Before the Hearings Panel
At Waimakariri District Council

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

Council reply on Rezoning requests – Oxford and Settlement Zone (Ohoka and Woodend Beach) – Rachel McClung on behalf of Waimakariri District Council

Date: 5 July 2024

INTRODUCTION:

1 My full name is Rachel Sarah McClung. I am employed as a Principal Policy Planner for Waimakariri District Council. I am the Reporting Officer for Rezoning requests – Oxford and Settlement Zone (Ohoka and Woodend Beach) topic and prepared the s42A Report.

2 I have read the evidence and tabled statements provided by submitters relevant to this Section 42A Report.

3 I have prepared this Council reply on behalf of the Waimakariri District Council (**Council**) in respect of matters raised through Hearing Stream 12A. Specifically, this statement of evidence relates to the matters in the Section 42A Report - for Rezoning requests – Oxford and Settlement Zone (Ohoka and Woodend Beach).

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

QUALIFICATIONS, EXPERIENCE AND CODE OF CONDUCT

5 Appendix H of my section 42A report sets out my qualifications and experience.

6 I confirm that I am continuing to abide by the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2023.

SCOPE OF REPLY

7 This reply follows Hearing Stream 12A held on Tuesday 4th and Wednesday 5th June 2024. Minute 2 of the Hearing Procedures allows for s42A report authors to submit a written reply within 10 working days of the adjournment of the hearing.

8 The main topics addressed in this reply include:

- Answers to questions posed by the Panel
- Response to evidence presented at the hearing
- Changes to recommendations in s42A report

9 Appendix 1 has a list of materials provided by submitters including expert evidence, legal submissions, submitter statements etc. This information is all available on the Council website[1].

10 Appendix 2 has recommended amendments to PDP provisions, with updated recommendations differentiated from those made in Appendix A of the s42A report.

11 Appendix 3 has an updated table of recommended responses to submissions and further submissions, with updated recommendations differentiated from those made in Appendix B of the s42A report.

12 Appendix 4 contains the reformatted Engineering and Greenspace advice as requested by the hearing panel.

13 Appendix 5 has a geotechnical report that is referred to in response to a question on the Waghorn submission.

ANSWERS TO QUESTIONS POSED BY THE PANEL

14 My responses are set out below.

Please set out how the risk of natural hazards to a property or area has been considered when determining the zoning to be applied in the PDP, for both existing urbanised areas and new proposed urban areas.

15 The NH chapter introduction in the PDP states that a risk-based approach is taken which factors in the need to allow people and communities to use their property and undertake activities, while also ensuring that life or significant assets are not harmed or lost as a result of a natural hazard event.

16 The Natural Hazards s32 states that an anticipated outcome from the proposed provisions (which includes zoning) are that the risk from

[1] https://www.waimakariri.govt.nz/council/district-development/proposed-district-plan-hearings/hearing-streams/hearing-stream-12a-commercialindustrial,-oxford-and-surrounds,-pegasus-resort

natural hazards to property and people will not increase with time as development with inappropriate levels of risk will not be able to proceed and more developments will include mitigation measure to address the risks associated with a range of natural hazards[2].

17 The s32 report goes on to say that natural hazards are significant because they are widespread, and because of the risk that these events pose to human health, property and infrastructure. The proposed provisions incorporate the latest scientific and technical knowledge and cover the identified natural hazards. It is therefore important for the PDP to identify areas susceptible to natural hazards and to restrict or manage subdivision, land use and development (including infrastructure) in these areas proportionate to the risk posed, in order to reduce the potential effects of future natural hazard events.[3]

18 It is recognised that for existing urban areas the community has already accepted some natural hazards risk in order to support the ongoing development of the District's existing towns. However, for new proposed urban areas with known natural hazards, or areas where rezoning will increase density with known natural hazards, then sufficient scientific and technical information is required to ensure that the natural hazard can be either avoided or mitigated (either at time of subdivision or development) before the rezoning can be supported.

Please provide an updated Appendix C which clearly differentiates the threewaters, greenspace and transport assessments for the different submissions. Please ensure that an assessment for 351 Bradleys Road Ohoka is included.

19 This has been updated as requested and is enclosed at Appendix 4.

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[2] https://www.waimakariri.govt.nz/__data/assets/pdf_file/0021/136092/7.-NATURAL-HAZARDS-S32-REPORT-DPR-2021..pdf page 5
[3] https://www.waimakariri.govt.nz/__data/assets/pdf_file/0021/136092/7.-NATURAL-HAZARDS-S32-REPORT-DPR-2021..pdf page 6

Please provide us your opinion as to whether the stormwater and fault hazard matters in respect to the Mooney and Campbell submission fatal to the rezoning of the land, or are these matters that could be addressed through a subsequent subdivision application?

20 For the reasons set out in my response to the initial question on paras 143 and 144, and in the absence of the technical information outlined in that response coming forward; yes, the stormwater and fault hazards matters are the reason why I do not recommend the area be rezoned from LLRZ to GRZ.

In respect to Waghorn, please explain what is the geotechnical risk associated with a fourth dwelling being permitted on the site through the requested rezoning?

21 I have liaised with Mr John Aramowicz in responding to this question, as I have relied on his expert geotechnical opinion in assessing the submission. Mr Aramowicz has read the NZ Geotechnical Consultants report, dated 18/04/2023 that was provided with the subdivision and land use application (RC225255/RC225256) and referenced by Mr McLachlan on behalf of the submitter at the hearing. I enclose a copy of it at **Appendix 5** for your reference.

22 Mr Aramowicz comments are as follows (para's 22-29 below):

23 The geotechnical report by NZ Geotechnical Consultants, dated 18/04/2023 did not attempt to map the Starvation Hill fault at a scale of 1:35,000, nor did their investigations include any trenching to confirm the locations where the fault crosses the site. The report also highlights the need for Council to take a risk-based approach.

24 Given this, the geotechnical report that was accepted by Council for RC25255/RC225256, in my opinion, does not provide any useful information that Council can now use or rely on to understand where

the fault is located for the purpose of the rezoning sought by the submitter.

25 Further, Mr MacLachlan's evidence paraphrases only part of my comment on the fault, when he implies that I am supportive of light timber framed dwellings being used within the fault avoidance zone. This is only partially correct. To be clear, I provide the comment I made earlier in full below.

26 *"There are suspected active fault/s that passes through the area of s355/365/366 (north of Commercial Rd). GNS report 2033/44 for eastern Oxford (Lots 2 & 3 DP51992) assumes the Starvation Hill fault has a recurrence interval III and that the fault area be zoned GRUZ to minimise the density of development, but concedes that within GRUZ light timber framed single storey dwellings with a suspended timber floor supported on shallow timber piles could be used as partial mitigation of the risk of fault rupture. I recommend a similar approach be adopted to any areas of s274/355/365/366 that are within 20m of the faults shown on the GNS active faults database. The problem is that GNS, or another experienced geologist, have not determined the location of ground rupture/deformation that the 20m setback would need to apply. In short, further geological investigation of the active fault across the site is needed before WDC can assess whether the site can be used in part for the proposed GRZ. Until this is done, WDC recommend the proposed rezoning be rejected. General Residential zoning is not supported within the 20m fault avoidance zone setback".*

27 My previous comment required:

- the need for the fault to be located, and
- that the existing zoning be applied to the 20m fault avoidance area to avoid increasing density (and therefore risk), and

- that light timber framed single storey dwellings with a suspended timber floor on shallow timber piles be used in the fault avoidance area (once the fault location is confirmed), and
- that these measures, particularly the proposed limit on building structure, are only 'partial mitigation'.

28 To be clear, any new development over the fault, regardless of any structural limitations that could be imposed, will increase risk. The question that needs to be addressed by the submitter is what is the economic and life-safety risk at the site, how will the proposed rezoning increase those risks, and will the risk after rezoning (if this was to occur) be at a level that is societally acceptable?

29 As previously explained, GNS assumed the Starvation Hill fault may have a recurrence interval of around 3500-5000yrs. It is entirely possible that site-specific investigation by trenching to expose the historic fault rupture surface could alter the view on recurrence interval. If the fault is found to be more likely to rupture then this would clearly indicate the risk, particularly life safety risk, will be higher.

30 Quite simply, at this stage it is my opinion that Council do not have enough information on the location and recurrence interval of the Starvation Hill Fault in the area of the submission to be satisfied that the risk associated with the proposed land use will be acceptable. The submitter needs to provide this information.

31 In summary, Mr John Aramowicz is not satisfied that the information has been provided by the submitter to appropriately determine the geotechnical risk for a fourth dwelling that would be enabled through zoning.

Please respond to all evidence presented at and tabled for the hearing, that is not otherwise set out in the questions.

32 I have no further comments in relation to the following:

- Statement of Evidence of James Weir [161], dated 19 May 2024
- Statement of Evidence of Matt McLachlan for Waghorn Builders Limited [274], dated 19 May 2024
- Statement of Evidence of Matt McLachlan for Patrick Campbell and Elvere Mooney [365 and 366], dated 22 May 2024
- Statement of Evidence of Patrick Campbell and Elvere Mooney [365 and 366], dated 23 May 2024

33 I wish to clarify matters raised by Elvere Mooney in her hearing presentation and Speaking notes, dated 4 June 2024.

34 As her third point, Elvere Mooney raised the York Street Diversion work in her speaking notes. Mr Chris Bacon did take this work into account in his flood risk assessment and is of the opinion that the York Street diversion will at best convey a 5 year ARI storm event, and it will have little to no impact in a 200 year flood event. Mr Bacons advice is that when considering flooding and designing secondary stormwater systems, it is standard practice to assume the primary system will be blocked. Therefore, it is his view that any measures required to mitigate flood effects or provide secondary flowpaths will not be impacted by the York Street diversion being completed.

Legal Boundary of 6 York Street

35 The Fourth point raised by Elvere Mooney was in relation to the legal boundary of 6 York Street 'having been erased', and the ownership of Commercial Road.

36 With regard to 6 York Street, the boundary line exists. The source I used for the figures in my s42A report was the 'Property Boundaries with Attributes' layer in Waimap. This is the layer that is used in the District Plan Planning Maps. It is derived from parcels that share a ratings assessment number and that make up one rating unit, but does not always show all parcel boundaries when the Aerial Basemap is turned

on. There is an alternative layer in Waimap called 'Deposited Land Parcels' which does shows 6 York Street as a separate land parcel (Part RS 1750) and Record of Title (CB262/222). Please refer to **Figure 1** and **Figure 2** below.

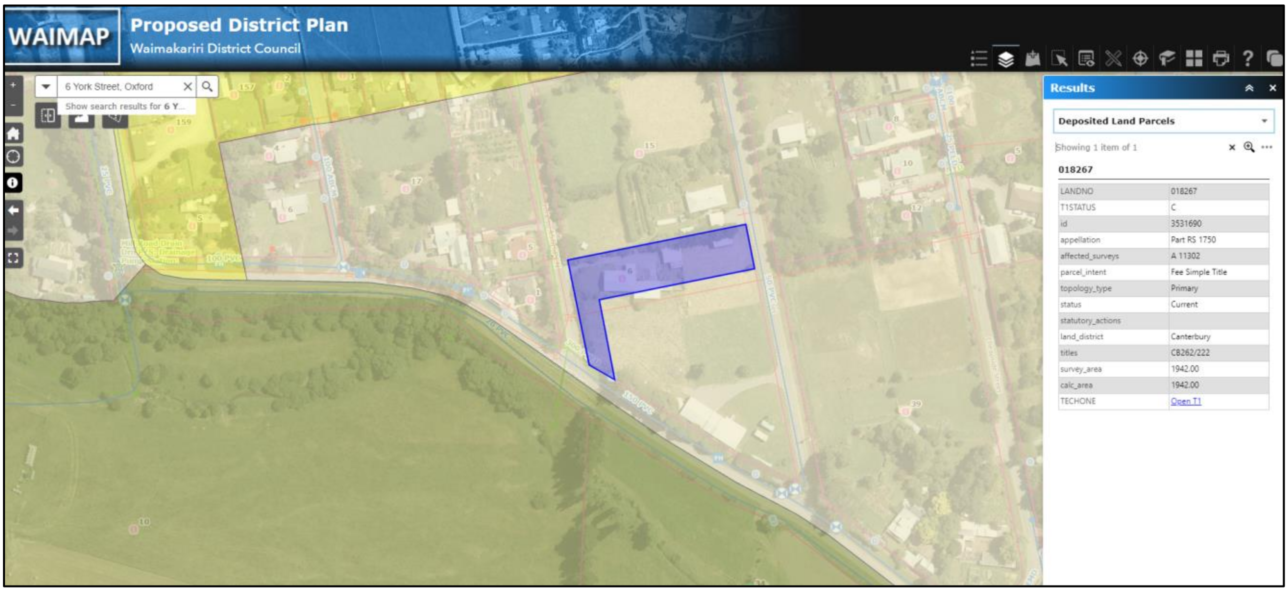

Figure 1 – 6 York Street – Waimap 'Deposited Land Parcels' map

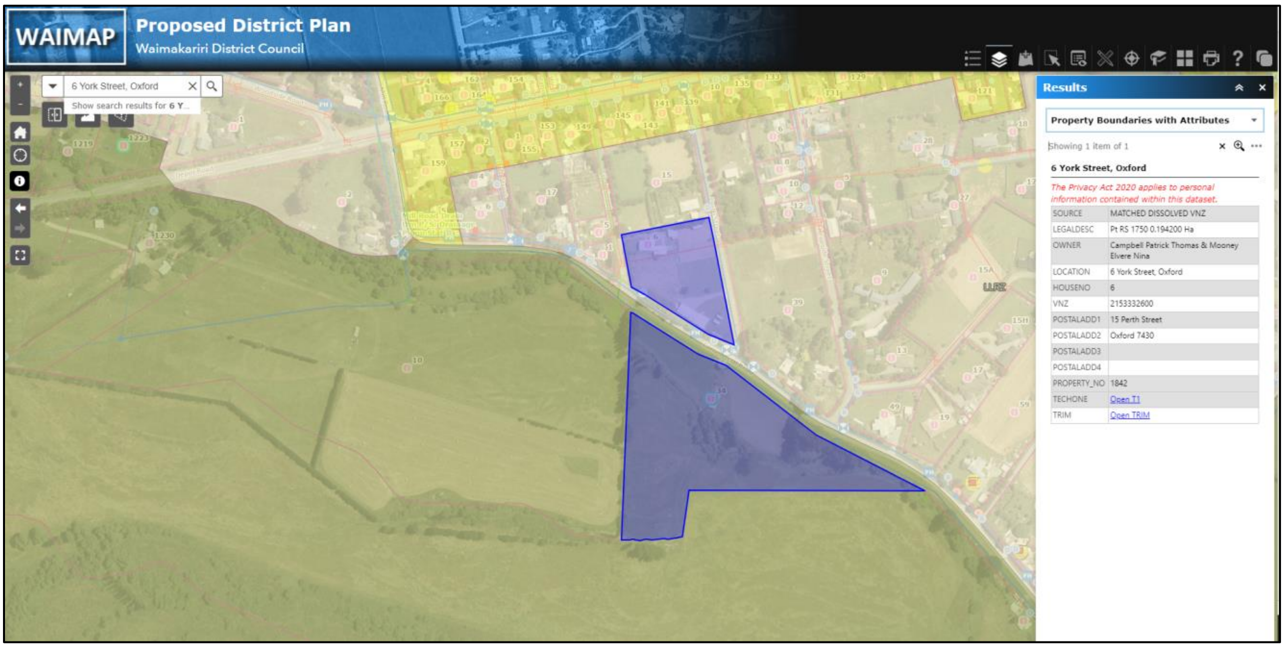

Figure 2 – 6 York Street – Waimap 'Property Boundaries with Attributes' map

37 If the 'Aerial' Basemap is turned off on the Planning Maps, and if the 'Transparency' layer is reduced, then both the 'Canvas' and 'Streets'

basemaps do show a faint line for this parcel boundary. This can be seen in **Figure 3** below. This is a level of technical detail that will not be obvious to many first-time users of the planning maps, and I apologise to Mrs Elvere Mooney for the confusion this will have caused in reading the report.

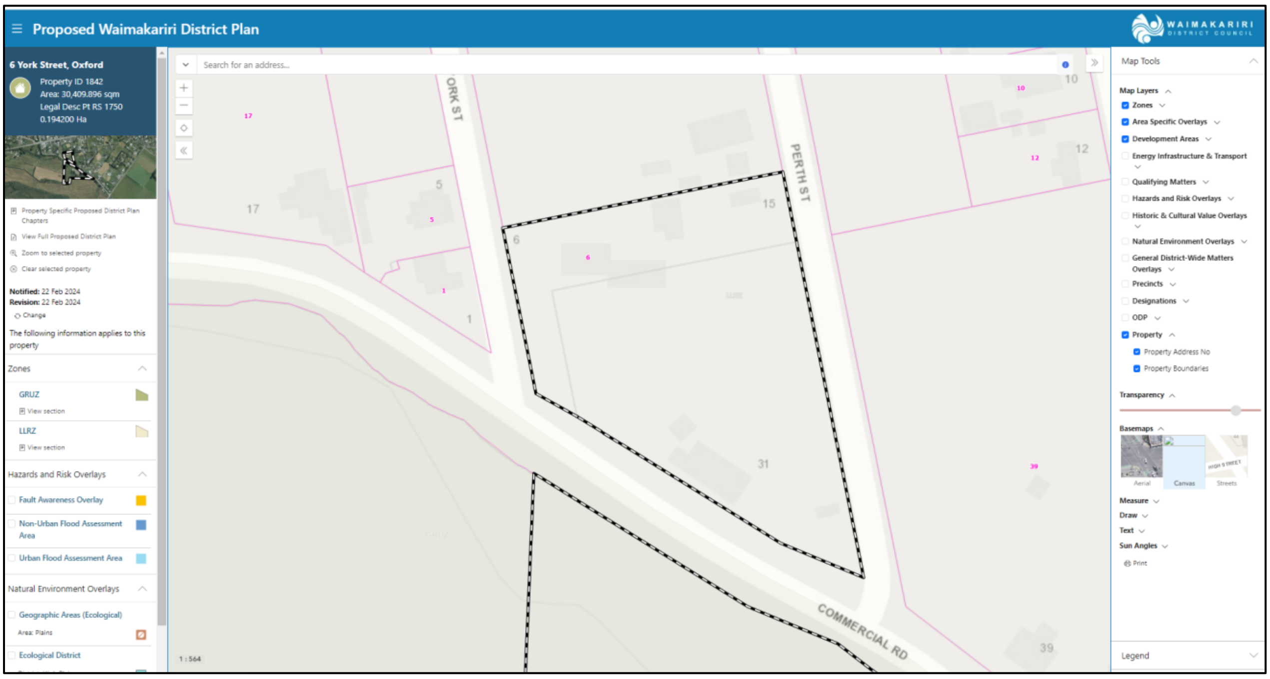

Figure 3 – 6 York Street – Planning Map with Areial basemap turned off

Ownership of Commercial Road

38 With regard to the ownership of Commercial Road, I have queried this with Ms Anna Childs, Property Acquisitions & Disposals Officer within the Council's Property Team. Ms Childs checked both the Record of Title provided by Elvere Mooney and the Landonline database. Ms Childs confirmed that the Commercial Road is noted as 'Road' on Landonline, and is therefore in Council ownership. Ms Childs also confirmed that roads themselves do not have Records of Titles and do not require an encumbrance when they have previously been legally vested as road.

