Before the Hearings Panel
At Porirua City Council

Under	Schedule 1 of the Resource Management Act 1991
In the matter of	the Proposed Porirua District Plan
Between	**Various**
	Submitters
And	**Porirua City Council**
	Respondent

Statement of evidence of Dr Nicola Jane Litchfield on behalf of Porirua City Council

Date: 20 October 2021

INTRODUCTION

1 My full name is Nicola Jane Litchfield. I am employed as a Senior Tectonic Geomorphologist / Earthquake Geologist at the Institute of Geological and Nuclear Sciences Limited (GNS Science), Lower Hutt, New Zealand.

2 I have prepared this statement of evidence on behalf of the Porirua City Council (**Council**) in respect of technical related matters arising from the submissions and further submissions on the Proposed Porirua District Plan (**PDP**).

3 Specifically, this statement of evidence relates to the matters in Chapter NH - Natural Hazards.

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

QUALIFICATIONS AND EXPERIENCE

5 I hold the qualifications of Doctor of Philosophy (Geology – 2000) from the University of Otago, a Master of Science with First Class Honours (Geology – 1996) from the University of Canterbury, and a Bachelor of Science (Geology – 1993) from the University of Canterbury.

6 I have worked for GNS Science for 21 years including 4 years as a New Zealand Science and Technology Post-doctoral fellow (2001-2004) and currently hold the role of Senior Tectonic Geomorphologist / Earthquake Geologist.

7 Since 1995 I have been involved in multiple active fault mapping, paleoseismology and fault characterisation studies and seismic hazard assessments.

7.1 Fault mapping studies include defining Fault Avoidance Zones (**FAZ**s) for District Plans for Upper Hutt City, Porirua, Kaikōura, Taupō, Whanganui (completed), South Wairarapa,

Carterton, Masterton, and Gisborne (ongoing) Districts, some individual faults (Masterton, Greendale, Wairarapa), and reviewing studies for other regions (Hawke's Bay, Horizons, West Coast, Marlborough, Canterbury, Otago).

7.2 Paleoseismology studies have included three trenching studies of the Ohariu Fault, as well as multiple faults around New Zealand (e.g., Wellington, Alpine, Dunstan, Akatore, Titri, Mohaka Faults and several in the Taupō Rift).

7.3 I was and continue to be involved in the development of the 2010 NZ National Seismic Hazard Model and in the current revision (planned for completion in 2022).

8 I am a member of the Geoscience Society of New Zealand, Seismological Society of America, American Geophysical Union, Australia New Zealand Geomorphology Group, New Zealand Coastal Society, and New Zealand Archaeological Association. I was a member of the team that received a New Zealand Society for Earthquake Engineering Commendation for the science response to the Christchurch Earthquakes in the Port Hills.

Code of conduct

9 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing my evidence and will continue to comply with it while giving oral evidence before the Hearings Panel. My qualifications as an expert are set out above. 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.

SUMMARY

10 My name is Dr Nicola Jane Litchfield.

11 I have been asked by the Council to provide active fault line evidence in relation to the appeal on Chapter NH – Natural Hazards, which primarily relates to the Ohariu and Moonshine Faults.

12 My statement of evidence addresses three submissions seeking amendments to the proposed Fault Rupture Zone as it relates to the Ohariu Fault (submissions 59, 156 and 157) and a set of submission points (44.1, 76.1, 89.2, 90.1, 93.1, 246.1 and 246.5) raising matters relating to development in the vicinity of the Moonshine Fault.

13 Regarding submission 59 I agree that the Ohariu Fault Hazard Zone through the Kenepuru Landing Site should be amended using some of the new data provided, but I do not agree with the zone mapped by the submitter. As requested by Council, I present for consideration a revised FAZ using the methodology of Litchfield and Van Dissen (2014) and taking into account some of the new data referred to in submission 59.

14 Regarding submission 156 and 157 I provide clarification that the same Ohariu Fault data has been used for the Greater Wellington Regional Council Natural Hazard Strategy (Feb 2017) as for the FAZs that underly the PDP.

