRI DISTRICT COUNCIL**

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|---|---|
| **IN THE MATTER OF** | The Resource Management Act 1991 (**RMA** or **the Act**) |
| **AND** | |
| **IN THE MATTER OF** | Hearing of Submissions and Further Submissions on the Proposed Waimakariri District Plan (**PWDP** or **the Proposed Plan**) |
| **AND** | |
| **IN THE MATTER OF** | Hearing of Submissions and Further Submissions on Variations 1 and 2 to the Proposed Waimakariri District Plan |
| **AND** | |
| **IN THE MATTER OF** | Submissions and Further Submissions on the Proposed Waimakariri District Plan by **Momentum Land Limited** |

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**EVIDENCE OF ANNA FRASER SLEIGHT**
**ON BEHALF OF MOMENTUM LAND LIMITED REGARDING STREAM 12 REZONING OF LAND**

DATED: 5 March 2024

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Presented for filing by:
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**INTRODUCTION**

1 My name is Anna Fraser Sleight.

2 I am a Geotechnical Engineer at Tonkin & Taylor Ltd.

3 I hold the qualifications of Bachelor of Civil Engineering with Honors from the University of Canterbury.

4 I have 30 years' experience in New Zealand and the United Kingdom within the Geotechnical Engineering sector. I am a Chartered Professional Engineer (CPEng) and a member of Engineering New Zealand (CMEngNZ) and New Zealand Geotechnical Society.

5 I have extensive experience in geotechnical engineering. I have worked on land development projects for private developers and government entities. I have worked on numerous building development projects, infrastructure projects and natural hazards assessments, including many assessments for EQC and private insurers following the Canterbury Earthquake Sequence. Recent projects I have been involved with include:

(a) Geotechnical design lead for projects completed under the NCTIR alliance umbrella, repairing the road and rail corridors following the Kaikoura earthquake.

(b) Geotechnical design lead for the Canterbury Museum Redevelopment project.

(c) Project Director for technical (geotechnical, contaminated land, stormwater) assessments of proposed redevelopment sites for Kainga Ora.

(d) Project Director or technical reviewer for solar farm developments in the Canterbury region.

(e) Geotechnical lead for Beach Road Estates Ltd undertaking geotechnical investigations, assessment and design of the Beach Grove subdivision located adjacent to the plan change area.

(f) I have also appeared before the High Court as an expert witness in the field of geotechnical engineering.

6 I am familiar with the area to which the application for plan change relates and have visited the site on several occasions.

7 I have read the Environment Court's Code of Conduct and agree to comply with it. My qualifications as an expert are set out above. The matters addressed in my evidence are within my area of expertise, however where I make statements on issues that are not in my area of expertise, I will state whose evidence I have relied upon. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in my evidence.

**SCOPE OF EVIDENCE**

8 In my evidence I address the following matters:

(a) The context of my evidence

(b) A summary of the proposal

(c) Summary of the geotechnical and geomorphological setting of the site

(d) A description of the assessment of potential geotechnical effects on the proposed development

(e) A description of proposed mitigation measures to address the potential geotechnical effects

**CONTEXT**

9 This evidence is in respect of a submission by Momentum Land Limited (**Momentum**) on the Waimakariri District Council (**WDC**) notified proposed District Plan and a submission by Momentum on Variation 1 to the Proposed Plan which allows for housing intensification in accordance with the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021.

10 Momentum's submission seeks to rezone two blocks of land from Rural Lifestyle to Medium Density Residential. The two blocks comprise of the following land parcels:

(a) "South Block": Lot 2 DP 83191, being 6.04 hectares of land at 310 Beach Road.