39 Ms Childs has provided the below screenshot (Figure 4 below) from Landonline showing the intent of Commercial Road as 'Road'.

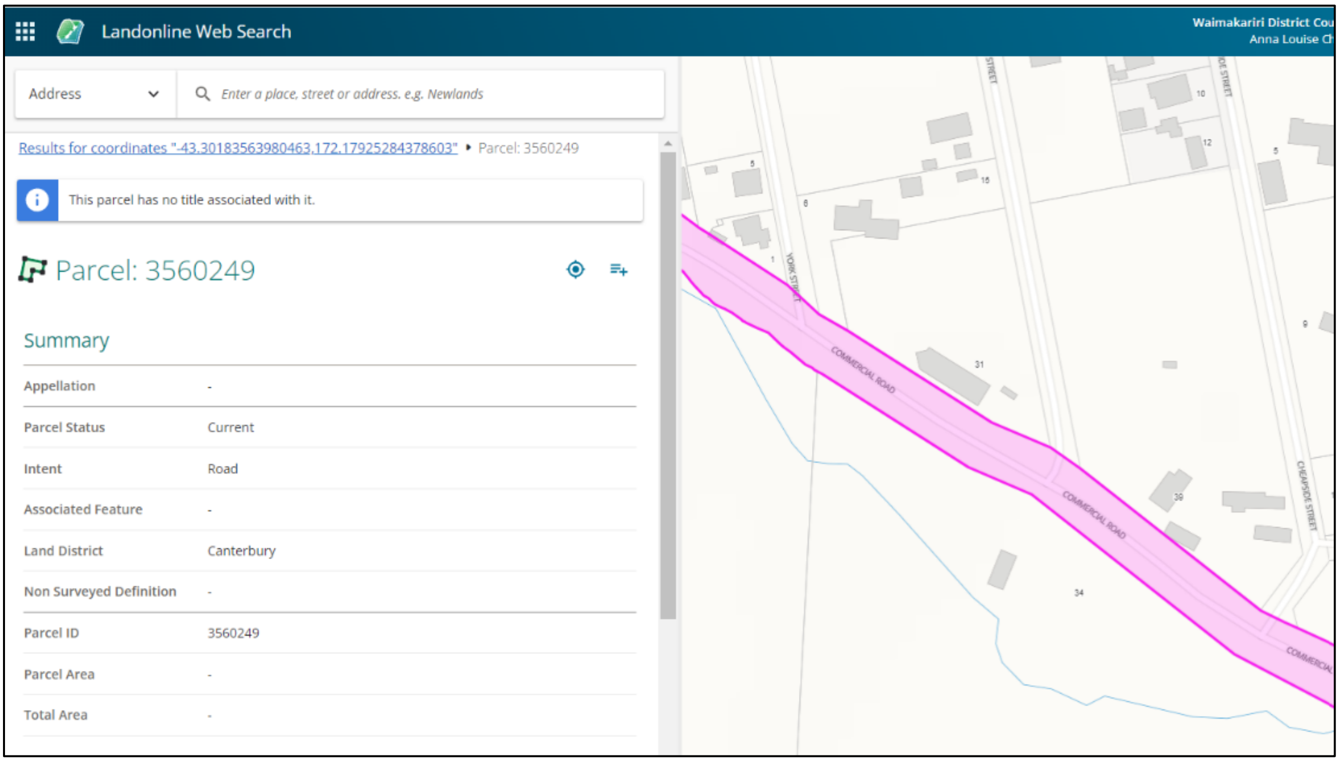

Figure 4: Landonline screenshot of Commercial Road, Oxford abutting 31 and 34 Commercial Road.

Changes to recommendations in the s42A report

40 In reviewing my recommended changes in Appendix A, it has come to my attention that I did not include a recommendation to 'update the non-urban flood assessment overly to urban flood assessment overlay as necessary', which was sought by Geoff Mehrtens [175.1]. I have now included this in the recommended provisions contained in **Appendix 2**.

Date: 5 July 2024

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Appendix 1 – List of materials provided by submitters

- Statement of Evidence of James Weir [161], dated 19 May 2024
- Statement of Evidence of Matt McLachlan for Waghorn Builders Limited [274], dated 19 May 2024
- Statement of Evidence of Matt McLachlan for Patrick Campbell and Elvere Mooney [365 and 366], dated 22 May 2024
- Statement of Evidence of Patric Campbell and Elvere Mooney [365 and 366], dated 23 May 2024
- Speaking notes of Elvere Mooney, dated 4 June 2024

Appendix 2 – Recommended amendments to PDP provisions

In order to distinguish between the recommendations made in the s42A report and the recommendations that arise from this report:

- s42A recommendations are shown in red text (with underline and ~~strike out~~ as appropriate); and
- Recommendations from this report in response to evidence are shown in blue text (with underline and ~~strike out~~ as appropriate).

Insert new Southeast Oxford Development Area and ODP, and amend planning map to rezone 53 Harewood Road to GRZ as follows:

Part 3 – Area specific matters / Wāhanga waihanga - Development Areas / Existing Development Areas

SOX - South Oxford Development Area[4]

Introduction

The South Oxford Development Area comprises approximately 3.5ha of land fronting Harewood Road. It is directly to the east of Oxford Hospital. The area is General Residential Zone.

The DEV-SOX-APP1 area includes:

- Roading connections through to Harewood Road and neighbouring land;
- pedestrian/cycle connections (within the road);
- stormwater treatment area; and
- an identified reserve area.

Activity Rules

DEV-SOX-R1 South Oxford Development Area Outline Development Plan	
Activity status: PER Where: 1. development shall be in accordance with DEV-SOX-APP1.	**Activity status when compliance not achieved: DIS**
Advisory Note • For the avoidance of doubt, where an Activity or Built Form Standard is in conflict with this ODP, the ODP shall substitute the provision.	

Built Form Standards

There are no area-specific built form standards for the South Oxford ODP area.

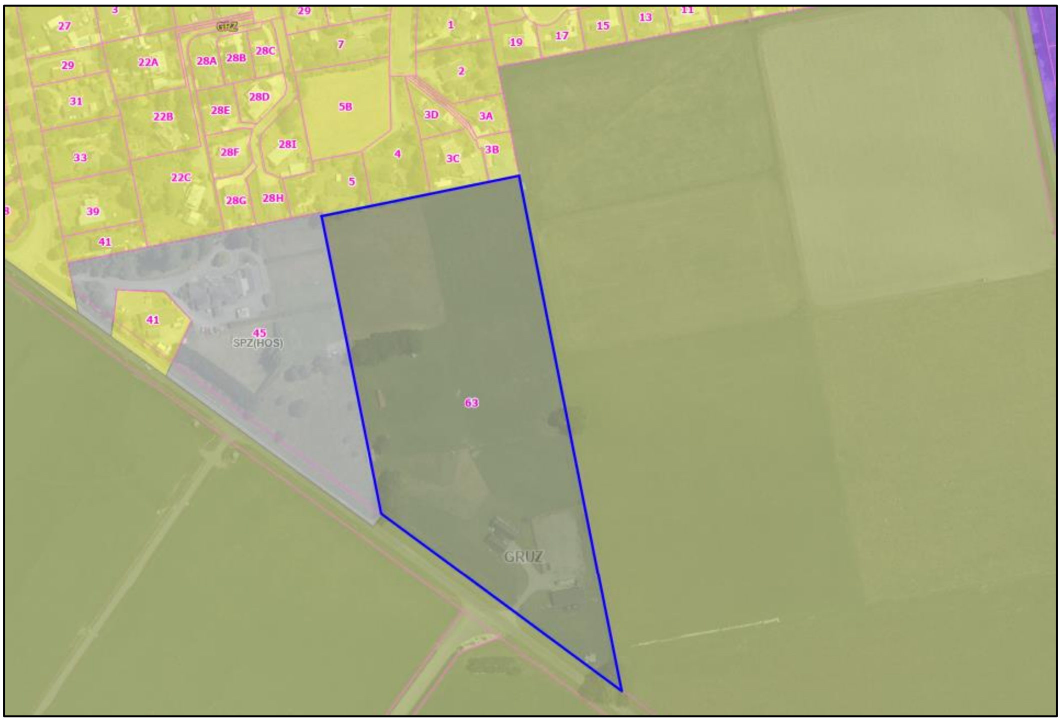
Appendix

DEV-SOX-APP1 Southeast Oxford ODP

[4] Geoff Mehrtens [175.1], Oxford-Ohoka Community Board [172.2] and Claudia & Geoff Mehrtens [FS24]

Include an ODP to like effect of the below including standardised Council format

Planning Map – Oxford – amend to show 63 Harewood Road, Oxford (identified below inside the blue line) as GRZ, and update the non-urban flood assessment overlay to urban flood assessment overlay as necessary.



Appendix 3 – Recommended responses to submissions and further submissions

Table B: Recommended responses to submissions and further submissions

Sub. Ref.	Submitter / Further Submitter	Provision	Decision Requested (Summary)	Section of this Report where Addressed	Officer's Recommendation	Officers' Reasons/Comments	Recommended Amendments to Proposed Plan?
Oxford							
175.1	Geoff Mehrtens	Planning Maps – General	Rezone 63 Harewood Road, Oxford, from General Rural Zone to General Residential Zone.	3.3	Accept	A Joint Witness Statement (JWS) between myself and Ms Claire McKeever (Planner representing Geoff Mehrtens [175.1]) has been prepared. Key matters addressed in the JWS include: • the National Policy Statement for Highly Productive Land 2022 (NPS-HPL); • the objectives and policies of the Proposed Plan; • Consideration of Council's Engineering and Reserve Advice; and • The proposed area specific matters for insertion in the Proposed Plan. We agreed on all matters. There were no matters of disagreement. It is the joint opinion of both Ms McKeever and me that the overall conclusions of the s32AA provided with the original submission remain the same. I recommend that 63 Harewood Road, Oxford is rezoned from GRUZ to GRZ.	Yes
172.2	Oxford-Ohoka Community Board	SUB-S1	Provide for smaller sections on Oxford outskirts as infill housing adversely affects Oxford rural character. Zone land around Oxford Frew's Yard and Harewood Road as industrial.	3.3 The industrial rezoning aspects of this submission point are being addressed by the Industrial	Accept in part	Rezoning 63 Harewood Road provides for The Boards preference for land on the outskirts of Oxford to be rezoned to allow for more residential development.	Yes

Sub. Ref.	Submitter / Further Submitter	Provision	Decision Requested (Summary)	Section of this Report where Addressed	Officer's Recommendation	Officers' Reasons/Comments	Recommended Amendments to Proposed Plan?
				Rezoning s42A report.			
FS24	*Claudia & Geoff Mehrtens*		*Support in part (related to zoning for housing on outskirts of oxford)* *Oppose in part (related to industrial zoning aspects)*		*Accept*		*Yes*
172.3	Oxford-Ohoka Community Board	Planning Maps – General (incorrectly referenced as EI-R45 in the summary of submissions)	Oppose infill housing in Oxford. Seek smaller sections on outskirts of Oxford. Rezone area around the Oxford Frews' Yard and the Harewood Road for industrial.	3.3 The industrial rezoning aspects of this submission point are being addressed by the Industrial Rezoning s42A report.	Accept in part	Rezoning 63 Harewood Road provides for The Boards preference for land on the outskirts of Oxford to be rezoned to allow for more residential development.	Yes
FS24	*Claudia & Geoff Mehrtens*		*Support in part (related to zoning for housing on outskirts of oxford)* *Oppose in part (related to industrial zoning aspects)*		*Accept*		*Yes*
161.1	James Brett Weir	SUB-R10	Amend zoning from rural to residential between 12 Bush Road and Mill Road (on the even-numbered side of the road).	3.3	Reject	The subject sites are proposed to be zoned General Rural Zone and contain LUC 2 and 3 soils. The exceptions for restricting urban zoning of HPL within the NPS-HPL are not meet. Rezoning the land would not give effect to the NPS-HPL.	No
FS82	*Rolleston Industrial Developments Limited, Carter Group Property Limited, and CSI Property Limited*		*Support*		*Reject*		*No*
274.1	Waghorn Builders Ltd – Luke and Jake Waghorn	Planning Maps – General	Rezone 131 Main Street to General Residential Zone.	3.4	Reject	Would not avoid or mitigate natural hazards or land uses that would likely result in increases in frequency and/or severity of hazards, therefore, not achieving CRPS Policy 5.3.2(2)(a). In addition, rezoning this land does not avoid new subdivision, use and development of land that increases risks associated with natural hazards, and	No

Sub. Ref.	Submitter / Further Submitter	Provision	Decision Requested (Summary)	Section of this Report where Addressed	Officer's Recommendation	Officers' Reasons/Comments	Recommended Amendments to Proposed Plan?
						therefore does not achieve Objective 11.2.1, Policy 11.3.3 (Earthquake hazards) or 11.3.5 (general risk management approach) of the CRPS.	
355.1	Dennis James Powell	Planning Maps – General	Rezone the large sections between Main St. Commercial Rd and Cheapside St., Oxford from Large Lot Residential Zone to General Residential Zone.	3.4	Reject	Would not avoid or mitigate natural hazards or land uses that would likely result in increases in frequency and/or severity of hazards, therefore, not achieving CRPS Policy 5.3.2(2)(a). In addition, rezoning this land does not avoid new subdivision, use and development of land that increases risks associated with natural hazards, and therefore does not achieve Objective 11.2.1, Policy 11.3.3 (Earthquake hazards) or 11.3.5 (general risk management approach) of the CRPS.	No
365.1	Patrick Thomas Campbell and Elvere Nina Mooney	Planning Maps – General	Rezone 6 York Street Oxford and Lot 1 from 34 Commercial Road, and all properties in the triangle between Commercial Road and Cheapside Street, and including Bath Street, York Street, Perth Street and Cheapside Street, from Large Lot Residential Zone to General Residential Zone.	3.3 (34 Commercial Rd) and 3.4 (other properties identified)	Reject	Would not avoid or mitigate natural hazards or land uses that would likely result in increases in frequency and/or severity of hazards, therefore, not achieving CRPS Policy 5.3.2(2)(a). In addition, rezoning this land does not avoid new subdivision, use and development of land that increases risks associated with natural hazards, and therefore does not achieve Objective 11.2.1, Policy 11.3.3 (Earthquake hazards) or 11.3.5 (general risk management approach) of the CRPS.	No
366.1	Patrick Thomas Campbell and Elvere Nina Mooney	Planning Maps – General	Rezone 15 Perth Street, Oxford and all properties in the triangle between Commercial Road and Cheapside Street, including Bath Street, York Street, Perth Street and Cheapside Street, from Large Lot Residential Zone to General Residential Zone.	3.4	Reject	Would not avoid or mitigate natural hazards or land uses that would likely result in increases in frequency and/or severity of hazards, therefore, not achieving CRPS Policy 5.3.2(2)(a). In addition, rezoning this land does not avoid new subdivision, use and development of land that increases risks associated with natural hazards, and therefore does not achieve Objective 11.2.1, Policy 11.3.3 (Earthquake hazards) or 11.3.5	No

Sub. Ref.	Submitter / Further Submitter	Provision	Decision Requested (Summary)	Section of this Report where Addressed	Officer's Recommendation	Officers' Reasons/Comments	Recommended Amendments to Proposed Plan?
						(general risk management approach) of the CRPS.	
93.1	George Welch	GRZ - General Residential Zone – General	Consider extending the residential zone North along High Street, Oxford to include smaller properties adjacent to the current residential zone.	3.4	Reject	Would not avoid or mitigate natural hazards or land uses that would likely result in increases in frequency and/or severity of hazards, therefore, not achieving CRPS Policy 5.3.2(2)(a). In addition, rezoning this land does not avoid new subdivision, use and development of land that increases risks associated with natural hazards, and therefore does not achieve Objective 11.2.1 or 11.3.5 (general risk management approach) of the CRPS.	No
Ohoka							
228.1	Grace Cameron and Nathan Wilson	Planning Maps – General	Rezone 351 Bradleys Road, Ohoka, from Rural Lifestyle Zone to Settlement Zone.	3.5	Reject	This is not considered to be a significant development in terms of Policy 8 of the NPS-UD. The property is not located within an existing urban area or a greenfield priority area identified on Map A of the CRPS, nor is the urban rezoning sought provided for elsewhere in the CRPS. Consequently, the rezoning of 351 Bradleys Road from RLZ to SETZ would not give effect to the objective and policy direction in the CRPS to avoid the further urban development of the Ohoka area.	No
Woodend Beach							
394.1	David Butt Catherine Butt	Planning Maps – General	Retain the current Settlement Zone at Woodend Beach.	N/A	Accept	Agree. There is no contention that the Settlement Zone at Woodend Beach should be retained as notified.	No
397.1	Catherine Butt	Planning Maps – General	Retain the current Settlement Zone at Woodend Beach.	N/A	Accept	Agree. There is no contention that the Settlement Zone at Woodend Beach should be retained as notified.	No
399.1	Ronnie Dawe	Planning Maps – General	Retain the current Settlement Zone at Woodend Beach.	N/A	Accept	Agree. There is no contention that the Settlement Zone at Woodend Beach should be retained as notified.	No

Appendix 4 – Reformatted Engineering and Greenspace Advice

WAIMAKARIRI DISTRICT COUNCIL

MEMO

FILE NO AND TRIM NO:	DDS-14-13-02 / 240613096111
DATE:	5 July 2024
MEMO TO:	Rachel McClung, Principal Policy Planner
FROM:	S Binder (Transport) J Aramowicz (Servicing, Hazards) C Bacon (Servicing, Hazards) J Read (Green Space) On behalf of Waimakariri District Council
SUBJECT:	Proposed District Plan Rezoning Requests Stream 12A – Servicing, Hazards, Geotechnical, Green Space

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Oxford Rezoning Submission GRUZ to GRZ

Submission 161 (James Weir) - 12, 38, 52, 54, 68, 74 and 88 Bush Road, Oxford

Transport – *S Binder 19 June 2024*

1. Bush Road has a very narrow road reserve, well below the operative and proposed District Plan standards. I consider that full GRZ density cannot be appropriately serviced from a road reserve of 10m – the road reserve should be widened in order to contain roading features, e.g., an appropriate width carriageway, footpath(s), lighting, street trees, underground services. If a lower density residential zoning were to be considered, the road could have fewer features added but will still require substantial investment, and I would also recommend widening for any upzoning.