15 Regarding submission points 44.1, 76.1, 89.2, 90.1, 93.1, 246.1 and 246.5 I provide clarification of current state of knowledge of Moonshine Fault data at Judgeford Flats and potential further investigations that could be undertaken.

INVOLVEMENT WITH THE PROPOSED PLAN

16 I have been involved in the PDP since 8 September 2021 when engaged to provide this statement of evidence. I have had no prior involvement

with the PDP, but I was the lead author of the study Litchfield and Van Dissen (2014)[1] commissioned by Greater Wellington Regional Council and Council that forms the underlying data for the Fault Rupture Zone overlays in the PDP.

SCOPE OF EVIDENCE

17 My statement of evidence addresses the following matters:

- Submission 59, which requests that "the Ohariu Fault Hazard Zone through the Kenepuru Landing Site needs to be amended to reflect the amended Fault Avoidance Zone shown on the Coffey reports submitted as part of the Kenepuru Landing Project work and agreed with PCC";

- Submissions 156 and 157, which "opposes the introduction of the Fault Rupture Zones and associated rules" and requests that "the approach to seismic risk in the district plan be amended"; and

- Submission points 44.1, 76.1, 89.2, 90.1, 93.1, 246.1 and 246.5, which oppose the proposed Future Urban Zone area at Judgeford Flats on the basis of multiple points including "Geotechnical safety considering the topography and the Moonshine Rupture Zone"

OHARIU FAULT HAZARD ZONE: SUBMISSION 59

18 Submission 59 requests that "the Ohariu Fault Hazard Zone through the Kenepuru Landing Site needs to be amended to reflect the amended Fault Avoidance Zone shown on the Coffey reports submitted as part of the Kenepuru Landing Project work and agreed with PCC". It is my

[1] References are listed in Appendix 2

opinion that the Ohariu Fault Rupture Zone overlay may be revised using the Coffey data, but not as proposed by Coffey. This is based on the following analysis of the currently available data:

18.1 The east branch of the Ohariu Fault passes through the Kenepuru Landing Site, and the Fault Rupture Zone in the PDP is based upon the FAZ developed by Litchfield and Van Dissen (2014) and is 170 m wide (Figure 1)[2].

18.2 I have reviewed the data used by Litchfield and Van Dissen (2014) to define the FAZ in the vicinity of the Kenepuru Landing Site. These data are shown in Figure 1 and are stream alignments on 1940s aerial photographs in the southwest part of the site (Mitchell Stream) and ~650 m northeast of the site. The location across the remainder of the Kenepuru Landing Site was considered uncertain in large part because of extensive ground surface modifications associated with the former Kenepuru Hospital.

18.3 Coffey Geotechnics (NZ) Ltd (Coffey) have undertaken several studies in an attempt to better constrain the location and complexity of the Ohariu Fault through the Kenepuru Landing Site. GNS Science was commissioned to review the methodology proposed by Coffey (Van Dissen, 2016), and concluded the proposed methodology was fit-for-purpose but made some recommendations including the trench depth be deepened to 2-3 m and the trench walls be meticulously cleaned. GNS Science has had no subsequent involvement in the work at the Kenepuru Landings Site.

18.4 In preparing this statement of evidence I have reviewed four Coffey reports (2016, 2020a, 2020b, 2021) and a review

[2] Figures are contained in Appendix 1.

report by J Begg Geo (2020) supplied by Council. Coffey propose a Fault Buffer Zone that is 40 m wide in the south (Mitchell Stream) and 54 m wide in the centre and north (Figure 2). They have also proposed a Distributed Deformation Zone adjacent to the northern Buffer Zone.

19 My review of these reports identifies the following key matters associated with each Fault Buffer Zone:

Southern Fault Buffer Zone

19.1 The Coffey southern Fault Buffer Zone is defined by the current centreline of Mitchell Stream and a 20 m buffer either side. I consider this zone to be too narrow for several reasons:

1) Mitchell Stream in this area appears to have been modified (moved northwest) from the presumed natural location on the 1940s aerial photographs;

2) The centreline doesn't take into account the sinuosity of the stream and therefore the related uncertainty of the fault location;

3) The use of a centreline (rather than an uncertainty zone) implies that the Ohariu Fault is of 0 m width, contrary to the northern Fault Buffer Zone; and

4) it is my opinion that trenches FT09 and FT11b were too shallow, with a base in alluvium (FT09) and silt (FT11b) that could be younger than the most recent metre-scale surface rupturing earthquake on the Ohariu Fault (1050-1000 years ago; Litchfield et al. 2004, 2006, 2010). Therefore, I consider the presence of the Ohariu Fault below the base of these trenches cannot be ruled out.