(b) "North Block": Lot 2 DP 4532, Lot 1 DP 5010 and Lot 5 DP 313322, totalling 28.5 hectares of land at 177 Ferry Road

11 The two blocks are identified on Figure 1 (highlighted in blue shade).

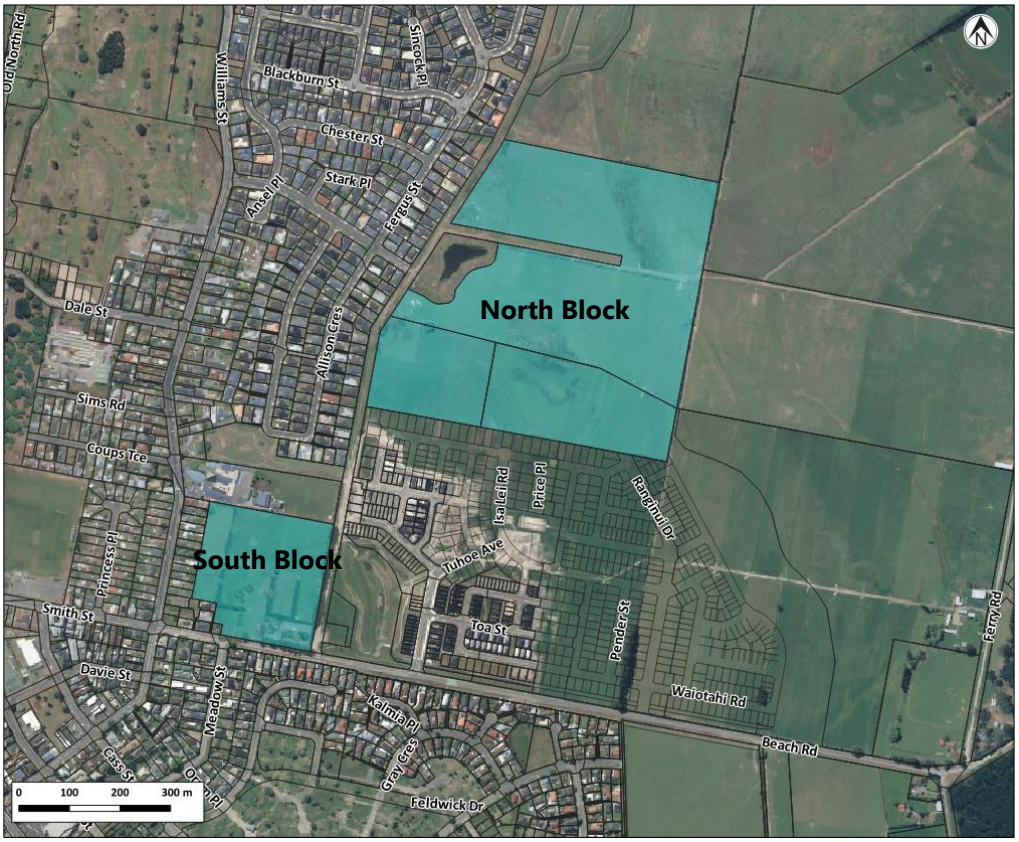



**Figure 1: Block location**

12 My evidence is in support of the rezone proposed by Momentum and covers aspects relating to geotechnical engineering.

13 In my evidence, I refer to the North and South blocks collectively as the "Site". Where a distinction between the blocks is necessary, I use the naming convention "North Block" and "South Block".

14 Throughout my evidence I refer to two geotechnical reports prepared on behalf of Momentum. I reviewed the draft versions of the reports and authorised the final version of the reports. These reports are:

(a) Momentum Land, Geotechnical report for proposed subdivision – North Block – for plan change application, May 2023, 1019317.1000R v3. I refer to this report in my evidence as **Report 1**.

(b) Momentum Land Living, Geotechnical report for plan change application, May 2023, 1019317.1000R v3. I refer to this report in my evidence as **Report 2**.

15 Report 1 relates to the North Block and is attached as **Appendix 1**. Report 2 relates to the South Block and is attached as **Appendix 2**.

**SUMMARY OF EVIDENCE**

16 The proposed development at the site is considered feasible from a geotechnical perspective.

17 The two key geotechnical related natural hazards for the site are considered to be earthquake-induced liquefaction and static settlement. Other geotechnical hazards are considered to either have a low likelihood of occurring or are unlikely to result in significant material damage to land or structures.