2. No traffic assessment has been conducted so we do not know whether enough new traffic will be generated to create major traffic effects. The existing background traffic is quite low (183 ADT estimated on MobileRoads), but the road is under width and not to operative or proposed local road standard.

3. This area is close to the school (~1.0 km) and a distance from the town centre that could be walked or cycled (~1.75 km), such that with aforementioned infrastructure upgrades, it could be served adequately by appropriate modes.

Servicing – *J Aramowicz 2 July 2024*

Stormwater

4. It is difficult to assess the likely stormwater requirements without a proposed layout for the site. However, at a high-level, there are two stormwater channels

running through the site. One in the southwest corner, and another along the northern boundary, which are evident in the aerial photography. These would need to be allowed for in any development design.

5. There is also an area of low flood hazard on the eastern side of the site (12 Bush Road) which would need to be managed, and this may be a logical location for stormwater management areas (depending on the fall of the land).

6. I note that further downstream, the Church Street/Burnett Street area has historically had drainage issues.

7. Stormwater would need to be attenuated and managed within the development to avoid any offsite effects.

Wastewater

8. A high-level assessment assumes this rezoning could generate around 150 additional residential lots. Council's Network Planning team have confirmed the existing system is not designed to service this scale of development, and modelling is needed to understand the specific upgrades required to service the area. At a high level, significant upgrades would most likely be required to service the additional residential lots.

Water

9. As above for wastewater, the network in this area is not designed to service a general residential development of this scale. Modelling is required to understand the specific upgrades required to service the area. At a high level, significant upgrades would most likely be required to service the additional residential lots.

Geotechnical & Natural Hazards - *J Aramowicz, 2 July 2024*

10. The site is in an area where groundwater is recorded on Waimaps to be ~2.5m bgl. There are no springs recorded on Waimaps.

11. Groundwater resurgence is not a known hazard at this site/ or in this area.

12. There are no known active faults that cross the site that are shown on the WDC GIS. Given this, ground rupture is not a known risk at this site.

13. In general, there are no steep slopes across most parts of the site, except for parts of 68 & 74 Bush Rd where the aerial photography indicates there is a moderate to steep slope with a driveway that has been formed across the slope to access a dwelling at the upper part of the site. Given this, land slippage and rockfall are unlikely to pose a significant risk, albeit that careful geotechnical consideration will need to be given on any development that may be proposed in the areas of the moderate to steep slope.

14. The area is not at risk from Tsunami.

15. The topography suggests the site is unlikely to be underlain by any thick layers of soft, loose, saturated sands, and is more likely to be underlain by gravels which are recorded in a well log that is shown on the ECan GIS to the southeast of the site (L35/0718). Given this, the site is unlikely to have significant risk of liquefaction.

16. There are no significant waterways that cross the site, or are located near. Erosion/sedimentation are not likely hazards at this site.

17. The site generally has a Very Low flood hazard in the All Flood Hazard 200 year mapping. As mentioned in the stormwater section, there is an area of low flood hazard at both the eastern and western ends of the site which would need to be allowed for in development design.

18. In summary, there are no known ground conditions or significant risks from natural hazards that would prevent the proposed land use.

Greenspace – *Jon Read 25 June 2024*

19. The Bush Road properties relating to this submission are in a location that is not currently prioritised for future residential growth in the Oxford area. Not being part of a planned urban growth zone, structure plan or outline development plan, means that efficient and effective provision of a neighbourhood community park space for residents is not feasible. In this context, the area could remain a poorly serviced outlier for many years.
20. Under Council levels of service for park provision, the proposed rezoning area is well outside of community access guideline of 500m walking distance to an existing neighbourhood park (Pearson Park). Distances via existing road corridors vary from approximately 750m to 1500m. The slightly closer Oxford School grounds and associated facilities are not designated public reserve assets; they can complement but not replace Council provision of purpose-built public spaces.
21. The proposed rezoning sites currently lack adequate infrastructure to service non-motorised activity within, or to and from, the area. This includes a lack of safe movement corridors for cyclists and pedestrians.

<u>Ohoka Rezoning Submission RLZ to SETZ</u>

<u>Submission 281 (Grace Cameron and Nathan Wilson) - 351 Bradleys Road, Ohoka</u>

Transport – *S Binder 19 June 2024*

22. I would not support changing the zoning to SETZ because of its potential for future subdivision, as the west side of Bradleys Road is not well served by the transport network (except for private motor vehicle use via Bradleys Road itself).

Servicing – *J Aramowicz 2 July 2024*

Stormwater

23. The Ohoka Stream runs through the northeastern side of the site. There is a large area of medium flood hazard associated with the Ohoka Stream. The site is located at the true right edge of the overland flow path.

24. Roughly half of the site is subject to medium and low flood hazard.

25. Stormwater runoff from a future development would need to be managed on site such that offsite effects are neutral. I note that in an area that is subject to a medium flood hazard and typically with high groundwater that stormwater attenuation will most likely need to be achieved using roofwater attenuation tanks, and avoiding of placing fill material within the overland flow path area.

Wastewater

26. Under a SETZ zoning I understand one additional lot could be created. This could be accommodated in the existing reticulated system.

Water

27. Under a SETZ zoning I understand one additional lot could be created. This could be accommodated in the existing reticulated system.

Geotechnical & Natural Hazards - *J Aramowicz, 2 July 2024*

28. There are no known active faults in the nearby area recorded by GNS.

29. The site does not have any significant slopes and therefore land slippage, falling debris are not likely hazards.

30. The site is not at likely risk from Tsunami.

31. The applicant has not provided a geotechnical report and therefore it is unknown if the site contains uncontrolled fill materials.

32. The applicant notes the site is an area where groundwater is typically shallow in winter conditions.

33. A nearby well log from ECan's GIS indicates the presence of shallow gravels that extend to considerable depth. This suggests that despite the shallow depth to groundwater, due to the presence of deep gravels, liquefaction is not a likely hazard.
34. The Ohoka Stream also runs through the northeast part of the site. This stream is known to rise and overtop in larger rainfall events.

35. Importantly, roughly the northeastern half the site is affected by a medium and high flood hazard in the All Flood Hazard 200 year flood mapping.

36. The extent of the blue (medium) flood hazard indicates 351Bradleys Rd is located at the true right edge of what is actually a large overland flow path.

37. I have reviewed the historic aerial photography of the site. Despite the flood hazard, there is no evidence in the historic aerial photography that I have seen of any significant erosion or sediment that has occurred in the last c.50 years due to overland flows of stormwater.

38. To ensure the risk from inundation to surrounding property does not increase, no filling should be allowed within the area of medium flood hazard.

39. Given this, I would not support a dwelling being established within the medium hazard area shown in the All Flood Hazard 200 year flood mapping.

40. The only area mapped as Very Low Hazard (clear) in the All Flood Hazard 200 year mapping is at the southwestern end of the site, adjacent to the Ohoka Water Supply well. A dwelling is already consented for this area, which means there is no remaining area clear of flood hazard to establish a second dwelling.

41. I would not support a second dwelling being constructed on this site due to the presence of medium flood hazard and the difficulty in mitigating the potential effects of a development subject to those constraints.

Greenspace – Jon Read (25 June 2024)

42. There are no triggers for Greenspace or public streetscape amenity provision triggered by this zone change proposal. The portion of Ohoka Stream (north branch) that lies within the property does not trigger any esplanade reserve or strip requirement under the current or proposed District Plan.

Submission 175 (Geoff Mehrtens) – 63 Harewood Road

Transport - *WSP*

43. Refer to WSP Advice – Record No. 240321045341

Servicing – *J Aramowicz 18 March 2024*

Stormwater

44. There are no significant constraints that would prevent rezoning to GRZ.

Wastewater

45. Rezoning of the site to GRZ as part of the 2024 PDP, and assuming subsequent subdivision development, would trigger the need to upgrade of the wastewater pipe along Harewood Rd, possibly ahead of the 11-20yr timeframe shown in the WDC growth model.

Water

46. Rezoning of the site as part of the 2024 PDP, and assuming subsequent subdivision development, would trigger the need to upgrade of the water supply

and w/w pipe along Harewood Rd, possibly ahead of the 11-20 year timeframe shown in the WDC growth model.

47. For wastewater, if they went first, they would need their own pump station to use reticulation to the west. If the bigger block to the east developed to residential standard, 63 Harewood could connect into their system and the proposed new pump station would service the area (ultimately).

Geotechnical – *J Aramowicz 18 March 2024*

48. There are no significant risks from potential natural hazards that would prevent rezoning to GRZ.

Hazards – *J Aramowicz 18 March 2024*

49. There is the remnant of an overland flow path in the southern portion of the site, but this appears to have been broken up by modifications already undertaken to land levels. There is no significant flood hazard on the site.

Greenspace – *J Read 28 March 2024*

50. The Mehrtens rezoning submission advocates a proposed zone change from General Rural Zone to General Residential Zone at 63 Harewood Road. It includes an extensive Planning Assessment and a proposed Outline Development Plan (ODP). This documentation references perceived benefits and positive outcomes relating to:
    - Integration with the existing Oxford township,
    - An integrated neighbourhood adjoining the existing township of Oxford,
    - Social benefits via adjoining existing residential development and close proximity to community facilities and town centre,
    - The site is considered walkable to Oxford and the townships community amenities,
    - Community health and well-being encouraging walking, cycling and other non-motorised transport options,
    - Resilience via connectivity and social interaction and connectivity throughout the future residential development to the east and to Oxford.

51. It will be very difficult for all of the above aims to be realised in the foreseeable future given that the ODP site will be surrounded by extensive rural land to the East and established urban residential properties to the north. There are no direct connections to Oxford township. Consequently, none are being shown on the ODP.

52. Access to the township's park spaces and key facilities will be by vehicle or via a long indirect walk off the development's southern (Harewood Rd) boundary. This does not meet Council's Parks level of service standards regarding acceptable distances and walking time to a neighbourhood park space. The physical barrier formed by the unbroken line of existing residential boundary lots to the north makes it difficult for Council to advocate or support the potential provision of an otherwise justifiable new neighbourhood Park within the Mehrtens proposed ODP area.

53. In this scenario, there is still an opportunity for a neighbourhood park space to be planned for within the future development area to the east of the current proposal. The proposal to rezone 63 Harewood Road may have merits, but when it comes to resident access to public park spaces and opportunities for physical and social connection and integration with the wider community, I believe it is currently lacking.

Oxford Rezoning Submission LLRZ to GRZ

Submission 274 (Waghorn Builders Limited) – 131 Main Street

Transport – *S Binder 15 March 2024*

54. Cheapside Street will require urbanisation and widening.

55. Cheapside Street has a very narrow road reserve, but I do not anticipate that the level of traffic generated by this change to create major traffic effects.

Servicing – *J Aramowicz 19 March 2024*

Stormwater

56. The area is underlain by silty loam soils with medium-low infiltration capacity soils. Engineering design will need to ensure the rate/volume of stormwater runoff is attenuated to pre-development levels to avoid exacerbating the existing flood hazard. There should be no filling of the land to raise ground levels due to the existing risk of inundation.

Wastewater

57. There is an existing wastewater main along Main St (TRIM 231206196571). It is considered there will be sufficient wastewater capacity to supply demand from the proposed GRZ.

Water

58. There is an existing water main along Main St, and upgrade works are forecast for period 1 (1-10yrs) in the 50 years 2023 growth model (TRIM 231206196571). It is considered there will be sufficient capacity to supply demand from the proposed GRZ.

Geotechnical – *J Aramowicz 19 March 2024*

59. There is a suspected active fault (Starvation Hill fault) that passes through the site. GNS report 2033/44 for eastern Oxford (Lots 2 & 3 DP51992) assumes the Starvation Hill fault has a recurrence interval III and (at that location) that the fault area be zoned GRUZ to minimise the density of development, but concedes that within GRUZ light timber framed single storey dwellings with a suspended timber floor supported on shallow timber piles could be used as partial mitigation of the risk of fault rupture.

60. I recommend a similar approach be adopted to the part of the site that is within 20m of any faults shown on the GNS active faults database, unless further geological investigation is carried out and is able to justify an alternative approach. General Residential zoning not supported within that setback.

Hazards – *C Bacon 22 March 2024*

61. There is substantial medium hazard flooding across the site. RC225255 consented subdivision to 3 lots. Each lot has a consent notice requiring houses to be constructed on pile foundations; no major earthworks are permitted without an assessment of flood effect. On site system to manage the 10% AEP is required - either soakpits, or other attenuation. Secondary flow paths need to be allowed for in stormwater design for the site. Tawera Lane drain downstream has capacity issues - existing LOS challenges; requires upgrade. LOS would be primary event in the channel, but needs to be able to convey the 50 year.

62. There are major flooding and drainage challenges at this site, and an active fault runs through southern portion of it. If rezoning to GRZ would permit another dwelling to be established here, we do not support the rezoning of this site.

<u>Oxford Rezoning Submission LLRZ to GRZ (Group)</u>

<u>Submission 355 (Denise Powell) – 39 Commercial Road</u>
<u>Submission 365 (Patrick Campbell & Elvere Mooney) – 6 York Street</u>
<u>Submission 366 (Patrick Campbell & Elvere Mooney) – 16 Perth Street</u>

Transport – *S Binder 15 March 2024*

<u>Main St, Commercial Rd, Cheapside St, Oxford</u>

63. All of the north-south streets will likely require urbanisation and widening.

64. All of the north-south streets have very narrow road reserves, well below the operative and proposed District Plan standards. I consider that full GRZ density cannot be appropriately serviced from a road reserve of 10m – the road reserve should be widened in order to contain roading features, e.g., an appropriate width carriageway, footpath(s), lighting, street trees, underground services.

65. No traffic assessment has been conducted so we do not know whether enough new traffic will be generated to create major traffic effects. The existing background traffic is quite low on all streets, but streets are under width and not of local road standard.

66. It would appear that Submission 365 does not include 34 Commercial Road (which is on the south side of Commercial Road and outside of the "triangle" common across all three submissions). Hopefully this is a correct interpretation because the "triangle" north of Commercial Rd already has a transport network and connections appropriate for GRZ, but land south of Commercial Road is relatively isolated and poorly connected.

Servicing – *J Aramowicz 19 March 2024*

Stormwater

67. The area is underlain by silty loam soils with medium-low infiltration capacity soils. Engineering design will need to ensure the rate/volume of stormwater runoff is attenuated to pre-development levels to avoid exacerbating the existing flood hazard. There should be no filling of the land to raise ground levels due to the

existing risk of inundation. There may be an opportunity to divert stormwater south away from Flannigans Drain (which has existing issues). Note flood hazard comments re the east of the site.

Wastewater

68. There is an existing wastewater main along Commercial St, and upgrade works are forecast for period 1 (1-10yrs) in 50yr 2023 growth model (TRIM 231206196571). It is considered there will be sufficient capacity to accept future waterwater demand from the proposed GRZ.

Water

69. There is an existing water main at the NE corner of the site at Commercial St. Subdivision of OXG01 would require upgrade of the water supply main along Commercial Rd which is scheduled to occur in the period 1 (10-20yrs) in the 50 year 2023 growth model (TRIM231206196571). WDC may need to bring forward wastewater upgrade if OXG01 is rezoned to GRZ.

Geotechnical – *J Aramowicz 19 March 2024*

70. There are suspected active fault/s that passes through the area of submissions 355/365/366 (north of Commercial Rd). GNS report 2033/44 for eastern Oxford (Lots 2 & 3 DP51992) assumes the Starvation Hill fault has a recurrence interval III and that the fault area be zoned GRUZ to minimise the density of development, but concedes that within GRUZ light timber framed single storey dwellings with a suspended timber floor supported on shallow timber piles could be used as partial mitigation of the risk of fault rupture.

71. I recommend a similar approach be adopted to any areas of submissions 274/355/365/366 that are within 20m of the faults shown on the GNS active faults database. The problem is that GNS, or another experienced geologist, have not determined the location of ground rupture/deformation that the 20m setback would need to apply.

72. In short, further geological investigation of the active fault across the site is needed before WDC can assess whether the site can be used in part for the proposed GRZ. Until this is done, WDC recommend the proposed rezoning be rejected. General Residential zoning is not supported within the 20m fault avoidance zone setback.

Hazards – *C Bacon 22 March 2024*

73. The west of this area is mostly outside of low, medium and high flood hazard and is located in very low flood hazard (200 year mapping).

74. The eastern side of the 'triangle' area, between Cheapside Street and Perth Street, is in low/medium flood hazard located in the overland flow path which crosses Oxford south of Main Street. Earthworks are not recommended in this area due to likelihood of causing effects to neighbours.

75. The presence of the flood hazard overland flow path and the faults together make it difficult to support rezoning the area between Perth Street and Cheapside Street to General Residential. We do not recommend rezoning this area of land to GRZ based on presence of hazards.

Greenspace – *J Read 28 March 2024*

76. The rezoning submissions related to these various other individual sites in Oxford raise no particular public open space or community green space matters of relevance to a decision. The general principles of maintaining and creating a stable, integrated and well-connected community still apply.

Oxford Rezoning Submission LLRZ to GRZ
Submission 93 (George Welch) – 179B High Street and other 'small lots'
26, 50, 50A, 52 Church Street (split zoning)

Transport – *S Binder 15 March 2024*

77. Many of these sites gain access through narrow driveways/accessways/ROWs, and these are not likely suitable for servicing GRZ density (e.g. 50B-E Church Street in particular). Access into these LLRZ sites behind current GRZ sites is likely to be a constraint on future development.