Northern Fault Buffer Zone

19.2 The Coffey northern Fault Buffer Zone is defined by a 14 m wide zone of concentrated micro-fractures found in several trenches and a 20 m buffer either side. It also incorporates two of three geophysical anomalies (A and B) identified in a separate study.

19.3 While I concur that the micro-fractures could represent distributed deformation of the Ohariu Fault at depth, in my opinion, like the trenches in the south, the northern trenches were too shallow, and the base of FT03 and FT10 in particular were within alluvium that could be younger than the most recent surface rupturing earthquake on the Ohariu Fault. Therefore, I consider the presence of the Ohariu Fault below the base of these trenches and beyond the proposed Fault Buffer Zone cannot be ruled out.

Centre of the Kenepuru Landing Site

19.4 In the centre of the Kenepuru Landing Site, the Fault Buffer Zone is not constrained by trench evidence. The northern Fault Buffer Zone has been extended southward at the same width (54 m) to a point where Mitchell Stream deflects to the northeast, where the Fault Buffer Zones abruptly narrows to 40 m width. This implies that the Ohariu Fault undergoes a step and an abrupt change in width but no evidence is presented for either.

19.5 I consider it unlikely that the Ohariu Fault undergoes these changes because they are too abrupt and there is no evidence for them, therefore a tapering zone between the northern and southern areas is equally as likely.

Distributed Zone

19.6 The Distributed Zone is based upon there being a "risk of distributed ground deformation, due to a 'kink' in the buffer zone/fault" (Coffey 2021 page 2). This zone also includes a set of micro-fractures in FT10 and geophysical anomaly C.

19.7 While the presence of this zone is possible, it is unclear to me why such a kink would produce a Distributed Zone only on one side of a strike-slip fault. That is, if the Distributed Zone is the result of compression on the northwest side of the northern Fault Buffer Zone, why is there no equivalent Distributed Zone adjacent to the southeast side of the southern Fault Buffer Zone?

20 Based upon the above analysis of the Coffey reports, I do not agree with the location and definition of the Fault Buffer/Distributed Zones included in the Coffey reports and referred to in Submission 59.

Supported amendments

21 In my opinion the eastern Ohariu Fault FAZ through the Kenepuru Landing Site could be revised as identified in Figure 3[3]. The revision uses the methodology[4] and some data from Litchfield and Van Dissen

[3] Note the FAZ in Figure 3 was revised using georeferenced maps from the Coffey reports, so there may be some additional small (a few metres) uncertainty resulting from the georeferencing. If Council decide to adopt this revised FAZ then the final version could be constructed using Coffey survey and/or GIS data of the locations of trenches and the geophysical anomalies.

[4] The methodology to revise the FAZ in Figure 3 is the same as that used by Litchfield and Van Dissen (2014). In brief, it follows the MfE active fault guidelines (Kerr et al. 2003) and is a two-step process: 1) Construct a likely fault rupture zone from the available data, 2) Add a 20 m buffer setback zone either side. The combined zone is in my opinion the revised FAZ.

(2014) and the Coffey data that I consider to be robust enough to use to define a FAZ. My reasoning is set out as follows:

21.1 In the south a likely fault rupture zone (red) is constructed from a buffer either side of the Mitchell Stream trace mapped by Litchfield and Van Dissen (2014) from the 1940s aerial photographs (green line). The buffer is 22.25 m wide (noting that this may change slightly if the Coffey survey/GIS data could be obtained) constrained by the western end of FT11a (Figure 3a), which was entirely in bedrock and did not show any clear evidence of recent faulting. In the absence of any other information the same width is used on the west side of the fault. A 20 m buffer setback zone (pink) is then added either side, but this is modified on the east side to again meet the western end of FT11a. Thus, the total revised FAZ width would be 64.5–84.5 m, which is wider than, but does encompass, the Coffey Fault Buffer Zone (Figure 3b). It is narrower than the 170 m wide zone in the PDP.