18 I consider that:

(a) Liquefaction-induced ground surface damage is expected to be within the criteria for TC2 type foundations and for Medium Liquefaction Vulnerability after compacted gravel fill is placed to 2.4 m (LVD).

(b) Settlement due to compressible silts is expected to be controlled to within design tolerances using mitigation measures such as preloading.

19 The likely subsequent use of the land is unlikely to accelerate, worsen or result in geotechnical related hazards.

**SITE INVESTIGATIONS AND GEOTECHNICAL ASSESSMENT**

20 I have undertaken site investigations and geotechnical assessment and analysis commensurate with the concept stage of the development. The level of investigation undertaken for the preliminary geotechnical report was aimed at site-wide, broad-brush coverage and was aimed at providing a general understanding of the likely ground conditions at the site. This assessment comprised a desk study assessment of available data, intrusive investigations comprising cone penetration tests (CPTs), a machine drilled borehole located on the South Block, laboratory testing on recovered samples, multi-channel analysis of surface waves (MASW) and ground penetrating radar (GPR). A

standpipe piezometer was installed in the borehole and monitored during preparation of the report. Based on the above information a ground model was developed for the site and analysis was undertaken to assess the liquefaction and lateral spreading hazard. Analysis was also undertaken to assess ground settlement, bearing capacity and potential foundation options.

21 Additional site investigations are expected to be undertaken to provide a more detailed assessment of the site ground conditions to support subdivision consent. This staged investigation approach and the density of investigations completed to date are in general accordance with recommendations in Section 2.4 of MBIE/NZGS Module 2. It is understood that the geomorphic conditions at the site means that ground conditions vary, but the coverage of the site investigations undertaken to support this plan change application provide an understanding of site conditions.

22 The geology of the Site comprises alluvial estuarine and coastal Holocene Age (from approximately 11,700 years ago to the present day) silt deposits of the Christchurch and Springston Formations. These formations comprise layers of interbedded river deposited alluvial gravel, overbank alluvial silt and freshwater swamp peat, coastal sand deposits and estuarine sand and silt deposits.

23 The depositional environments associated with the above are generally low energy, which results in layers of loose or soft soils of varying thickness. Soils that are loose or soft can, under certain conditions, be susceptible to liquefaction and associated lateral spreading, and consolidation settlement.

24 Preliminary ground models were developed for the North Block and South Block. These have been summarised as generalised soil profiles and can be found in Report 1 and Report 2 at Table 2.1. In summary, the preliminary ground models have been assessed as comprising:

(a) Layer 1a: Firm sandy SILT (topsoil). overlying

(b) Layer 1b: Soft to stiff SILT to sandy SILT, overlying

(c) Layer 2z: Very soft SILT with occasional sand laminations, overlying

(d) Layer 2a: Loose to medium dense SAND with occasional silt bedding, overlying

(e) Layer 2b: Dense to very dense SAND to gravelly SAND, overlying

(f) Layer 3a: Very dense GRAVEL.

25 Groundwater at the Site is shallow and during certain times of the year, artesian conditions may be present (ie the groundwater pressures may suggest an unconfined groundwater level higher than the ground surface). However, the near surface groundwater is confined or semi-confined below a silt layer (aquitard) present over the Site immediately below the topsoil. The silt layer (Layer 1b) thickness varies between 1.0 m and 3.0 m over the South Block and between 0.5 m and 2.0 m over the North Block, which keeps the groundwater suppressed below the base of this layer.

26 The intention of the geotechnical philosophy for the site is to maintain the aquitard for management of the groundwater and liquefaction effects. Therefore, the intention is to maintain the aquitard during land preparation. This methodology is similar to that adopted for design and development of the Beach Grove subdivision.

**Liquefaction and Lateral Spreading**

27 The seismic site subsoil class, as defined in NZS 1170.5:2004 Structural Design Actions Part 5: Earthquake Actions – New Zealand, has been assessed Class D (deep or soft soil).

28 Evaluation of the expected seismic performance of the site, including liquefaction effects, described in depth in Report 1 and Report 2.

29 I note that the AF8 scale earthquake event is not directly referenced in the assessment or future design but is accounted for in the seismic hazard factor adopted in determining the design PGA.