78. Any upzoning north-west of Church Street will likely require urbanisation of Church Street and High Street frontages, including a sizeable drain and culvert at 197B High St. It is also worth considering that the operative District Plan requires a footpath on one side only, but the proposed Plan will require footpaths on both sides, which could be a change from historical levels of service in this area. Two footpaths would be required.

79. There could be some broader network benefit to extending the urbanisation north to Queen Street (north to 209) to provide better connectivity to the retirement village on Queen Street.

80. Queen Street itself is constrained (very narrow reserve and carriageway, with no footpath). There may need to be a broader conversation if we are going to extend to Queen Street, due to its limitations. This could also need a conversation around a north-south link through land between High Street and Wilsons Road (which would best be coordinated through an Outline Development Plan). Otherwise, I would not see a strong need from transport for an ODP.

81. No traffic assessment has been conducted so we do not know whether enough new traffic will be generated to create major traffic effects. There may not be enough new traffic generated to require substantial improvements to the Church / Weld / High intersection, but I cannot confirm this without more detail on total new yield and traffic generated. I do have concerns regarding lots which gain access from Church Street via long narrow accessways, and how these would function in a GRZ environment. They do not meet local road or cul-de-sac standard.

Servicing – *J Aramowicz 19 March 2024*

Stormwater

82. I am unable to determine from WDC GIS if stormwater infiltration into ground will be practical in this area, although Landcare soil mapping indicates the area is underlain by silt loam which suggests moderate to low infiltration capacity. Practicality of providing stormwater servicing to these lots is a concern. Engineering design would need to ensure the rate/volume of stormwater runoff is

attenuated to pre-development levels to avoid exacerbating the existing low flood hazard. WDC engineering staff are aware of known poor drainage issues in this area due to channel overflow. There are also challenges with direction of fall (away from road).

Wastewater

83. There is an existing wastewater main along High St, there will be sufficient capacity to accommodate the proposed GRZ.

Water

84. There is an existing water main along High St. There will be sufficient capacity to service the proposed GRZ.

85. I consider 52 and 26: better suited to LLRZ and do not recommend GRZ.

86. I consider that 50 and 50A could be GRZ on basis no additional dwelling could be established here (I query whether it is worth 'redrawing' the boundary just for these two lots).

87. Stormwater servicing is a major challenge in this area of Oxford, and for that reason rezoning 26 and 52 Church Street to GRZ is not supported.

Geotechnical – *J Aramowicz 19 March 2024*

88. There are no active faults.

Hazards – *J Aramowicz 19 March 2024*

89. These sites are in an area of low/medium flood hazard with silt loam soils. Stormwater runoff will need to avoid exacerbating the flood risk to surrounding/downstream properties. There should be no filling of the site to avoid worsening the flood risk to surrounding properties. We do not recommend rezoning any LLRZ properties to GRZ where they are located in an overland flow path (as they are here). This area already has extensive drainage issues which would be worsened with density.

Greenspace – *J Read 28 March 2024*

90. This stream has no implications for green space or open space matters.

<u>Split zone - 22, 24, 50B-E, 60B Church Street, Oxford</u>

Transport – *Covered in response to Submission 93.*

Servicing – *J Aramowicz 19 March 2024*

Stormwater

91. All of 22 & 24 Church St, and the north half of 50B-E and 60B Church St are affected by LOW flood hazard. However, WDC engineering staff report known drainage/issues due to channel overflow in nearby area.

Wastewater

92. There is an existing wastewater main along Church St., and upgrade works are not forecast for the general area in the in 50yr 2023 growth model (TRIM 231206196571). It is considered there will be sufficient capacity to accept future watewater demand from the proposed GRZ of the 'split' lots.

Water

93. There is an existing water main along Church St, and upgrade works are not forecast for the general area in the in 50yr 2023 growth model (TRIM 231206196571). It is considered there will be sufficient capacity to accept future wastewater demand from the proposed GRZ of the limited number of ‘split' lots.

94. Stormwater servicing is a major challenge and access would need to be planned properly. 22 Church Street has some of the worst drainage issues in the area, therefore rezoning to GRZ is not supported.

Hazards – *J Aramowicz 19 March 2024*

95. Presence of low and medium flood hazard across these sites is an overland flow path - stormwater servicing challenge. Historically Oxford land drains across to neighbours, and this will be worsened by development.

96. Engineering do not support rezoning from LLRZ to GRZ:
    - 22 Church Street
    - 24 Church Street
    - 50B - E Church Street
    - 60B Church Street

97. Due to stormwater management issues and presence of overland flow path. This is one of the worst areas in Oxford for drainage and stormwater issues.

Appendix 5 – NZ Geotechnical Consultants report, dated 18/04/2023

GEOTECHNICAL CONSULTANTS

Geotechnical Investigation Report

Address: 131 Main Street, Oxford, Canterbury

Date: 18/04/2023

Prepared by:

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Limitations

This report has been prepared by NZ Geotechnical Consultants Limited for the sole use of our client, as noted above. The findings in this report are not intended for use by other parties and may not contain sufficient information for the purposes of other parties or other uses. No third party (excluding the local authority) may use or rely upon this report unless authorised in writing by NZGCL.

The recommendations and opinions contained in this report are based on our visual reconnaissance of the site, information from geological maps and upon data from the field investigation as well as the results of in situ testing of soil. Inferences are made about the nature and continuity of subsoils away from and beyond the exploratory holes which cannot be guaranteed. The descriptions detailed on the exploratory hole logs are based on the field descriptions of the soils encountered.

NZ Geotechnical Consultants Limited cannot anticipate or assume responsibility for any unexpected variations in ground conditions. If conditions encountered on-site during construction appear to vary from those contained within this report, NZ Geotechnical Consultants Limited should be notified immediately. In accepting delivery and/or using this report, the recipient agrees that he/she accepts the report on the basis set out herein.

Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report, in regard to its accuracy or completeness.

This report includes Appendices. These appendices should be read in conjunction with the main part of the report and this report should not be considered complete without them.

Table of Contents

1.0 INTRODUCTION

1.1 Terms of Reference

NZ Geotechnical Consultants Ltd (NZGCL) was commissioned by Waghorn Builders Limited on the 4th May 2022 to provide a combined Resource and Building Consent Geotechnical Report for the proposed development at 131 Main Street, Oxford, Canterbury (Lot 1 DP 80871 BLK VIII OXFORD SD).

1.2 Proposed Development

It is proposed to subdivide the site into three separate lots, with the existing residential building remaining on-site and two relocated properties constructed to the south and one relocated property constructed to the north. NZGCL are not in receipt of any plans/drawings at the time of writing this report, however the proposed site division is highlighted in Figure 1 below.

Figure 1: Site Aerial Photo with Proposed Subdivided Boundaries (Courtesy of Canterbury Maps)

1.3 Objective/Scope

The objective of this report is to describe the ground conditions encountered during the geotechnical investigation with comments on subgrade conditions, Ultimate Bearing Capacities (UBC's), liquefaction susceptibility and provide foundation recommendations for the proposed residential structures to assist with the Building Consent and Resource Consent. To achieve the outlined objectives this geotechnical investigation comprised the following:

- A geotechnical desktop study to review geological mapping and geotechnical information resources.
- A review of historical aerial photographs.
- A site walkover.
- A shallow intrusive investigation comprising machine excavated Test Pits (TP's) to a target depth of 3.0m below ground level (bgl).
- A Resource Management Act Section 106 assessment and provision of a Geotechnical Statement of Professional Opinion.
- Provision of an interpretive report summarising the above, highlighting geotechnical constraints, recommending suitable foundation types and providing geotechnical parameters for foundation design.

2.0 SITE DESCRIPTION

2.1 Site Location

The site is located approximately 45km northwest of central Christchurch and approximately 1.4km southwest of central Oxford, located to the south of Main Street. The site is L-shaped and covers a total area of 2,362m^2. The Google Earth coordinates of the approximate centre of the site are: 43°18’0.19”S, 172°10’50.67”E.

2.2 Site Walkover

The site is generally flat and is bordered by Main Street to the north, Cheapside Street to the west, and residential properties to the south and east. The following highlights information from the NZGCL site walkover:

- A single-storey residential structure, located toward the northern extent of the site, is clad with lightweight weatherboard cladding and lightweight metal roofing.
- A separate garage structure, located toward the southeast of the dwelling, is founded on a concrete slab-on-grade foundation (MBIE Type C).
- There are two other smaller structures on-site, used for storage, one located to the southeast of the garage and the other to the southwest of the dwelling.
- The site is generally covered with grass, soil and gravel. There are multiple trees and shrubs located around the boundary of the site.

No evidence of any geotechnical hazards or ground damage was observed during the NZGCL site walkover. Figures 2 to 6 show the site, taken during the NZGCL site walkover:

Figure 2: View of the entrance to the site (Looking East)

Figure 3: View of the road and southwestern boundary (Looking Southeast)

Figure 4: View of the existing dwelling and separate structures (Looking North)

Figure 5: View of the rear yard and separate structures (Looking Northeast)

Figure 6: View of the digger used for test pits and the soil conditions (Looking Southwest)

3.0 DESK-BASED INFORMATION

3.1 Historical Aerial Mapping

Historical aerial photographs available on the Canterbury Maps Viewer have been reviewed by NZGCL for the years 1940 through to the present. This review indicated the following:

- The site was developed in 1940 with a large structure observed in the northern extent of the site. It appears that this is different to the dwelling presently on-site.
- The 1955-1959 historical aerial shows the site to be developed with the residential dwelling that is present today.
- The 1965-1969 historical aerial shows a small garden area toward the north-eastern corner of the site.
- The later aerials also show a small, localised surficial rubbish stockpile in the southern extent of the site.
- The site generally remains relatively consistent from this period, with the addition of the separate garage structure and separate smaller structures occurring post-1999.

3.2 Historical Land Use

The ECan Listed Land Use Register (LLUR) holds information regarding sites that have been or currently are used for activities which have the potential to cause contamination.

According to the LLUR, there are currently no Hazardous Activities or Industries listed on or within 50m of the site. The full LLUR response is attached in Appendix A.

4.0 GEOLOGICAL DESK BASED INFORMATION

4.1 Geological Mapping

According to the GNS Geological Unit QMap, available on the New Zealand Geotechnical Database (Earthquake Commission/Ministry of Business, Innovation & Employment, 2016), the site is close to a geological boundary but is expected to be predominantly underlain by Late Pleistocene to Holocene river deposits, comprising '*Grey to brown, variably weathered, silty subangular gravel & sand forming alluvial fans (slope 1-20^{o}); some gully dissection'* (IQa). The south-eastern extent of the site is expected to be underlain by Late Pleistocene river deposits, comprising '*Unweathered, brownish-grey, variable mix of gravels/sand/silt/clay in low river terraces; locally up to 2m silt (Loess) cap'* (Q2a).

4.2 Geological Investigation Data

The New Zealand Geotechnical Database (NZGD) holds information regarding previous geotechnical investigations undertaken across the country. The website shows no information recorded within 200m of the site, therefore the data cannot be relied upon to provide accurate information for the soil conditions on-site.

5.0 GEO-HAZARDS

5.1 Land Zoning

According to the Waimakariri Liquefaction Susceptibility (2009) map, available on the Canterbury Maps Viewer, the site is in an area listed with the following:

- Zone of very low liquefaction potential – areas of alluvium older than Holocene.

A small area, in the south-eastern corner of the site, is shown to be in a zone of low liquefaction potential – areas of recent Holocene age alluvium (active riverbeds and flood plains). This follows the same path as the geological boundary across the site.

Figure 7: Site Aerial Photo with Liquefaction Susceptibility (Courtesy of Canterbury Maps)

5.2 Seismic Site Subsoil Classification

NZGCL considers that a seismic site subsoil classification 'Class D – Deep or soft soil sites', as defined in NZS:1170.5 is appropriate for the site.

5.3 Flooding

The Waimakariri District Council (WDC) GIS database indicates that the site is located in an area predominantly classified as having a medium flooding hazard from a 200-year event, but does show small, localised areas with a low flooding hazard (Figure 8). The Waimakariri District Council should be contacted to provide accurate Finished Floor Levels (FFL) for the proposed developments.

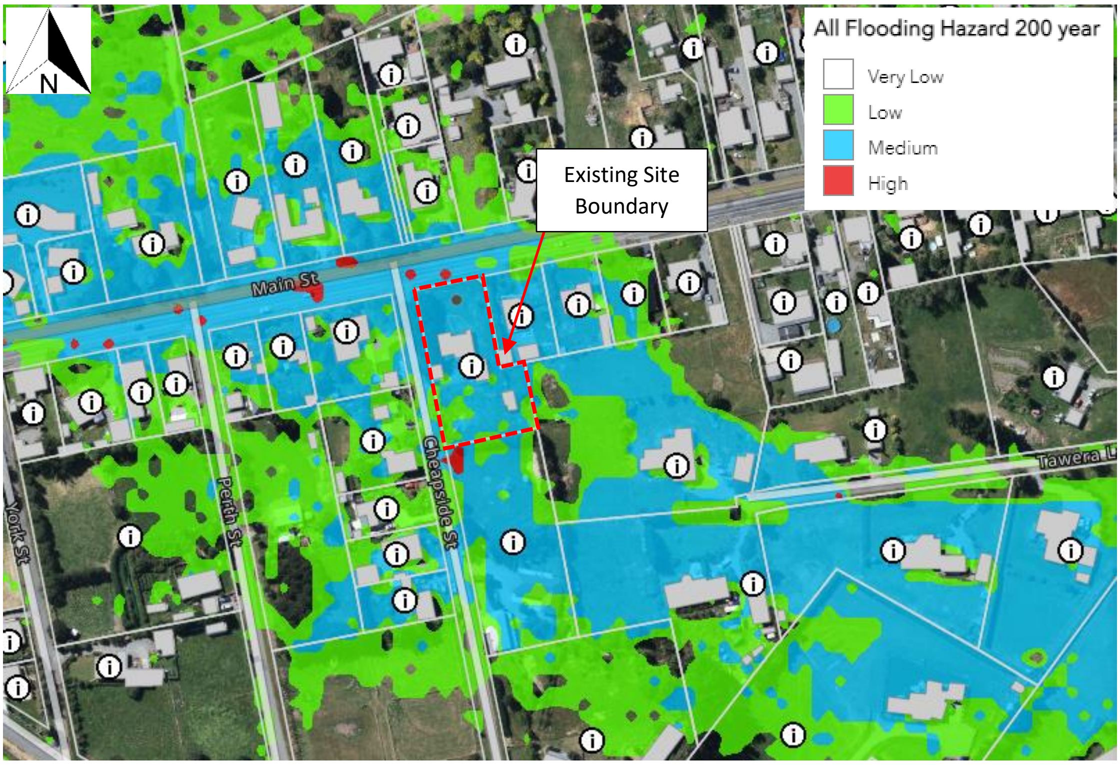

Figure 8: On-Site Flooding Risk (Courtesy of WDC)

5.4 Fault Hazard

According to the Waimakariri District Council (WDC) 'Natural Hazards Site Viewer' the site is within a Fault Awareness Area (FAA) associated with the Starvation Hill Fault (Figure 9). The fault awareness areas show areas where there might be a surface fault rupture hazard. Surface fault rupture is the permanent breaking, ripping, buckling or warping of the ground on or near the line where a fault meets the ground surface, as a result of movement on the fault. It is different from earthquake shaking. Fault awareness areas are categorised as Definite, Likely and Possible. The FAA transecting the site is classed as 'Likely – moderately expressed'. The fault recurrence interval is 1,700 – 8,500 years, which equates to a Recurrence Class of I to IV.

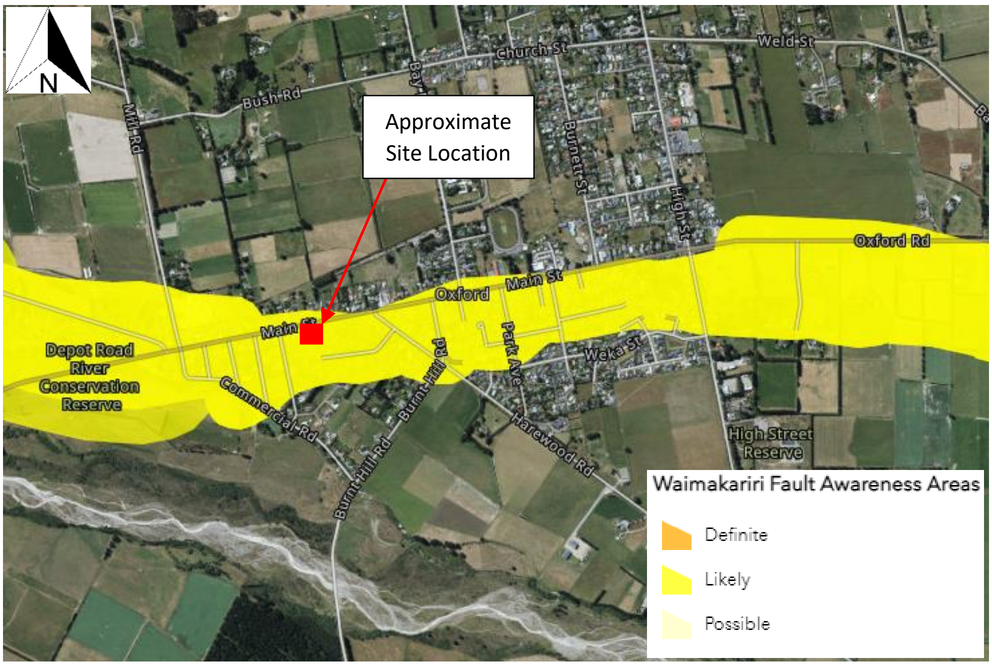

Figure 9: Highlighted Fault Awareness Areas (Courtesy of WDC)

The FAA information is derived from a GNS report (Guidelines for using regional-scale earthquake fault information in Canterbury' (ref:2014/211), Appendix B. Recommendations in the GNS report include actions for different proposed activities within FAA's, Figure 10.