21.2 In the north, a likely fault rupture zone (red) is constructed that is bound by the outer edges of (from top right to top left): geophysical anomaly A, geophysical anomaly B, the outer edge of the total zone of microfractures in FT03, geophysical anomaly C, and a step in bedrock in FT10. This step has not been identified as a fault, and could be a terrace riser, but the trench was not deep enough to rule it out as a fault scarp. The final (northernmost) point is projected along the same orientation. A 20 m buffer setback zone (pink) is then added either side. The total width of this revised FAZ is 101–119 m, similar to, but slightly wider than, the combined Coffey Fault Buffer and Distributed Zones (Figure 3b), but narrower than the 170 m wide zone in the PDP.

21.3 Between the two areas, the revised FAZ is joined with straight lines, and is also tapered to the existing FAZ

northeast and southwest of the Kenepuru Landing Site. In my opinion this is an appropriate method to identify the FAZ for this area.

21.4 The FAZ fault complexity classification of *uncertain – constrained* assigned by Litchfield and Van Dissen (2014) is in my opinion still appropriate.

BEST AVAILABLE INFOMATION: SUBMISSIONS 156 AND 157

22 Submission 156 and 157 oppose "...the introduction of the Fault Rupture Zones and associated rules" and requests that "... the approach to seismic risk in the district plan be amended to be consistent with: Greater Wellington Regional Council Natural Hazard Strategy (**GWRCNHS**) (Feb 2017) and in particular: a….b Appendix B…2…3…". Based on 1, 2 and 3 they "seek that the "High" risk of the Ohariu Fault Rupture Zone …be reassessed" and "a more holistic approach be taken to addressing the risk to buildings and property from seismic events…". The analysis I have undertaken below is limited to specific points raised regarding Ohariu Fault data. I do not address general consistency with the GWRCNHS (Feb 2017).

Consistency with the GWRCNHS

23 Submissions 156 and 157 state: "Appendix B which indicates the recurrence interval of the Ohariu Fault is 2200 years with an elapsed time of 1050-1000 years since the last event….". This information is from the studies of Litchfield et al. (2004, 2006, 2010) and as far as I am aware is still the best available data for the Ohariu Fault. The 2200 years quoted in the GWRCNHS is the mean value, however there are large uncertainties (800-7000 years at 95% confidence limits; Litchfield et al., 2006) which were not quoted by the GWRCNHS.

24 The same data were used by Litchfield and Van Dissen (2014) to assign the Ohariu Fault to Recurrence Interval Class II (2000-3500 years) with

low-medium confidence. Therefore, there is no inconsistency between the data in the GWRCNHS and that used to underpin the PDP Fault Rupture Zones.

25 In response to submission 156 and 157 subpoint "Letter Report No. CR 2018/LR [Van Dissen, 2018] referred to in the section 32 report raises the need to have GNS investigate new information available on the Ohariu Fault in the Kenepuru Hospital area", I have reviewed this information in preparation of this statement of evidence. The findings of those reports (Coffey Reports) are summarised and addressed in response to submission point 59 in paragraphs 18 to 21 of this statement of evidence.

MOONSHINE FAULT: SUBMISSION POINTS 44.1, 76.1, 89.2, 90.1, 93.1, 246.1 AND 246.5

26 Submission points 44.1, 76.1, 89.2, 90.1, 93.1, 246.1 and 246.5 oppose the proposed Future Urban Zone area at Judgeford Flats on the basis of multiple points including "Geotechnical safety considering the topography and the Moonshine Rupture Zone". My consideration of these submission points addresses the current state of knowledge on the Moonshine Fault at Judgeford Flats. I consider detailed matters pertaining to geotechnical safety issues are beyond my expertise.

26.1 The state of knowledge about the Moonshine Fault is low relative to other faults within the Porirua City district and the Greater Wellington Region.

26.2 The state of knowledge is unchanged since the study of Litchfield and Van Dissen (2014), which developed the FAZ that underpins the Fault Rupture Zone in the PDP.