30 Satellite and aerial photographs taken following the 4 September 2010 earthquake event indicates evidence of moderate surface liquefaction ejecta across the South Block site, but largely concentrated in the south-eastern third of the site. On the North Block site there is evidence of moderate surface ejecta across the site.

31 Shaking intensity experienced by the North Block and South Block during the 4 September 2010 event were approximately 170% of SLS level shaking,

suggesting that the sites have been "sufficiently tested at SLS" according to Section 13.5.1 of the MBIE Guidance, Repairing and rebuilding houses affected by the Canterbury earthquakes (2014). This means that the assumption can be made that ground damage in a future SLS earthquake will be no worse than observed during the Canterbury Earthquake Sequence (CES), assuming no substantial changes to ground level or conditions at the site.

32 Based on experience gained during the CES and the various tools available for characterising and analysing the geotechnical nature of the soils underlying the North Block and South Block, the liquefaction susceptibility of each of the soil layers outlined in the geological models described in paragraph 16, is assessed to be:

(a) Layer 1a (topsoil) is not expected to liquefy.

(b) Layer 1b (sandy silt to silt) is considered to generally be susceptible to liquefaction. The interbedded nature of this layer means that there are liquefiable sand and silt mixtures interlayered between non-liquefiable (more plastic) silts.

(c) Layer 2a (sand) is generally considered to be liquefiable given its composition and density.

(d) Layer 2b (sand to gravelly sand) is less likely to be susceptible to liquefaction due to the density and material composition, however some lenses within this deposit are likely to liquefy. Ground surface consequences are likely to be reduced by the depth and density of the layer.

(e) Layers 2z, 2c and 3a (very soft silt, soft silt, firm silt and gravel) are not expected to be susceptible to liquefaction due to the composition and/or density of these deposits. The silts encountered in these layers generally have plasticity. Occasional sand layers encountered in the soft silt and identified in investigation points within the North Block, are likely to liquefy.

33 Liquefaction triggering analyses have been undertaken for the North and South Blocks, utilising the available data. In general, excluding lateral spreading effects, the results of the liquefaction triggering analysis indicate that:

(a) There is a variable response across the South Block site which has informed initial indications for geotechnical zones. This is discussed in paragraph [34].

(b) In general, liquefaction is expected to be triggered in a proportion of Layers 1b (sandy silts) and 2a (sands) under SLS shaking. Additionally, lenses of Layer 2b (sand) are expected to liquefy under ULS IL2 and IL3 shaking.

(c) The cumulative thickness of the materials expected to liquefy increases as the shaking intensity level increases from SLS to ULS IL3, with most of the development of liquefiable layers occurring between SLS (25 year) and 100-year return periods.

(d) The placement of imported fill helps to reduce the severity of ground damage at the ground surface caused by liquefaction of the underlying soils.

34 Once liquefaction has triggered, the consequences of liquefaction (without any fill added to the surface) can include:

(a) Ground surface damage including total and differential settlement.

(b) A sudden reduction in bearing capacity of the liquefied soils.

(c) Lateral spreading of soils towards free faces.

35 Without fill placed on the sites, the liquefaction performance would correspond to a TC3 site.

36 Mitigation measures can be designed to reduce the consequences of liquefaction to levels such that the sites can be considered to correspond to a TC2 site.

37 The mitigation measures are likely to vary depending on location within the site and height/size and end use of a proposed building. The minimum mitigation measure proposed is to raise the ground surface with imported compacted gravel fill to 2.4 m RL (LVD). Where no lateral spread hazard exists, this measure can be used to mitigate against the consequences of liquefaction for one to two storey residential dwellings located on the North Block and Zone 1 (and possibly Zone 2) of the South Block. Based on our current understanding of the site, buildings located close to any potential

lateral spread zone will require deep ground improvement and/or deep foundations.

38 Lateral spreading is assessed as likely to occur around the perimeter of the South Block, where a stormwater swale is expected to be located. Lateral spreading is also assessed as likely to occur adjacent to swales and stormwater ponds, which are either existing or will be formed on site as part of the proposed development.