Proposed Activity	**Recommended Actions**		
	For FAA categories: definite (well expressed) definite (mod expressed) likely (well expressed) likely (mod expressed) with RI < 5,000 years	For FAA categories: definite (well expressed) definite (mod expressed) likely (well expressed) likely (mod expressed) with RI > 5,000 years	For all other FAA categories: definite (not expressed) likely (not expressed) possible
Single residential dwelling (BIC 2a and 2b in part)	Fault maps in District Plans *and* fault information on LIMs and PIMs		
Normal structures and structures not in other categories (BIC 2b, apart from single dwellings)	Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).	Fault maps in District Plans *and* fault information on LIMs and PIMs	
Important or critical structures (BIC 3 and 4)	Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures determined for the accurately mapped fault (e.g. set back or engineering measures).		
New subdivision (excluding minor boundary adjustments)	Consideration of the surface fault rupture hazard should be a specific assessment matter. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).		Fault maps in District Plans *and* fault information on LIMs and PIMs
Plan Changes	Consideration of the surface fault rupture hazard should be a specific assessment matter. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures.		

Figure 10: Excerpt of the GNS Report 2014/211: Table 4.1

Another GNS report, 'Planning for Development of Land on or Close to Active Faults' provides guidance on building structures within Fault Awareness Areas and that in certain conditions, a risk-based approach needs to be taken when developing structures that are already in a town affected by the FAA (Appendix C).

The Fault Awareness Area, cutting through the site, has not been mapped to a high definition and is therefore a rough guidance of the approximate fault trace. The proposed development on-site is for two single-storey residential dwellings which would be classified as a BIC 2a development. In absence of undertaking detailed fault mapping through the town, it is recommended that the foundations of the proposed developments are robust enough to reduce/withstand the effects of fault rupture.

6.0 SITE INVESTIGATION

6.1 Site Specific Investigations

NZGCL visited the site on the 12th May 2022 and at a later date of 22nd March 2023 to undertake a site-specific geotechnical investigation. In order to achieve the outlined objectives, the field investigations comprised:

- Six machine Test Pit investigations to a target of 3.0m below ground level (bgl).
- Six associated shallow investigations involving Scala Penetrometer (DCP) tests to 3.0m depth bgl.

The tests were positioned in areas to provide the most effective coverage of the site considering access, underground services and the proposed development. Test locations, highlighted in Figure 11, were approximated from site measurements and reduced levels interpreted from LiDAR and are therefore approximate only.

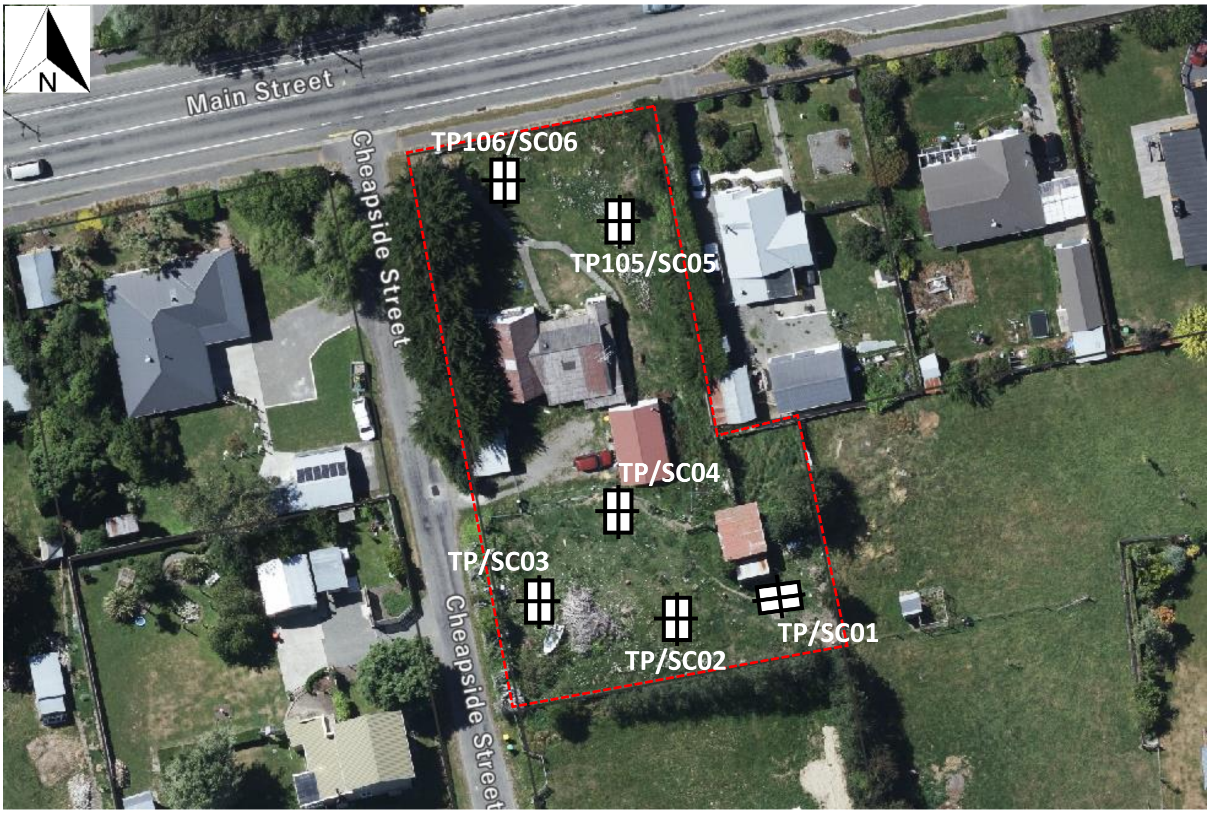

Figure 11: Intrusive Investigation Approximate Locations

Investigation details are provided in Table 1 below:

Table 1: Shallow Intrusive Investigation Summary

Test Id	Elevation	Termination Depth	Reason for Termination / Further Information
TP 01	240m RL	3.00m	Target Depth Reached No Groundwater Encountered
TP 02	240m RL	3.00m	Target Depth Reached No Groundwater Encountered
TP 03	240m RL	3.00m	Target Depth Reached No Groundwater Encountered
TP 04	240m RL	2.80m	Target Depth Reached No Groundwater Encountered

TP1 05	240m RL	1.30m	Target Depth Reached No Groundwater Encountered
TP1 06	240m RL	1.20m	Target Depth Reached No Groundwater Encountered
SC 01 – 06	240m RL	0.60m, 0.90m, 1.00m, 0.80m, 0.90m & 0.80m	Scala Refusal No Groundwater Recorded

6.2 Summary of Ground Conditions

This investigation indicates the following approximate soil section across the site. Subsoils encountered during the intrusive investigations have been described in accordance with the NZGS: Field Description of Soil and Rock. The results of these investigations are shown on the TP logging sheet attached in Appendix D.

Table 2: Ground Condition Summary

General Depth Range (m)	Generalised Ground Description	Density/Strength
Surface to 0.45	TOPSOIL - SILT	Firm
0.45 to 0.80/1.00*	SILT & FILL*	Firm
0.70/1.00 to 3.00	GRAVEL	Dense

Note: * - The non-engineered Fill was only observed in one of the Test Pits. The Fill comprised tree roots, metal, brick and concrete.

6.3 Groundwater

Groundwater was not recorded within the intrusive investigations; however, it was noted that the gravels were becoming wet from a depth of approximately 2.70m below ground level (bgl). This appears to be consistent with nearby groundwater monitoring wells which shows groundwater to be at depths of approximately 3m bgl in some areas.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Static Ultimate Bearing Capacity

The Scala Penetrometer results have been assessed using a correlation between Scala blow counts and allowable bearing capacity by Stockwell (Stockwell, 1977). Using this correlation, the Scala Penetrometer results indicate the following Geotechnical Ultimate Bearing Capacities (UBC's):

Table 3: Available UBC Depth Summary

Depth bgl (m)	UBC (kPa)
Surface to 0.45	N/A (Topsoil)
0.45 to >3.00m	>300

It should be noted that non-engineered Fill was observed in only one of the Test Pit investigations (TP04) to a depth of 1.00m below ground level (bgl). This Fill cannot be relied upon as a suitable bearing stratum and should be removed prior to the development of any foundations. A copy of the Dynamic Cone Penetrometer Ultimate Bearing Capacity Graph is attached in Appendix E.

7.2 Qualitative Liquefaction Analysis

For liquefaction to occur there generally needs to be three preconditions, coupled with ground motions of at least 0.1g:

- Young (Holocene or less than 10,000 years old) sediments
- The soils include fine-grained and non-cohesive material (silts and sands)
- The soils are saturated (below the water table)

The soils at the site generally consist of a layer of Topsoil and Silt to approximately 0.70m to 1.00m below ground level (bgl). This is underlain by dense gravels, deposited in the Late Pleistocene to Holocene epoch, extending past the termination depth of the investigations (>3.00m bgl). No groundwater was encountered within the upper 3.00m of the soil profile. The site is therefore considered to be at a very low to low risk of liquefaction following future earthquake events.

7.3 NZS 3604 "Good Ground" Assessment

NZS 3604:2011 indicates "Good Ground" is where "Any soil or rock capable of permanently withstanding an Ultimate Bearing Capacity of 300kPa (i.e. an allowable bearing pressure of 100kPa using a factor of safety 3.0)…' It excludes expansive soils, topsoils or organic rich soils, uncompacted loose gravel and any ground likely to experience ground movements of 25mm or more.

The soils at the site do not meet the NZS 3604 definition of "Good Ground" within the upper 1.0m of the soil profile due to the presence of the non-engineered Fill. However it is considered that "Good Ground" can be achieved within the dense gravel layer below the silts and non-engineered Fill.

8.0 RESOURCE MANAGEMENT ACT ASSESSMENT

Section 106 (1) of the Resource Management Act (RMA) states:

'A consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent subject to conditions, if it considers that:

(a) *The land in respect of which a consent is sought, or any structure on the land, is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or*
(b) *Any subsequent use that is likely to be made of the land is likely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source; or*
(c) *Sufficient provision has not been made for legal and physical access to each allotment to be created by the subdivision'*

Table 4 provides our assessment of parts (a) and (b) of the above. Section 106 1(c) is not relevant to a geotechnical assessment.

Table 4: RMA Section 106 (1) Assessment

Hazard	Potential Susceptibility	
	Current part (a)	**Post Development part (b)**
Erosion	No signs of erosion were observed during the site walkover.	It is not anticipated that the proposed development will accelerate or worsen the erosion rates if appropriate stormwater collection and disposal methods are implemented.
Falling Debris	N/A – The site and surrounding area are relatively flat and therefore no issues are anticipated.	
Slippage	N/A – The site and surrounding area are relatively flat and therefore no issues are anticipated.	
Subsidence	Based on the UBC's, non-organic and coarse granular material beneath the silt and non-engineered Fill layer, the risk of static settlement is considered to be very low. According to the WDC the site is in an area of having a very low to low liquefaction susceptibility	It is generally anticipated that NZS:3604 'Good Ground' conditions will be present within the gravels underlying the silts and non-engineered fill. The site is in a Fault Awareness Area (FAA) and is potentially at risk from fault rupture. The proposed development is within a township and an element of risk must be taken in order to continue development within the town. Provided that foundations are located on a suitable bearing layer, and to an engineered design, the risk of subsidence is unlikely to be worsened.
Inundation - Flooding	The Waimakariri District Council (WDC) indicates that the site is at a low to medium risk of flooding from a 1 in 50-year event.	No FFL's have been recommended by the council and confirmation from the WDC should be sought for accurate Finished Floor Level (FFL) requirements.
Inundation - Liquefaction	The site has not been 'sufficiently tested' to any of the earthquake events of the CES. It is considered that the site is at a very low to low risk of liquefaction.	It is considered that the proposed FFL, with regards to flooding will provide adequate protection from the risk of any liquefaction inundation the site may experience in a future event.

It is considered, under Section 106 (1) of the RMA, that there are no reasons from a geotechnical perspective that the site is considered unsuitable for development, provided any development is undertaken with appropriate engineering design measures. This is especially relevant considering the site will be located within a Fault Awareness Area (FAA), and a risk-based approach to constructing residential developments within the Oxford township needs to be taken.

Our Geotechnical Statement of Professional Opinion forms Appendix F.

9.0 RECOMMENDATIONS

9.1 Site Clearance

The site still houses separate garage/shed/workshop structures which will need to be demolished or removed from site prior to the construction of the proposed developments. Following this, any fill or buried material waste encountered on-site will need to be removed.

9.2 Potential Foundation Types

It is our understanding that two relocatable dwellings are to be placed in the southern area of the site and one relocatable dwelling to be placed to the north of the existing dwelling. The site is currently highlighted by the WDC to be within a Fault Awareness Area (FAA) however no evidence of a fault trace or previous damage was observed on-site, and it is considered that a risk-based approach should be taken in townships that are already within FAA's. We have not been provided with any proposed plans, but it is considered the following foundation options are appropriate to the ground conditions:

9.2.1 Concrete Floor

Enhanced Slab TC2 Foundation Options 1 to 4, Section 5.3 Part A of the MBIE Guidance are suitable for the site, although an Option 4 (Waffle Slab) type foundation solution is recommended.

The foundation should be founded in the natural inorganic soils, generally encountered at a depth of 0.45m where a Geotechnical UBC of 300kPa can be used for design. The Fill encountered in TP04 should be removed to the natural, dense gravel layer (~1.00m) which shows a Geotechnical UBC of >300kPa.

Any fill beneath the slab should consist of an appropriately compacted, well graded gravel (AP40 or AP65), with a layer of geotextile (DuraForce AS280 or Bidim A19 or engineer approved equal) on the base and lapping up the sides of the excavation.

If using an Option 1 foundation, a minimum 600mm thick compacted gravel raft should be installed.

9.2.2 Timber Floor

It is our understanding that a timber floor foundation option is the preferred solution. This option will require specific engineering design from a Chartered Structural Engineer to account for any nearby faulting. The piles should be founded to a depth of at least 0.50m below ground level (bgl), where a Geotechnical UBC of at least 300kPa can be used for design.

The Fill encountered in TP04 cannot be relied upon as a suitable bearing stratum and so any piles in this area will have to continue to depths greater than 1.00m bgl. A geotechnical engineer, familiar with this report, should be engaged to check the excavations for the piles to confirm suitable bearing has been reached and no fill is present.

The foundation option highlighted above should be produced and designed by a Chartered Structural Engineer in accordance with the MBIE Guidance.

10.0 Further Information

Should dewatering be required, the works should be undertaken in accordance with the Christchurch City Councils Dewatering Guideline (SCIRT 1001-CN-GE-GL-001, dated 03/11/2016).

If gravel hardfill is required, it should be compacted in accordance with NZS 4431:1989 Code of Practice for Earthfill for Residential Development and MBIE Module 5A: Specification of ground improvement for residential properties in the Canterbury region (MBIE & NZGS, 2015). Validation testing of the compacted gravel should be undertaken and signed off by a suitably experienced Geotechnical Engineer.

According to the New Zealand Building Code, Ultimate Bearing Capacities should be multiplied by 0.80 – 0.90 for load combinations involving earthquake over strength and 0.40 – 0.55 for all other load combinations.

It is the Structural Engineer or designer’s responsibility to ensure that the recommendations of this report are correctly understood and applied. We are happy to discusss the project with the Structural Engineer or designer and recommend that we review the final design documentation prior to construction.

Any topsoil/fill, very soft or organic materials encountered are not considered a suitable bearing stratu for new foundations and will require removal beneath the building platform.

Advice from a Geotechnical Engineer should be sought if ground conditions differ to those encountered from the intrusive investigations during foundation construction works.

11.0 Foundation Inspections

It is recommended that a Chartered Professional Engineer with appropriate geotechnical experience be engaged to supervise any future bulk earthworks or foundation excavations. This is in accordance with normal council practice at the Building Consent stage. It should also be noted that under the Building Act (2004), there are specific requirements for supervision by appropriately qualified personnel.

The Geotechnical Engineer should inspect the formation level of any new, temporary or permanent foundation element. If gravel hardfill is required, compaction testing should be undertaken. Frequency is to be determined by the Geotechnical Engineer, but should occur once the gravel fill has been placed and compacted.

12.0 REFERENCES

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11. GNS Science Consultancy Report 2014/211, Environment Canterbury Report No. R14/76, December 2015, 'Guidelines for using regional-scale earthquake fault information in Canterbury'.

12. Ministry for the environment, 'Planning for Development of Land on or Close to Active Faults', 'A guideline to assist resource management planners in New Zealand', July 2003.

Appendix A

Listed Land Use Register Results

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Customer Services
P. 03 353 9007 or 0800 324 636

PO Box 345
Christchurch 8140

P. 03 365 3828
F. 03 365 3194
E. ecinfo@ecan.govt.nz

www.ecan.govt.nz

Dear Sir/Madam

Thank you for submitting your property enquiry from our Listed Land Use Register (LLUR). The LLUR holds information about sites that have been used or are currently used for activities which have the potential to cause contamination.

The LLUR statement shows the land parcel(s) you enquired about and provides information regarding any potential LLUR sites within a specified radius.

Please note that if a property is not currently registered on the LLUR, it does not mean that an activity with the potential to cause contamination has never occurred, or is not currently occurring there. The LLUR database is not complete, and new sites are regularly being added as we receive information and conduct our own investigations into current and historic land uses.

The LLUR only contains information held by Environment Canterbury in relation to contaminated or potentially contaminated land; additional relevant information may be held in other files (for example consent and enforcement files).

Please contact Environment Canterbury if you wish to discuss the contents of this property statement.

Yours sincerely

Contaminated Sites Team

Property Statement
from the Listed Land Use Register

Visit ecan.govt.nz/HAIL for more information or
contact Customer Services at ecan.govt.nz/contact/ and quote ENQ317003

Date generated: 30 May 2022
Land parcels: Lot 1 DP 80871

The information presented in this map is specific to the area within a 50m radius of property you have selected. Information on properties outside the serach radius may not be shown on this map, even if the property is visible.

Sites at a glance

Sites within enquiry area

There are no sites associated with the area of enquiry.

Nearby sites

There are no sites associated with the area of enquiry.

More detail about the sites

There are no sites associated with the area of enquiry.

Nearby investigations of interest

There are no investigations associated with the area of enquiry.

Disclaimer

The enclosed information is derived from Environment Canterbury's Listed Land Use Register and is made available to you under the Local Government Official Information and Meetings Act 1987.