26.3 The Moonshine Fault is mapped as a bedrock fault and a topographic feature for most of its length and the best evidence for the location and activity of the Moonshine Fault

is at Judgeford Flats. The location of the Moonshine Fault at Judgeford Flats is inferred from a faint topographic step feature on Light Detecting and Ranging (**LiDAR**) data that is interpreted as a fault scarp (Litchfield and Van Dissen, 2014) and three drillholes that document a step in the greywacke basement surface inferred to be the result of movement on the Moonshine Fault (Begg, 1994) (Figure 4).

26.4 These data, along with the local topography, were used by Litchfield and Van Dissen (2014) to define the FAZ, which runs through the proposed Future Urban Zone (Figure 4).

26.5 It may be possible to further refine the location of the Moonshine Fault at Judgeford Flats using detailed fault mapping, geophysical or paleoseismological studies. This may reduce the width of the FAZ, but it is unlikely to remove it from crossing the proposed Future Urban Zone.

26.6 It may also be possible to better constrain the Recurrence Interval of the Moonshine Fault at Judgeford Flats using paleoseismological studies. The current estimate of 5000-10,000 years has low confidence so the Recurrence Interval could increase or decrease with further investigation.

Date: 20/10/2021

APPENDICES

1. FIGURES

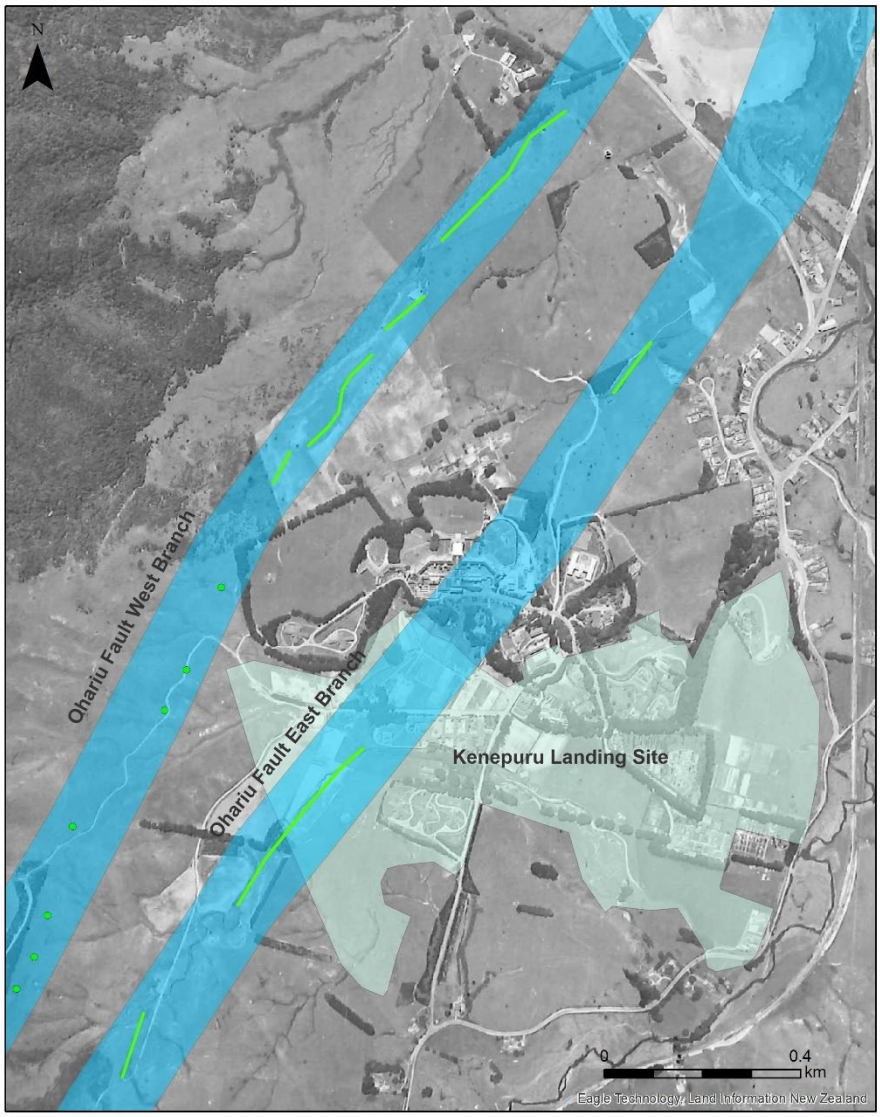
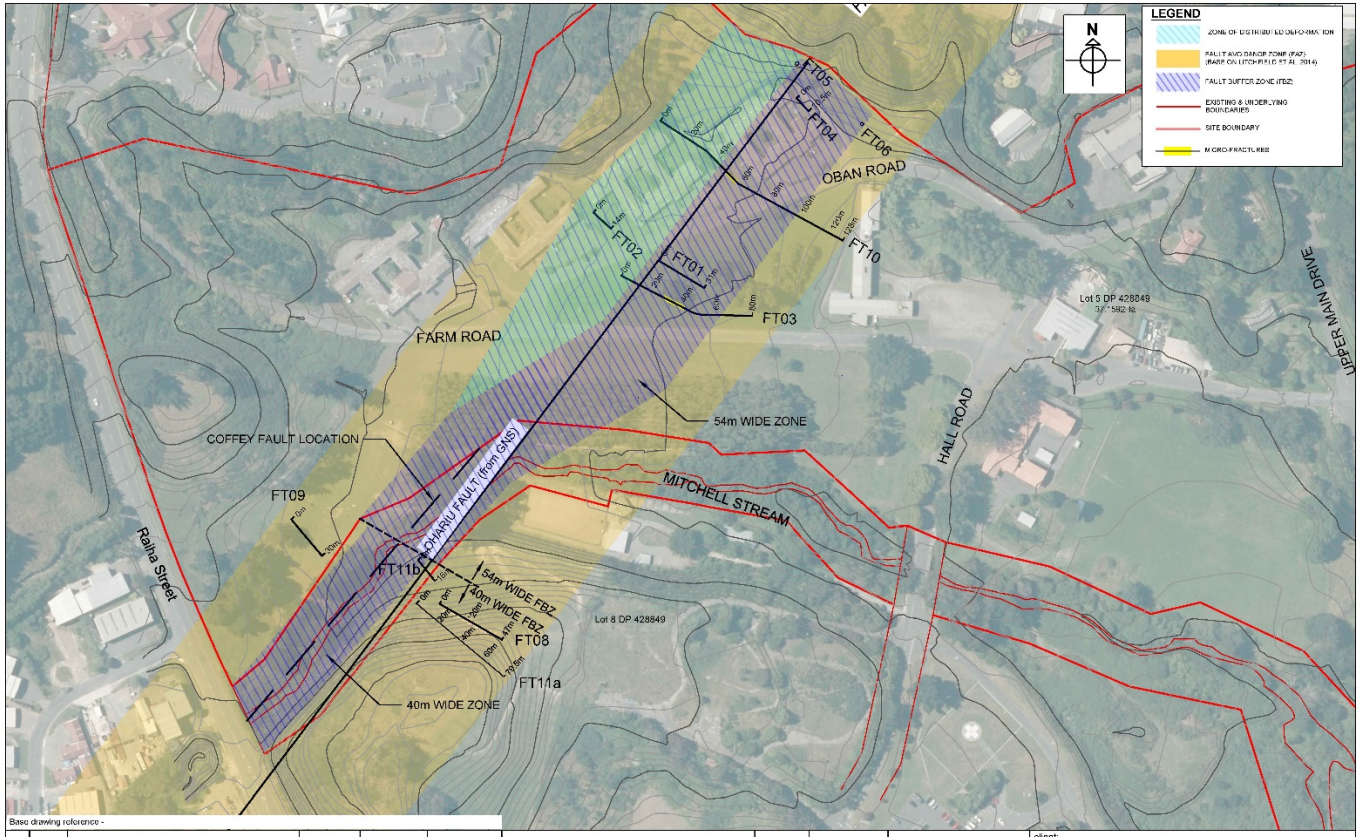


Figure 1. 1940s aerial photograph showing the topographic features (green lines and dots) used by Litchfield and Van Dissen (2014) to define the location of the Ohariu Fault FAZ (blue) in the vicinity of, and crossing, the Kenepuru Landing Site. The Fault Hazard Zone in the PDP is based upon this FAZ.