39 Lateral spread mitigation using stone column ground improvement, or other ground improvement methods designed to achieve a similar outcome is expected to be required. However, it is possible that further geotechnical investigations show that mitigation measures may be reduced from deep to shallow ground improvement in favourable areas with less liquefaction hazard.

40 The one and two storey residential developments on the edges of the ODP are not there to protect the edges of the fill from lateral spreading. The lateral spreading protection treatment is in and beneath the gravel raft. Edge treatments may consist of reinforcement of the gravel raft, or deep treatment (such as stone columns). The one and two storey residential developments fitted a concept design master plan layout and may be modified in future stages if desired, although foundation requirements and/or lateral spreading treatment may be greater to support a greater building height.

**Settlement**

41 Very soft to soft deposits of SILT have been identified beneath the North Block and South Block sites. Based on the existing geotechnical investigation information, the thickness of this deposit appears to be up to 3 m at the South Block and 6.5 m at the North Block.

42 Investigations to date have not identified peat deposits beneath the sites.

43 Preloading the sites is suggested as a method to mitigate consolidation settlements.

**Bearing capacity**

44 Allowable bearing capacity on the compacted hardfill is expected to be at least 100 kPa. For 1-2 storey residential buildings, this value will need to be confirmed by shallow geotechnical investigations at each proposed building location. This a routine requirement for all construction, following the

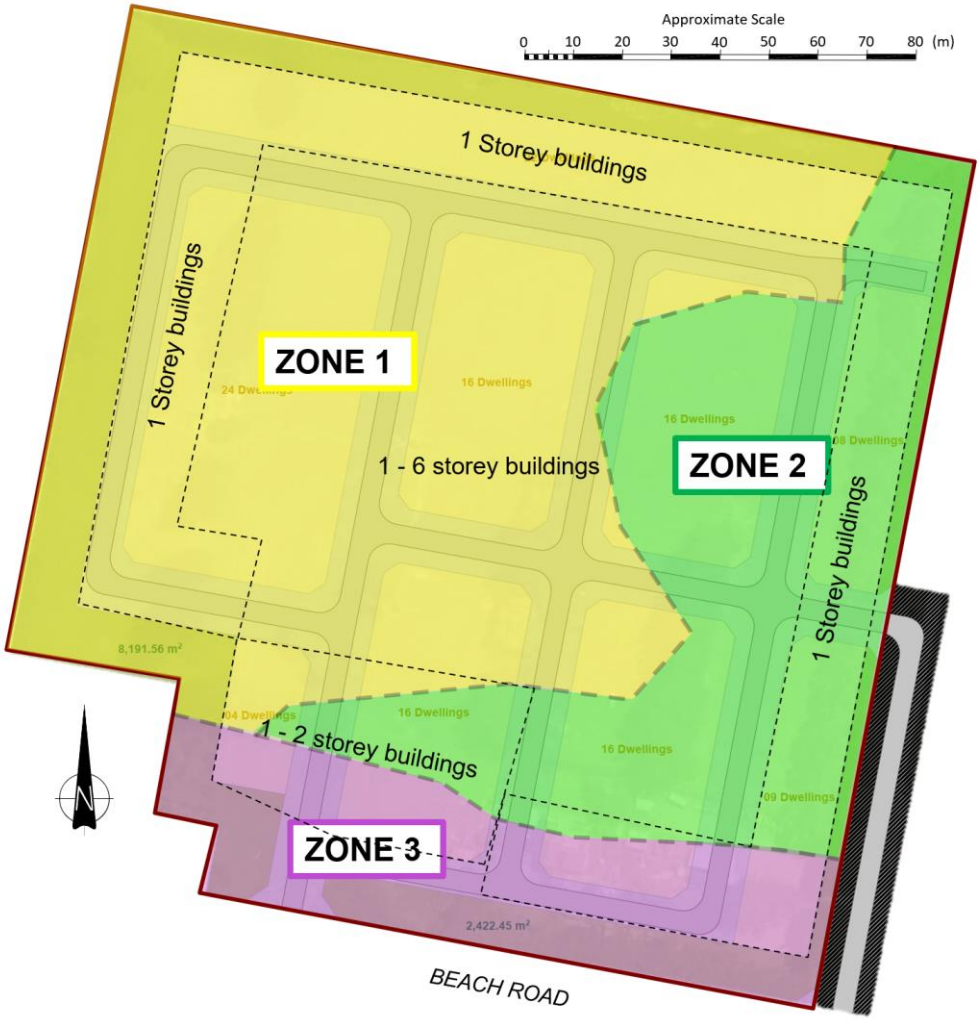
requirements of industry standards. For buildings higher than 2 storeys, specific foundation design, will need to be conducted once building details are known.