The information contained in this report reflects the current records held by Environment Canterbury regarding the activities undertaken on the site, its possible contamination and based on that information, the categorisation of the site. Environment Canterbury has not verified the accuracy or completeness of this information. It is released only as a copy of Environment Canterbury's records and is not intended to provide a full, complete or totally accurate assessment of the site. It is provided on the basis that Environment Canterbury makes no warranty or representation regarding the reliability, accuracy or completeness of the information provided or the level of contamination (if any) at the relevant site or that the site is suitable or otherwise for any particular purpose. Environment Canterbury accepts no responsibility for any loss, cost, damage or expense any person may incur as a result of the use, reference to or reliance on the information contained in this report.

Any person receiving and using this information is bound by the provisions of the Privacy Act 1993.

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

Listed Land Use Register

What you need to know

Everything is connected

What is the Listed Land Use Register (LLUR)?

The LLUR is a database that Environment Canterbury uses to manage information about land that is, or has been, associated with the use, storage or disposal of hazardous substances.

Why do we need the LLUR?

Some activities and industries are hazardous and can potentially contaminate land or water. We need the LLUR to help us manage information about land which could pose a risk to your health and the environment because of its current or former land use.

Section 30 of the Resource Management Act (RMA, 1991) requires Environment Canterbury to investigate, identify and monitor contaminated land. To do this we follow national guidelines and use the LLUR to help us manage the information.

The information we collect also helps your local district or city council to fulfil its functions under the RMA. One of these is implementing the National Environmental Standard (NES) for Assessing and Managing Contaminants in Soil, which came into effect on 1 January 2012.

For information on the NES, contact your city or district council.

How does Environment Canterbury identify sites to be included on the LLUR?

We identify sites to be included on the LLUR based on a list of land uses produced by the Ministry for the Environment (MfE). This is called the Hazardous Activities and Industries List (HAIL)[1]. The HAIL has 53 different activities, and includes land uses such as fuel storage sites, orchards, timber treatment yards, landfills, sheep dips and any other activities where hazardous substances could cause land and water contamination.

We have two main ways of identifying HAIL sites:

- We are actively identifying sites in each district using historic records and aerial photographs. This project started in 2008 and is ongoing.
- We also receive information from other sources, such as environmental site investigation reports submitted to us as a requirement of the Regional Plan, and in resource consent applications.

[1] The Hazardous Activities and Industries List (HAIL) can be downloaded from MfE's website www.mfe.govt.nz, keyword search HAIL

How does Environment Canterbury classify sites on the LLUR?

Where we have identified a HAIL land use, we review all the available information, which may include investigation reports if we have them. We then assign the site a category on the LLUR. The category is intended to best describe what we know about the land use and potential contamination at the site and is signed off by a senior staff member.

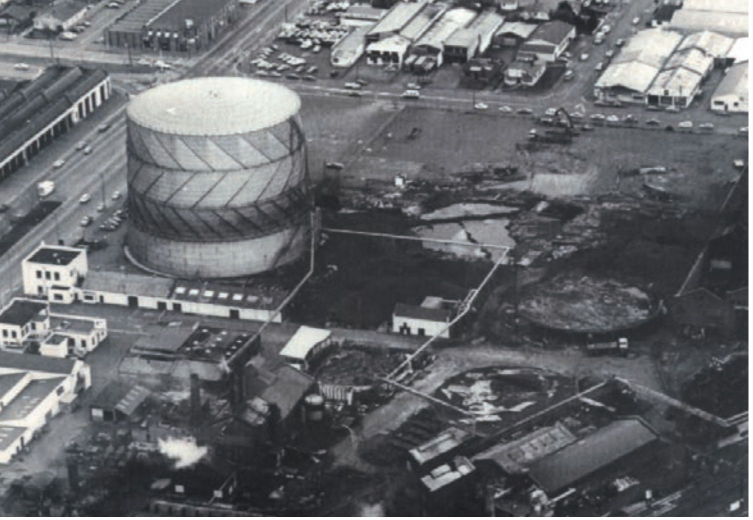
Please refer to the Site Categories and Definitions factsheet for further information.

What does Environment Canterbury do with the information on the LLUR?

The LLUR is available online at www.llur.ecan.govt.nz. We mainly receive enquiries from potential property buyers and environmental consultants or engineers working on sites. An inquirer would typically receive a summary of any information we hold, including the category assigned to the site and a list of any investigation reports.

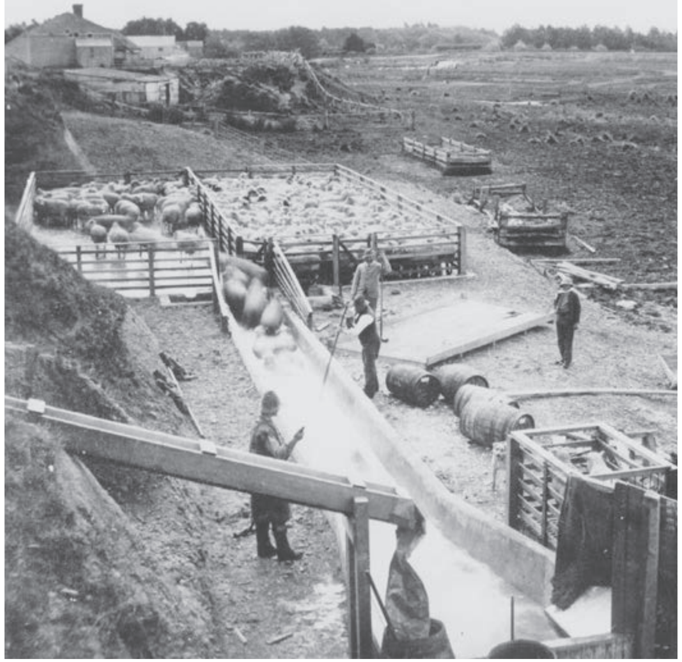
We may also use the information to prioritise sites for further investigation, remediation and management, to aid with planning, and to help assess resource consent applications. These are some of our other responsibilities under the RMA.

If you are conducting an environmental investigation or removing an underground storage tank at your property, you will need to comply with the rules in the Regional Plan and send us a copy of the report. This means we can keep our records accurate and up-to-date, and we can assign your property an appropriate category on the LLUR. To find out more, visit www.ecan.govt.nz/HAIL.



IMPORTANT!

The LLUR is an online database which we are continually updating. A property may not currently be registered on the LLUR, but this does not necessarily mean that it hasn't had a HAIL use in the past.



Sheep dipping (ABOVE) and gas works (TOP) are among the former land uses that have been identified as potentially hazardous. (Photo above by Wheeler & Son in 1987, courtesy of Canterbury Museum.)

My land is on the LLUR – what should I do now?

IMPORTANT! Just because your property has a land use that is deemed hazardous or is on the LLUR, it doesn't necessarily mean it's contaminated. The only way to know if land is contaminated is by carrying out a detailed site investigation, which involves collecting and testing soil samples.

You do not need to do anything if your land is on the LLUR and you have no plans to alter it in any way. It is important that you let a tenant or buyer know your land is on the Listed Land Use Register if you intend to rent or sell your property. If you are not sure what you need to tell the other party, you should seek legal advice.

You may choose to have your property further investigated for your own peace of mind, or because you want to do one of the activities covered by the National Environmental Standard for Assessing and Managing Contaminants in Soil. Your district or city council will provide further information.

If you wish to engage a suitably qualified experienced practitioner to undertake a detailed site investigation, there are criteria for choosing a practitioner on www.ecan.govt.nz/HAIL.

I think my site category is incorrect – how can I change it?

If you have an environmental investigation undertaken at your site, you must send us the report and we will review the LLUR category based on the information you provide. Similarly, if you have information that clearly shows your site has not been associated with HAIL activities (eg. a preliminary site investigation), or if other HAIL activities have occurred which we have not listed, we need to know about it so that our records are accurate.

If we have incorrectly identified that a HAIL activity has occurred at a site, it will be not be removed from the LLUR but categorised as Verified Non-HAIL. This helps us to ensure that the same site is not re-identified in the future.

Contact us

Property owners have the right to look at all the information Environment Canterbury holds about their properties.

It is free to check the information on the LLUR, online at www.llur.ecan.govt.nz.

If you don't have access to the internet, you can enquire about a specific site by phoning us on (03) 353 9007 or toll free on 0800 EC INFO (32 4636) during business hours.

Contact Environment Canterbury:

Email: ecinfo@ecan.govt.nz

Phone:
Calling from Christchurch: (03) 353 9007
Calling from any other area: 0800 EC INFO (32 4636)

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Everything is connected

Promoting quality of life through balanced resource management.

www.ecan.govt.nz E13/101

Listed Land Use Register

Site categories and definitions

When Environment Canterbury identifies a Hazardous Activities and Industries List (HAIL) land use, we review the available information and assign the site a category on the Listed Land Use Register. The category is intended to best describe what we know about the land use.

If a site is categorised as **Unverified** it means it has been reported or identified as one that appears on the HAIL, but the land use has not been confirmed with the property owner.

If the land use has been confirmed but analytical information from the collection of samples is not available, and the presence or absence of contamination has therefore not been determined, the site is registered as:

Not investigated:

- A site whose past or present use has been reported and verified as one that appears on the HAIL.
- The site has not been investigated, which might typically include sampling and analysis of site soil, water and/or ambient air, and assessment of the associated analytical data.
- There is insufficient information to characterise any risks to human health or the environment from those activities undertaken on the site. Contamination may have occurred, but should not be assumed to have occurred.

If analytical information from the collection of samples is available, the site can be registered in one of six ways:

At or below background concentrations:

The site has been investigated or remediated. The investigation or post remediation validation results confirm there are no hazardous substances above local background concentrations other than those that occur naturally in the area. The investigation or validation sampling has been sufficiently detailed to characterise the site.

Below guideline values for:

The site has been investigated. Results show that there are hazardous substances present at the site but indicate that any adverse effects or risks to people and/or the environment are considered to be so low as to be acceptable. The site may have been remediated to reduce contamination to this level, and samples taken after remediation confirm this.

Managed for:

The site has been investigated. Results show that there are hazardous substances present at the site in concentrations that have the potential to cause adverse effects or risks to people and/or the environment. However, those risks are considered managed because:

- the nature of the use of the site prevents human and/or ecological exposure to the risks; and/or
- the land has been altered in some way and/or restrictions have been placed on the way it is used which prevent human and/or ecological exposure to the risks.

Partially investigated:

The site has been partially investigated. Results:

- demonstrate there are hazardous substances present at the site; however, there is insufficient information to quantify any adverse effects or risks to people or the environment; or
- do not adequately verify the presence or absence of contamination associated with all HAIL activities that are and/or have been undertaken on the site.

Significant adverse environmental effects:

The site has been investigated. Results show that sediment, groundwater or surface water contains hazardous substances that:

- have significant adverse effects on the environment; or
- are reasonably likely to have significant adverse effects on the environment.

Contaminated:

The site has been investigated. Results show that the land has a hazardous substance in or on it that:

- has significant adverse effects on human health and/or the environment; and/or
- is reasonably likely to have significant adverse effects on human health and/or the environment.

If a site has been included incorrectly on the Listed Land Use Register as having a HAIL, it will not be removed but will be registered as:

Verified non-HAIL:

Information shows that this site has never been associated with any of the specific activities or industries on the HAIL.

Please contact Environment Canterbury for further information:

(03) 353 9007 or toll free
on 0800 EC INFO (32 4636)
email ecinfo@ecan.govt.nz

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

E13/102

Appendix B

GNS Guidelines for using regional scale fault information

Guidelines for using regional-scale earthquake fault information in Canterbury

D.J.A. Barrell H. Jack M. Gadsby

GNS Science Consultancy Report 2014/211
Environment Canterbury Report No. R14/76
December 2015

GNS SCIENCE
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BIBLIOGRAPHIC REFERENCE

Barrell, D.J.A.; Jack, H.; Gadsby, M. 2015. Guidelines for using regional-scale earthquake fault information in Canterbury, *GNS Science Consultancy Report* 2014/211. 30 p.

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EXECUTIVE SUMMARY

Background

Surface fault rupture is the permanent breakage and buckling of ground during an earthquake in the area where an earthquake fault meets the ground surface. It is typically the least widespread of earthquake hazards and generally affects far fewer properties than, for example, ground shaking. However, because areas affected by surface fault rupture suffer more damage compared to areas that experience only ground shaking, and because surface fault rupture only affects a limited area, potential damage from surface fault rupture could be avoided or mitigated at the locations where active faults meet the ground surface.

Neither the Building Act 1991 nor its 2004 revision address surface fault rupture hazard, only ground shaking. Thus, the Ministry for the Environment (MfE) prepared a report "Guidelines for Development of Land on or Close to Active Faults" (Kerr & others 2003). The MfE Guidelines aim to help land-use planners manage risks related to surface fault rupture hazard.

The MfE Guidelines advocate a risk-based approach, based on the Recurrence Interval of a fault (the long-term average time between earthquakes on that fault), and the type of development proposed. The MfE Guidelines recommend detailed mapping of faults, for example at a scale of 1:35,000 or better, and the delineation of Fault Avoidance Zones, within which development should be managed.

The cost of mapping all the earthquake faults in Canterbury – many of which are in sparsely populated areas – to that level of detail is difficult to justify in most places. Detailed mapping of faults in Canterbury has, to date, been focussed on the most active faults near developed areas: the Hanmer Fault, the Hope Fault Zone at Mt Lyford Village, the Ashley Fault Zone, the Ostler Fault Zone and the Greendale Fault. All other known earthquake faults in Canterbury have been mapped at a 'regional-scale' of 1:250,000, in a series of district-by-district reports produced between 2009 and 2016.

The problem

The regional-scale 1:250,000 fault mapping in the district reports is not detailed enough to be able to apply the MfE Guidelines directly using Fault Avoidance Zones. However, the 1:250,000-scale fault information is still useful because it shows local authorities, developers, landowners or prospective buyers the general location of faults and it highlights locations where more detailed investigations could or should be undertaken for certain developments. The regional-scale information is also useful for infrastructure managers and emergency managers. The fact that the surface fault rupture hazard is not mapped precisely in these areas should not inhibit action being taken to manage the risk.

What we did

In consultation with district councils we developed recommendations for using the 1:250,000-scale fault datasets. The recommendations include delineating Fault Awareness Areas (FAAs) of 125 metres either side of the mapped line for definite (well expressed), definite (moderately expressed), likely (well expressed), likely (moderately expressed) faults and monocline folds, and 250 metres either side of the mapped fault line for all other faults and monocline folds. This reflects the fact that the well expressed and moderately expressed faults and monocline folds are likely to be mapped more precisely than the not expressed and possible faults and monocline folds.

The recommendations include actions for different proposed activities within FAAs, as summarised below. The recommendation framework takes account of the estimated average recurrence interval (RI) for a surface rupturing movement on an earthquake fault, and the significance of proposed building activities, expressed as Building Importance Category (BIC). Definitions of BICs and RI classes are provided in Appendix 3 of this report.

<table>
<tr><th rowspan="2">Proposed Activity</th><th colspan="3">Recommended Actions</th></tr>
<tr><td>For FAA categories:
definite (well expressed)
definite (mod expressed)
likely (well expressed)
likely (mod expressed)
with RI < 5,000 years</td><td>For FAA categories:
definite (well expressed)
definite (mod expressed)
likely (well expressed)
likely (mod expressed)
with RI > 5,000 years</td><td>For all other FAA categories:
definite (not expressed)
likely (not expressed)
possible</td></tr>
<tr><td>Single residential dwelling
(BIC 2a and 2b in part)</td><td colspan="3">Fault maps in District Plans and fault information on LIMs and PIMs</td></tr>
<tr><td>Normal structures and structures not in other categories (BIC 2b, apart from single dwellings)</td><td>Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required.
Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).</td><td colspan="2">Fault maps in District Plans and fault information on LIMs and PIMs</td></tr>
<tr><td>Important or critical structures
(BIC 3 and 4)</td><td colspan="3">Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required.
Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures determined for the accurately mapped fault (e.g. set back or engineering measures).</td></tr>
<tr><td>New subdivision (excluding minor boundary adjustments)</td><td colspan="2">Consideration of the surface fault rupture hazard should be a specific assessment matter.
Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).</td><td>Fault maps in District Plans and fault information on LIMs and PIMs</td></tr>
<tr><td>Plan Changes</td><td colspan="3">Consideration of the surface fault rupture hazard should be a specific assessment matter.
Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures.</td></tr>
</table>

Recommendations also include suggested wording for Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs).

What does it mean?

The recommendations in this guideline provide a regional approach for using the 1:250,000-scale earthquake fault and fold information in Land Information Memoranda (LIMs), Project Information Memoranda (PIMs), Land Information Requests (LIRs) and in developing future District Plan and Regional Plan provisions.

The 1:250,000-scale earthquake fault and fold information will also be useful for infrastructure planning, emergency management planning and public education. All Fault Awareness Areas, as well as anticline and syncline folds, and any detailed fault mapping undertaken by Environment Canterbury, will be accessible on the Environment Canterbury website (www.ecan.govt.nz) and the Canterbury Maps website (www.canterburymaps.govt.nz).

1.0 INTRODUCTION

Earthquake hazards, including ground shaking, surface fault rupture and liquefaction are present in the Canterbury region (Figure 1.1). Canterbury's local authorities, comprising Environment Canterbury Regional Council and the region's city and district councils, have statutory duties to implement ways to avoid or mitigate natural hazards, including earthquake hazards. The roles of Canterbury's local authorities, with respect to surface fault rupture hazard, are outlined in Appendix 1.