Base drawing reference -

revision	rev	description	drawn	approved	date
	D	Revision 4	RZ	SM	25/05/2021
	C	Revision 3	NM	SM	28/05/2019
	B	Revision 2	LM	SM	08/02/2019
	A	DRAFT - Revised FBZ after all trenching	SM		26/04/2017

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Horizontal Scale (metres)
0 30.0 60.0 90.0 120.0
Vertical Scale (metres)

drawn	NM
approved	SM
date	25/05/2021
scale	1:2000
original size	A3

coffey
A TETRA TECH COMPANY

client:	KENEPURU LP
project:	KENEPURU SUBDIVISION PORIRUA
title:	FAULT TRENCH SUMMARY
project no:	773-WLGGE198865AE
figure no:	01
rev:	D

25/05/2021 C:\TS\GIS\52_TT_LOCAL\561\GENZ\0 773-WLGGE PROJECTS\197000 TO 202999\773-WLGGE198865 - KENEPURU SUBDIVISION - GEOTECH SERVICES_KEPG DRAWINGS\AG - FAULT TRENCH PRELIM LETTER\05\07\21\198865 FAULT TRENCH SUMMARY 2019.DWG

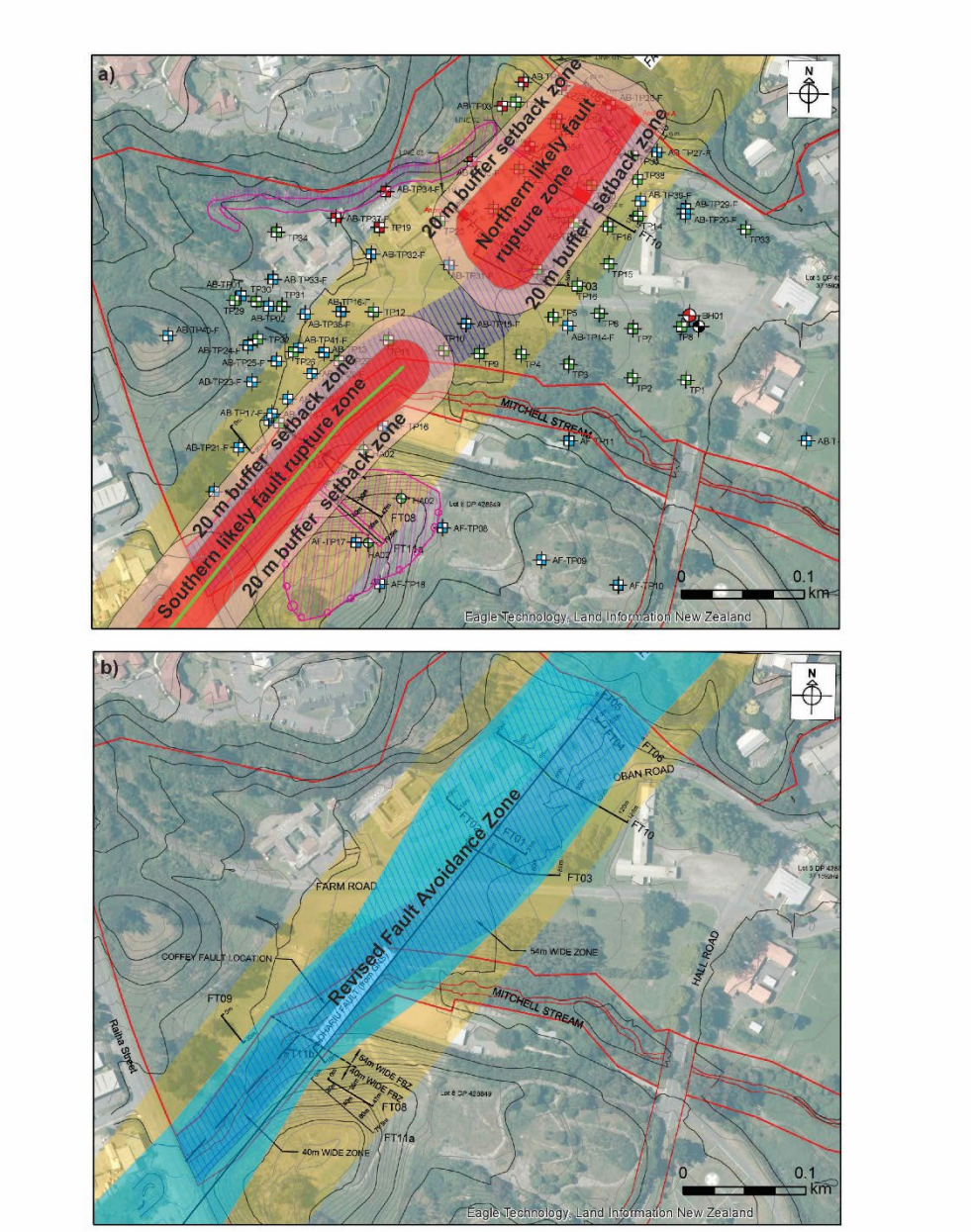