**SITE DEVELOPMENT**

**South block**

45 Based on the existing geotechnical investigation data, liquefaction assessment and soft soil assessments outlined above, the South Block has been divided into 3 zones.

*Figure 1:* South Block geotechnical zones




46 Zone 1 encompasses approximately half of the South Block site and is considered to be the better performing ground. It is likely to require lateral spread mitigation but is unlikely to require deep foundations. The remainder of the site is divided into Zone 2 and Zone 3. Zone 2 requires preload,

mitigation for lateral spread where free faces are present and deep foundations may be required, depending on building height. Zone 3 covers the worst performing land. Again, lateral spreading and liquefaction mitigation measures are expected to be required and deep foundations are likely required for all proposed building heights.

47 Report 2 provides recommendations for building foundations, preload for consolidation settlement, liquefaction and lateral spreading mitigation.

**North Block**

48 The North Block has not been divided into Zones. Deep ground improvement, such as stone columns are likely to be required to mitigate lateral spreading at free faces, although further investigations may indicate that shallow ground improvement is sufficient in some areas.

49 Report 1 provides recommendations for building foundations, preload for consolidation settlement, liquefaction and lateral spreading mitigation.

50 Based on the existing information and assuming building heights of 1-2 storeys, construction of the fill platform, with lateral spreading mitigation where required, is expected to provide building platforms equivalent to TC2. Report 1 provides further information.

**MEASURES TO MANAGE GEOTECHNICAL CONDITIONS**

51 Momentum proposes the following approach to manage geotechnical conditions present beneath the Site:

(a) Filling the Site to raise existing ground levels to provide suitable bearing platforms and to mitigate the effects of liquefaction of susceptible soils beneath the Site;

(b) Preload areas of the Site identified as likely to consolidate and settle under applied loads;

(c) Treat zones identified as susceptible to lateral spreading to mitigate the potential for lateral movement in the event of a large earthquake; and

(d) Recommend for construction, foundations appropriate for the expected ground conditions and applied building loads.

52 The above measures are consistent with current good practice and are a suitable response to the site conditions. They are similar to measures employed on nearby developments to address similar geotechnical issues.

53 I note that while there is a large volume of fill required to raise the site to the proposed platform levels, the fill is most likely to come from the Ashley or Waimakariri Rivers, which are reasonably close to the site and development is proposed to be staged over a 10-year construction programme. This is of a similar scale and timeframe to that of the Beach Grove development works.

**KEY ISSUES AND SUMMARY OF CONCLUSIONS**

54 The proposed development at the site is considered feasible from a geotechnical perspective.

55 The two key geotechnical related natural hazards for the site are considered to be earthquake-induced liquefaction and static settlement. Other geotechnical hazards are considered to either have a low likelihood of occurring or are unlikely to result in significant material damage to land or structures.

56 I consider that:

(a) Liquefaction-induced ground surface damage is expected to be within the criteria for TC2 type foundations and for Medium Liquefaction Vulnerability after compacted gravel fill is placed to 2.4 m (LVD).

(b) Settlement due to compressible silts is expected to be controlled to within design tolerances using mitigation measures such as preloading.

(c) The likely subsequent use of the land is unlikely to accelerate, worsen or result in geotechnical related hazards.

57 Thank you for the opportunity to present my evidence.

Anna Sleight

Date: 5 March 2024