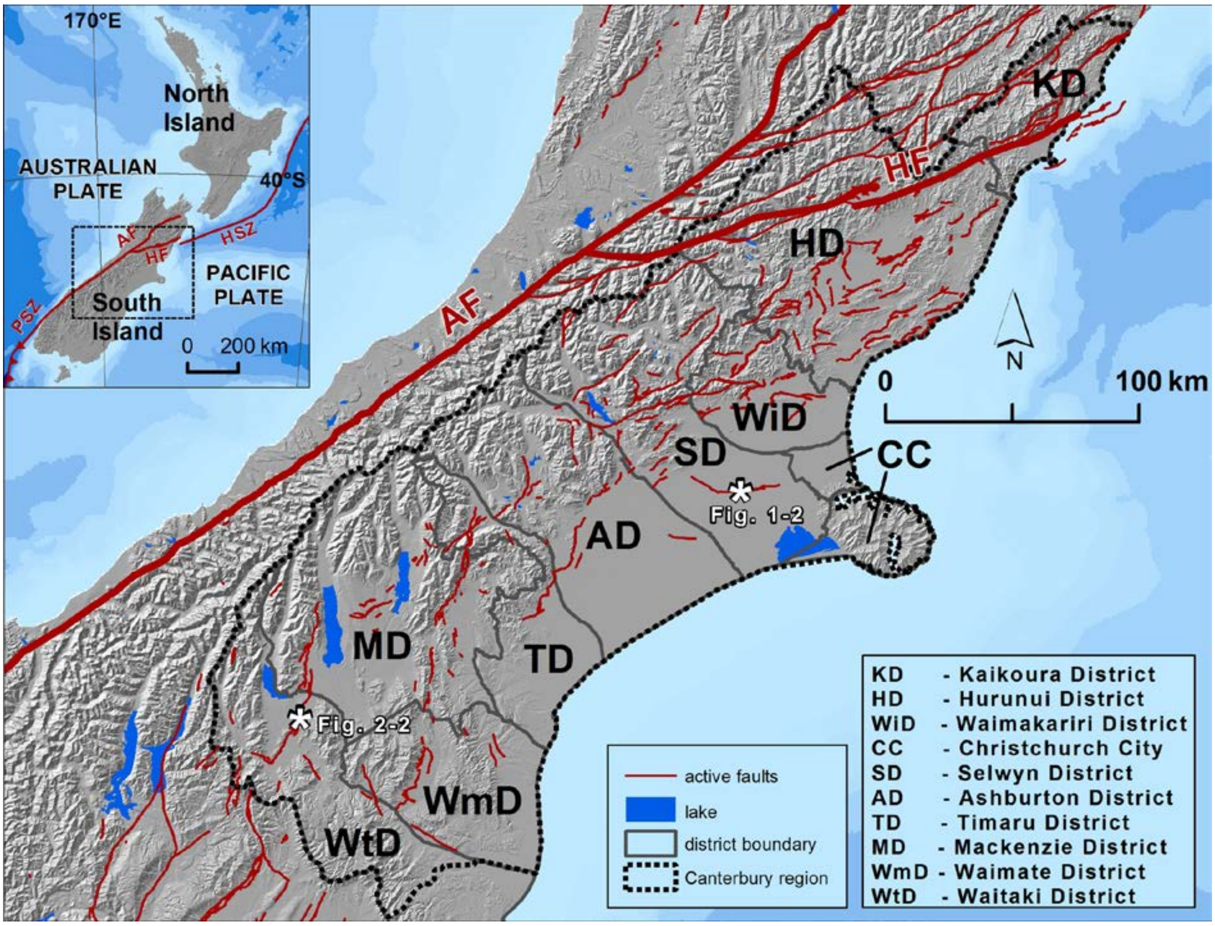

Figure 1.1 Location map of the Canterbury region and its territorial authority districts, along with active faults. Those within the Canterbury region are from the Environment Canterbury 1:250,000-scale district fault datasets, with the display showing active faults and monocline folds with 'certainty' values of definite or likely. Active faults shown outside of the Canterbury region are from the New Zealand Active Faults Database (Langridge & others. 2016). White stars denote locations of photos shown in Figure 1.2 and Figure 2.2 of this report. Inset shows the tectonic setting of New Zealand, with major elements of the Australian-Pacific plate boundary abbreviated as follows: Alpine Fault (AF), Hope Fault (HF), Puysegur Subduction Zone (PSZ) and Hikurangi Subduction Zone (HSZ).

Surface fault rupture hazard is the permanent breakage and buckling of ground along the fault on which an earthquake has happened (Figure 1.2). It is typically the least widespread of earthquake hazards and generally affects far fewer properties than ground shaking. However, because areas affected by surface fault rupture suffer more damage compared to areas that experience only ground shaking, and because surface fault rupture only affects a limited area, potential damage from surface fault rupture could be avoided or mitigated at the locations where active faults intersect the ground surface.

Neither the Building Act 1991 nor its 2004 revision address surface fault rupture hazard, only ground shaking. Thus the Ministry for the Environment (MfE) produced guidelines for development of land on or close to active faults (Kerr & others 2003), in order to help land use planners manage surface fault rupture risk through the Resource Management Act 1991.

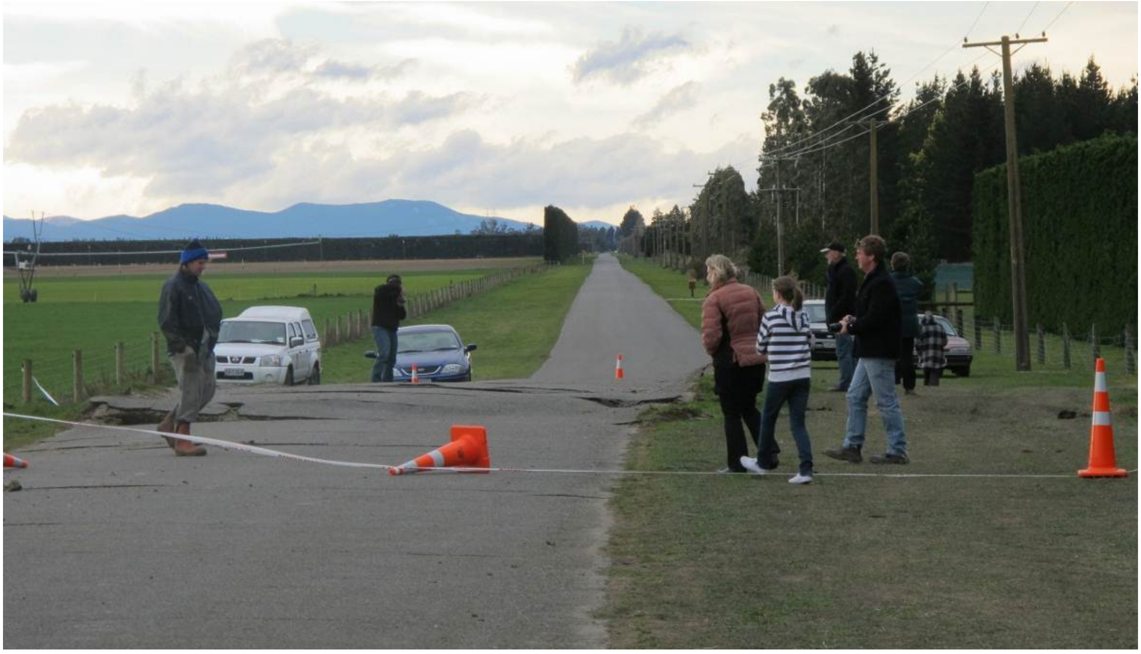

Figure 1.2 Surface fault rupture on the Greendale Fault at Highfield Road in Selwyn District (see Figure 1.1 for location) during the 4 September, 2010, Darfield (Canterbury) Earthquake. Before the earthquake, the road was straight and the ground was flat. At this location, surface fault rupture formed a ~40 m wide zone of fractures and broad folds in the ground resulting from mostly sideways ('strike-slip') ground shift of ~4.5 m. In addition, the south side (near the camera) was bulged up by about 1 m. Photo: D.J.A. Barrell, 5 September 2010.

The MfE Guidelines advocate a risk-based approach, based on the recurrence interval of a fault (the estimated long-term average time between large, surface-rupturing, earthquakes on that fault), which provides a measure of the degree of activity of the fault, and the type of development proposed. Recommended restrictions on development increase with the activity of the fault and the importance of the proposed development. The MfE Guidelines recommend defining Fault Avoidance Zones, within which development should be managed to avoid or mitigate the surface fault rupture hazard. Defining a Fault Avoidance Zone requires detailed mapping of faults at a scale of 1:35,000 or better. In Canterbury, detailed mapping of faults suitable for Fault Avoidance Zonation and application of the MfE Guidelines has, to date, been focussed on the most active faults near developed areas. This is because most earthquake faults in Canterbury are in sparsely populated rural or mountainous areas and the cost of mapping these faults in detail cannot currently be justified given the low surface fault rupture risk they pose to structures. Detailed fault mapping has been completed in five locations:

- the Hanmer Fault at Hanmer Springs in Hurunui District (Environment Canterbury/Hurunui District Council dataset)
- the Hope Fault Zone at Mt Lyford Village in Hurunui District (Hancox & others 2006);
- the Ashley Fault Zone in Waimakariri District (Barrell & Van Dissen 2014);
- part of the Ostler Fault Zone near Twizel in Mackenzie District (Barrell 2010);
- the Greendale Fault in Selwyn District following its emergence in 2010 (Villamor & others 2011, 2012).

Similar detailed mapping is likely to be completed for several other faults in the region in future years.

All other known earthquake faults in Canterbury have been mapped at a 'regional-scale' of 1:250,000, in a series of district-by-district reports produced between 2009 and 2016. These reports are listed in Appendix 2. These reports replace earlier earthquake fault reports produced for Environment Canterbury in 1998 and 2008 (Pettinga & others 1998, Kingsbury & Pettinga 2008).

The 1:250,000-scale fault mapping in the district reports is not detailed enough to be able to draw Fault Avoidance Zones around the faults and apply the MfE Guidelines directly. However, the 1:250,000-scale fault information is still useful because it shows local authorities, developers, landowners or prospective buyers the general location of faults and thereby highlights areas where more detailed investigations could be undertaken if more information about the fault is needed. The regional-scale information is also useful for infrastructure managers and emergency managers. The fact that surface fault rupture hazard has not been mapped precisely in some areas doesn't preclude action being taken to manage the risk.

The purpose of this report is to provide guidance to local authority resource management planners on how to use the regional-scale 1:250,000 fault information provided in the district reports. This includes developing policy in District Plans and wording for Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs).

2.0 EARTHQUAKE FAULT BASICS

2.1 WHAT IS SURFACE FAULT RUPTURE?

An earthquake fault is a fracture in the Earth's crust. Sudden movement on a fault (a 'rupture' or 'slip') causes an earthquake. Fault movement typically occurs in 'jerks' – nothing happens for a long period of time while strain is building up in the Earth's crust, and eventually a sudden movement on the fault releases that strain. Ruptures commonly begin deep in the crust and most of the movement happens completely underground. However, if the rupture is big enough and shallow enough, the movement may extend up to the ground surface causing surface fault rupture. This involves sudden fracturing (faulting) and buckling (folding) of the ground surface of as much as several metres (see Figure 1.2).

Buildings or infrastructure, like roads or pipes, within a zone of sudden fracturing or buckling are likely to suffer serious damage. Surface fault rupture typically only affects a narrow corridor of land a few tens of metres wide where the fault meets the ground surface. Surface fault rupture is a separate hazard from earthquake shaking created by movement on the fault, which affects a much larger area.

Surface fault rupture is a relatively uncommon occurrence during an earthquake. Only about ten historical earthquakes in New Zealand have generated surface fault rupture. In Canterbury, there are three known, or suspected, historical examples of where movement on a fault during an earthquake has come all the way up to break the ground surface: the 1888 North Canterbury Earthquake on the Hope Fault west of Hanmer Springs; the 1929 Arthur's Pass Earthquake on the Poulter Fault (Berryman & Villamor 2004); and the 2010 Darfield (Canterbury) Earthquake on the Greendale Fault (Barrell & others 2011).

A fault tends to rupture in the same location each time, due to the plane of weakness that has developed on the fault. As such, surface fault rupture commonly produces distinctive landform features, such as scarps (steps) or lineaments. These landform features provide a means of identifying areas that are potentially at risk from future surface fault rupture, and allow for planning or engineering measures, as well as emergency response procedures to be developed and applied.

2.2 MAPPING FAULTS

On maps, the location of a fault is shown by a line that represents the approximate place where a fault meets the ground surface; this line is sometimes called the fault trace. Where fault movement has created a step in the ground surface, the step is termed a fault scarp (Figure 1.2 and Figure 2.1). A fold location is also represented on maps by a line, which marks the approximate position of the centre of the bending. Most folds are thought to have formed over faults whose ruptures have not made it all the way up to the ground surface. Folds can be monoclines (one-sided folds), anticlines (upfolds) or synclines (downfolds). Monoclines tend to have deformation concentrated in a relatively narrow zone (fold scarp), whereas anticlines and synclines tend to be broader 'warps' in the ground surface. There is a continuum between fault scarps and fold scarps in the intensity of ground deformation, and in some places fault scarps and fold scarps occur together. Commonly along its length, a fault scarp may broaden out into a monoclinal fold scarp, and then further along the fold scarp redevelops into a fault scarp (Figure 2.2). The growth of anticlines or synclines during an earthquake on an underground fault generally does not pose as significant a life-safety hazard as the more direct hazard posed by faults or monoclines. This is because the ground deformation associated with anticline or syncline folding is spread out over a wider zone, rather than concentrated within a narrow zone.

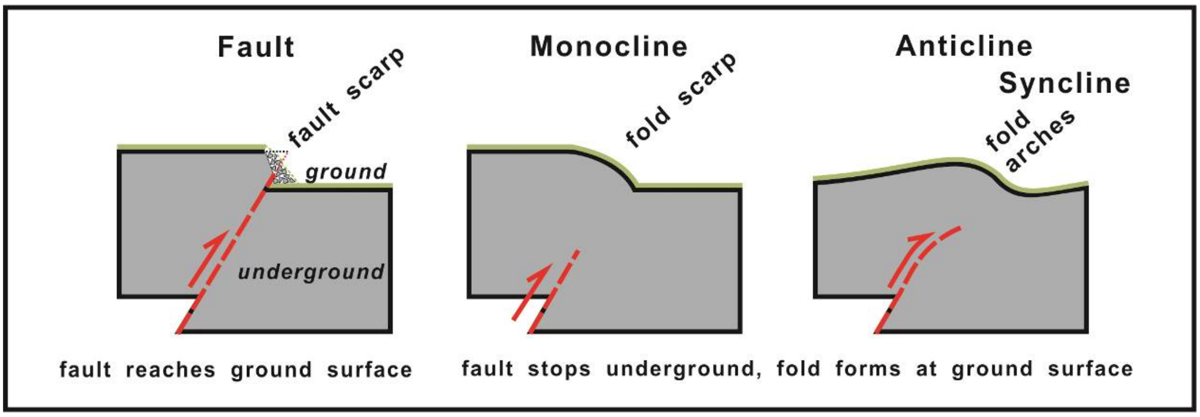

Figure 2.1 Cross-sections (diagrams looking from the side) illustrating the general character of active faults and folds. The diagrams show general concepts rather than actual details, and are not drawn to an exact scale.

Figure 2.2 The Ostler Fault Zone, in the Waitaki and Mackenzie districts, runs from upper left to lower right, and has offset and buckled old braided river channels. At the far left, the fault scarp (in shadow) is sharply expressed. Heading towards the photo centre, the fault scarp evolves into a broad fold which flattens out near the photo centre. At that point, another fault scarp and associated fold has emerged 200 m or so in front of it, and continues towards the right. This view shows an array of faults and folds which all form part of a single entity, the Ostler Fault Zone. Photo: GNS Science; D.L. Homer, catalogue number 3418/2 H, taken July 1982.

2.2.1 Certainty of mapping

Sometimes, geologists can be certain that a step or offset in the ground surface is a fault. Other times, the evidence is not so certain. Information columns were added to the regional-scale (1:250,000) datasets in the district-by-district reports produced between 2009 and 2016 (listed in Appendix 2) to describe the level of confidence that the mapped feature is in fact an active fault ('Certainty'), and on how clearly the mapped feature can be seen at the ground surface ('Surface form').

Fault certainty

'Certainty' has three categories; definite, likely, or possible.

Definite: the mapped feature is without a doubt an active fault.

Likely: the mapped feature is probably an active fault but other explanations for its origin cannot be ruled out (for example, it could have been formed by river erosion).

Possible: there is a possibility that the mapped feature is an active fault, but it is just as likely to be something else.

Surface form

'Surface form' has four categories; well expressed, moderately expressed, not expressed or unknown.

Well expressed: the mapped feature should be able to be located on the ground to better than ±50 metres – it can be clearly seen on the ground.

Moderately expressed: the mapped feature should be able to be located on the ground to better than ±100 metres – it is not so easily seen on the ground.

Not expressed: the mapped feature cannot be seen at the ground surface and would require detailed investigation to locate it (for example, it has been covered by river gravels since the last movement on the fault).

Unknown: This term is applied for example where vegetation obscures the ground surface, or where the natural landscape has been heavily modified by humans, and the degree of expression cannot be assessed using aerial or satellite photos, or where no photos of suitable scale, or other data such as lidar, are available for making an assessment.

This information on surface form is primarily intended to aid future detailed fault mapping or related investigations by providing a 'heads-up' about whether any particular sector of a fault would be easy to locate and delineate in detail.

2.2.2 Accuracy of mapping

Accuracy is how closely a line on a map corresponds to the actual feature on the ground. Unless the fault scarp is exactly surveyed, inaccuracies can be introduced at several stages in the mapping process:

- in drawing the feature onto an aerial photo or topographic base map;
- in digitising the line into a geographic information system (GIS);
- in smoothing the line for display at a small scale (i.e. 1:250,000);
- in the width of the line shown on the map.

The result is that the line shown on the map may end up being tens to hundreds of metres away from where the feature actually is on the ground.

The district fault datasets are based on the 1:250,000-scale national geological map GIS database (QMAP) (including datasets from Forsyth 2001, Rattenbury & others 2006; Cox & Barrell 2007; Forsyth & others 2008). The lines depicting the locations of faults in the database show an approximate general location of the faults, rather than an exact surveyed location.

On a 1:250,000-scale map, 1 cm on the map represents 2.5 km on the ground. On the printed map, the fault lines are about 1/3 of a millimetre wide, which equals about 80 m on the ground. Also, on a 1:250,000 map, some details have been omitted to provide a clear general picture of the geology over a wide area, so a feature being represented by a line is not necessarily located at that exact position. These two issues, along with inaccuracies in the original mapping of fault features onto a base map mean that the line in the datasets may only be accurate to within plus or minus a couple of hundred metres of the actual location of the feature on the ground.

2.3 FAULT ACTIVITY - SLIP RATE AND RECURRENCE INTERVAL

In New Zealand, a fault is considered active if it has experienced a ground-surface rupturing earthquake within the past 125,000 years or so (Langridge & others 2016).