Figure 3. Revised FAZ for the eastern branch of the Ohariu Fault through the Kenepuru Landing Site for consideration. The background map is the Coffey (2020b) map, which shows the Litchfield and Van Dissen (2014) FAZ in light orange and the Coffey Fault Buffer Zone and Distributed Zones in the hatch pattern (also shown in Figure 2). a) Components of the revised FAZ - Likely fault rupture zones (red) and 20 m buffer setback zones (pink) for the southern and northern areas using the Coffey data and the Litchfield and Van Dissen (2014) Mitchell Stream centreline (green line). b) Revised FAZ joining the zones in (a) and tapering (widening) to the previous FAZ outside of the Kenepuru Landing Site.

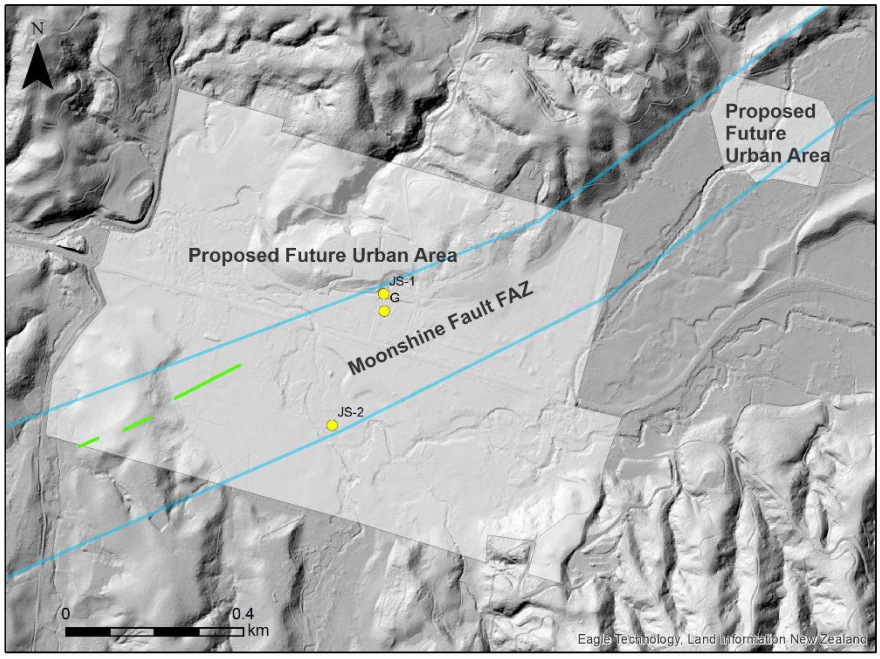

Figure 4. LiDAR map showing the features (green lines and yellow dots) used by Litchfield and Van Dissen (2014) to define the location of the Moonshine Fault FAZ (blue outline) crossing the proposed Future Urban Zone (white) at Judgeford Flats.

2. REFERENCES

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