Some faults move more often than others – generally faults nearer a plate boundary will move more often than those farther away. Two commonly used ways of describing the activity of a fault are its slip rate and its recurrence interval.

Slip rate values are calculated by measuring the amount by which a fault has offset a particular landform or near-surface sediment, and estimating the age of that landform or sediment. Dividing the amount of offset by the age provides an average slip rate, usually given in millimetres per year. In reality, most faults do not slip a little each year. Instead, strain deep underground builds up over time with no slip happening on the fault, and is released occasionally in earthquakes with a lot of slip all at once. Nonetheless, slip rate is a simple way of representing the relative activity of a fault and allows the activities of different faults to be compared. In New Zealand, active fault slip rates vary from >25 mm/yr to <1 mm/y, with a fault slip rate of more than 5 mm/year considered high, and a slip rate of less than 1 mm/year regarded as low.

Recurrence interval (RI) is the average amount of time between surface rupturing earthquakes on a fault estimated over a long time frame (e.g. many thousands of years). RI can be calculated by estimating of the amount of offset that occurs in a single fault rupture (single-event displacement), and dividing that value by the slip rate. RI values provide an indication of the relative hazard posed by a fault and also allow the activities of different faults to be compared. The shorter the RI, the more active the fault, and typically the higher the slip rate. Generally speaking, the shorter the RI of a fault, the higher the likelihood of that fault rupturing in the near future, and the RI is a key parameter in the MfE Guidelines (Kerr & others 2003).

In New Zealand, a short RI for an active fault is a few hundred years, and a long RI is many thousands of years. An example of a very active fault is the Alpine Fault, which has an average RI of ~300 years, based on detailed studies of the fault (Berryman & others 2012). An example of a much less active fault is the Greendale Fault, on the Canterbury Plains. Detailed investigations have found that, prior to the 2010 Darfield Earthquake, the last time the fault produced a surface rupture was sometime between ~20,000 and ~30,000 years ago, suggesting a RI in the region of a few tens of thousands of years (Hornblow & others 2014).

Because even the shortest RIs are longer than the duration of written scientific observation in New Zealand, the RI is estimated from prehistoric information preserved in geological deposits or landforms. Geological investigations have been carried out on most of the major faults in northern Canterbury (Hurunui and Kaikoura districts). As a result, those faults have reasonably well established estimates of RI and slip rate.

Most other active faults in Canterbury have not been investigated geologically to determine their movement histories. Fault movement parameters, including slip rate and RI, have been estimated for several of those faults (e.g. Pettinga & others 2001; Litchfield & others 2014), but those estimates are largely based on inferences from landforms rather than direct geological investigation. Those estimates are typically expressed as a range of RIs.

For faults lacking previously-obtained RI data, the district fault reports developed a standardised and consistent method for estimating the RI. The estimation, outlined in each district report, involves many assumptions and there are large uncertainties in the resulting RIs. Each district report contains a table setting out the estimates used in calculating RI for each fault. When applying RI information to land-use or development issues for a particular fault, the most defensible position in regard to health and safety, and the security of assets and lifelines, is to adopt the smaller (shorter) value of a RI range. This conservative approach is robust where the RI estimate has a large range of uncertainty and is not constrained by direct investigation data for the fault.

3.0 FAULT AWARENESS AREAS FOR 1:250,000-SCALE EARTHQUAKE FAULT DATASETS

Fault mapping at between 1:35,000 and 1:250,000 scale is not detailed enough to delineate Fault Avoidance Zones around the faults, nor for directly applying the MfE Guidelines (Kerr & others 2003) to manage the fault rupture hazard. For faults mapped at 1:35,000 to 1:250,000 scale, a Fault Awareness Area around the fault is recommended.

A Fault Awareness Area highlights that an active fault is known, or suspected, to be present, but existing mapping is not accurate enough to be sure of its exact location (see Section 2.2.2). In contrast, a Fault Avoidance Zone (as defined in the MfE guidelines) is based on fault mapping of sufficient detail and accuracy to justify the restriction of certain types of development within a well-defined area.

The intent of a Fault Awareness Area is that it is sufficiently large to encompass the full range of plausible locations of the active fault. This means that within a Fault Awareness Area, it is expected that some parts of the area may be subject to a fault rupture hazard, but other parts of the area will be away from the hazard. By itself, a Fault Awareness Area does not provide a defensible basis for controlling or restricting development, because the nature and extent of fault hazard is not specifically defined or documented. Rather, the Fault Awareness Area flags that there is a potential hazard to look for, and provides a focus area where more detailed mapping and assessment could, if needed, be undertaken to define Fault Avoidance Zones. A Fault Avoidance Zone is likely to comprise a relatively narrow corridor within a Fault Awareness Area.

- Fault Awareness Areas should be created around the mapped lines of faults and monocline folds only. Fault Awareness Areas do not need to be created around syncline and anticline folds because they do not pose a significant life-safety hazard to most types of land use.
- Faults and monocline folds with the following certainty and surface form should be buffered[1] by 125 metres either side of the mapped line to make a 250-metre-wide Fault Awareness Area:
  - definite (well expressed)
  - definite (moderately expressed)
  - likely (well expressed)
  - likely (moderately expressed)
- The 125-metre-wide buffer either side of the mapped line takes into account both the inaccuracies of mapping at a 1:250,000 scale (see section 2.2.2), and also the fact that a fault rupture is typically not a knife-sharp break but a zone of fracturing and buckling that can range from a few metres to many tens of metres wide. This takes into account the possibility that ground deformation (breaking and buckling) in a future earthquake could extend some distance either side of a mapped fault, or that a new fault scarp could emerge near an existing one.

[1] Buffering is a process undertaken within a GIS system, where a perimeter of a specified width is generated around a specific mapped feature.

- All other faults and monocline folds ('possible' and 'not expressed') should be buffered by 250 metres either side of the mapped line to make a 500-metre-wide Fault Awareness Area.
- This wider zone recognises that because these sections of fault are not expressed as clearly at the ground surface the margin of error in their mapped location is greater.
- Buffers of adjacent faults that overlap should not be merged, but rather overlaid, so that the information for each fault is available.

4.0 RECOMMENDED ACTIONS FOR PROPOSED ACTIVITIES WITHIN FAULT AWARENESS AREAS

The following approach is recommended in using the 1:250,000-scale earthquake fault datasets. Ideally, each territorial authority in the Canterbury region would develop and apply similar approaches to managing surface fault rupture hazard so that there is a consistent approach across the region. Nevertheless, it is not expected that the exact terminology used here is also used in district plans, but rather that the guidance is fitted to the language of each individual plan. This is particularly so for the proposed activities, which in some plans may not exactly fit the terminology of Building Importance Categories (BIC; see Appendix 3).

A risk-based approach to activities within Fault Awareness Areas is recommended, depending on the RI of the fault and the type of activity proposed. Many of the mapped earthquake faults in Canterbury have not been investigated in detail and their estimated RIs are given as a broad range. The shorter (lower) value of the RI range for a fault should be used in decision making.

A summary of the recommendations is given in Table 4.1, and in more detail in the following text.

4.1 DISTRICT PLAN MAPS

It is recommended that all Fault Awareness Areas are shown on District Plan maps.

4.2 SINGLE DWELLINGS (STRUCTURES WITHIN BUILDING IMPORTANCE CATEGORY 2A, AND SINGLE DWELLINGS WITHIN BUILDING IMPORTANCE CATEGORY 2B)

Ideally, any new single dwelling would be located at least 20 metres away from the zone of ground surface deformation associated with an earthquake fault, particularly if the shorter value of the Recurrence Interval Class for that fault is less than 2,000 years. However, because the mapping of faults at 1:250,000 is not detailed enough to accurately determine a 20-metre set back, an advisory, non-regulatory approach is recommended for proposed timber or steel framed single dwellings in Fault Awareness Areas.

As well as being shown on District Plan maps, information on Fault Awareness Areas should be provided in Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs).

If land owners, or prospective land owners, require more information on the exact location of the fault within the Fault Awareness Area so they can set back from the fault they can contact Environment Canterbury in the first instance to see if more detailed information is available on record. They may also want to engage a suitably qualified and experienced geoscience professional to determine the exact location of the fault; however, there will be a cost associated with this (likely to be in the order of a few thousand dollars).

Table 4.1 Recommended actions for proposed activities within Fault Awareness Areas (FAAs) in relation to surface fault rupture Recurrence Interval (RI), Building Importance Category (BIC) and fault Certainty and Surface Form classifications. Refer to Section 3 for definitions of the fault parameters, and Appendix 3 for BIC definitions.

Proposed Activity	**Recommended Actions**		
	For FAA categories: definite (well expressed) definite (mod expressed) likely (well expressed) likely (mod expressed) with RI < 5,000 years	For FAA categories: definite (well expressed) definite (mod expressed) likely (well expressed) likely (mod expressed) with RI > 5,000 years	For all other FAA categories: definite (not expressed) likely (not expressed) possible
Single residential dwelling (BIC 2a and 2b in part)	Information in District Plans and on LIMs and PIMs		
Normal structures and structures not in other categories (BIC 2b, apart from single dwellings)	Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).	Information in District Plans and on LIMs and PIMs	
Important or critical structures (BIC 3 and 4)	Consideration of the surface fault rupture hazard should be a specific assessment matter if resource consent for a new structure is required. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures determined for the accurately mapped fault (e.g. set back or engineering measures).		
New subdivision (excluding minor boundary adjustments)	Consideration of the surface fault rupture hazard should be a specific assessment matter. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures).		Information in District Plans and on LIMs and PIMs
Plan Changes	Consideration of the surface fault rupture hazard should be a specific assessment matter. Site-specific investigation including detailed fault mapping at 1:35,000 or better and appropriate mitigation measures for the accurately mapped fault (e.g. set back or engineering measures.		

4.3 MULTI-OCCUPANCY RESIDENTIAL, COMMERCIAL, INDUSTRIAL AND PUBLIC BUILDINGS (MOST STRUCTURES WITHIN BUILDING IMPORTANCE CATEGORY 2B)

These types of developments often require a resource consent including an Assessment of Environmental Effects for other reasons (not related to surface fault rupture hazard). Where an Assessment of Environmental Effects is required, if the shorter value of the estimated range of Recurrence Interval Classes is less than 5,000 years (RI Class I, II or III), and the Fault Awareness Area is definite (well expressed), definite (moderately expressed), likely (well expressed) or likely (moderately expressed), consideration of the surface fault rupture hazard should be a specific assessment matter for new structures. This would require a site-specific investigation including detailed fault mapping at 1:35,000 or better to ensure that the structure is at least 20 metres away from the detailed mapped area of fault rupture deformation, or the building is engineered to mitigate the fault rupture hazard.

For all other Fault Awareness Areas, information should be provided in Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs) for new structures. If land owners, or prospective land owners, require more information on the exact location of the fault within the Fault Awareness Area, they can contact Environment Canterbury in the first instance to see if more detailed information is available on record. Alternatively, they can engage a suitably qualified and experienced geoscience professional to determine the exact location of the fault and better constrain its RI if necessary.

The reasons for the more restrictive measures for the higher-activity active faults (RI < 5,000 years) where the fault is definite (well expressed), definite (moderately expressed), likely (well expressed) and likely (moderately expressed) are:

- Definite (well expressed), definite (moderately expressed), likely (well expressed) and likely (moderately expressed) faults correspond to "well-defined" deformation in the MfE Guidelines. While the Fault Awareness Area is 250 metres wide, within these areas there is a relatively certain and definable surface fault rupture hazard. The cost of a site-specific investigation within these Fault Awareness Areas should be towards the lower end of the scale because the fault or monocline can be relatively easily mapped at the ground surface.
- A RI value of less than 5,000 years corresponds to the acceptable risk for Building Importance Category 2b structures in greenfield areas in the MfE Guidelines.
- Definite (well expressed), definite (moderately expressed), likely (well expressed) and likely (moderately expressed) Fault Awareness Areas of higher-activity faults cover a very small area of any territorial authority, and most are in rural or mountainous areas. As such, few, if any, individual site-specific investigations for multi-occupancy residential, commercial, industrial and public buildings would be anticipated in any given year.

Definite (well expressed), definite (moderately expressed), likely (well expressed) and likely (moderately expressed) Fault Awareness Areas of higher-activity faults are areas of greatest priority for future detailed mapping. Greatest priority will be given to faults with the lowest (most frequent) RI and closest proximity to existing and potential development. It is therefore likely that, over time, these Fault Awareness Areas will be progressively replaced by more detailed Fault Avoidance Zones.

Information on Fault Awareness Areas should be provided in Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs) for land with existing structures in this category.

4.4 IMPORTANT OR CRITICAL STRUCTURES (BUILDING IMPORTANCE CATEGORY 3 AND 4)

Proposed important or critical structures (Building Importance Category 3 and 4) generally require a resource consent including an Assessment of Environmental Effects.

Where an Assessment of Environmental Effects is required for a new structure, consideration of the surface fault rupture hazard should be a specific assessment matter within any Fault Awareness Area. This would require a site-specific investigation including detailed fault mapping at 1:35,000 or better and assessment of its RI (if not already well constrained) to ensure that the structure is at least 20 metres away from the detailed mapped area of fault or fold deformation, or is engineered to mitigate the fault rupture hazard.

This may also be covered in natural hazard provisions in the District Plan in regards to critical infrastructure.

Information on Fault Awareness Areas should be provided in Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs) for land with existing structures in these categories.

4.5 SUBDIVISION

A resource consent is required for subdivision. As part of this resource consent it is recommended that a site-specific investigation including detailed fault mapping of the fault at 1:35,000 or better and assessment of its RI (if not already well constrained) be undertaken for any subdivision in a definite (well expressed), definite (moderately expressed), likely (well expressed) or likely (moderately expressed) Fault Awareness Area. Fault Avoidance Zones can then be delineated and the MfE Guidelines applied so that building sites are located at least 20 metres away from the detailed mapped area of fault or fold deformation, or buildings engineered to mitigate the surface fault rupture hazard.

It is desirable to avoid a fault wherever one can, regardless of its RI, as this has potential benefits in regard to resilience and public/purchaser perceptions. Being able to demonstrate that the design of the development and buildings are specifically located to avoid potential fault rupture hazard offers likely economic advantages, in terms of maximising sale value in relation to public/purchaser perceptions of fault hazard, and potential benefits from simplifying consent processes and insurance considerations. For subdivisions it is more cost effective to undertake an investigation of potential fault hazards for the whole subdivision rather than on a lot-by-lot basis.

A territorial authority may choose to adopt some discretion in relation to this guidance depending on the size and nature of the proposed subdivision, for example if the activity involves simple boundary adjustments, or small subdivisions (with any size thresholds to be determined by each territorial authority).

4.6 PLAN CHANGES

For proposed Plan Changes within a Fault Awareness Area, whether classed as definite, likely or possible, that enable intensification of land use, or where development could be damaged by surface fault rupture, Policy 11.3.3 (6) of the Canterbury Regional Policy Statement (see Appendix 1) applies. This requires a site-specific investigation including detailed mapping of the fault at 1:35,000 or better and assessment of its RI (if not already well constrained) be undertaken to a level sufficient to apply the MfE Guidelines.

4.7 REQUIREMENTS FOR DETAILED FAULT MAPPING

Detailed fault mapping is defined as mapping a fault and associated areas of ground deformation to a scale of 1:35,000 or better. A detailed map of a fault and associated areas of deformation provides sufficient basis for defining Fault Avoidance Zones, which would be used instead of the broader Fault Awareness Areas. Accurately mapped Fault Avoidance Zones can guide planning and manage development for specific land parcels.

Environment Canterbury has commissioned detailed mapping for several active faults in the Canterbury Region that are close to existing or potential development. So far, this has included the Hanmer Fault at Hanmer Springs, the Hope Fault at Mt Lyford, the Ostler Fault Zone at Twizel, the Greendale Fault in the Selwyn District, and the Ashley-Loburn Fault Zone near Rangiora. Some other parts of the Hope Fault, and possibly other faults, are expected to be mapped in detail in coming years. Detailed mapping of faults (and application of the MfE guidelines) has also been undertaken in several other regions, such as Wellington and Hawke's Bay.

Most of the active faults in Canterbury are in unpopulated or lightly populated areas where developments, other than new single dwellings, are uncommon. If a significant development (i.e. Building Importance Category 2b, 3 or 4, or a subdivision) is proposed then it is recommended that the applicant undertake a site-specific assessment, including detailed mapping, depending on the activity of the fault as outlined above.

The scope of investigation, and its cost, will depend on the type of development proposed. For faults that are classified definite (well expressed), definite (moderately expressed), likely (well expressed) or likely (moderately expressed), a suitably qualified and experienced geoscience professional should be able to identify and accurately survey in the location of a fault and associated areas of ground deformation for costs in the order of several thousand dollars. This level of investigation is likely to be adequate for proposed multi-occupancy residential, commercial, industrial and public buildings (most structures within Building Importance Category 2b) and subdivisions, and means that surface fault rupture hazards to the development can be mitigated, for example by appropriate set back from the areas of fault-related ground deformation.

The applicant may wish to undertake a more detailed investigation, involving trenching of the fault, where the fault is classed as likely (well expressed) or likely (moderately expressed), to determine whether the feature is definitely a fault or not. Trenching a fault involves digging a trench across the fault scarp (at right angles to it) so that sediments that have been offset or broken by the fault can be seen. Trenching has the potential to reveal whether the mapped scarp is indeed a fault (if there is any uncertainty around this), and helps to establish the exact position of the fault. The timing and size of past movements on the fault can also be determined by dating offset sediment layers in the trench and this helps to constrain the RI of a fault and the likelihood of future movement. However, trenching and dating is much more expensive than simply mapping the fault, and would likely cost in the order of several tens of thousands of dollars.

A more detailed investigation, involving both detailed mapping and trenching, is recommended for proposed important or critical structures (Building Importance Category 3 and 4) and Plan Changes. Only geoscience professionals with appropriate expertise and experience in active fault assessment should undertake or supervise detailed fault mapping and trenching.

In some circumstances there may be engineering solutions that provide acceptable alternatives to avoiding a fault, such as constructing strong and robust foundations (e.g. Bray 2001 and Bray 2009). For example, the Clyde Dam in Central Otago incorporates a 'slip joint' across a fault in its foundations, either side of which the concrete dam can move independently in the event that the fault ruptures. Local authorities should allow provisions for considering engineering mitigation of surface fault rupture hazard.

Any detailed fault mapping or investigations that are undertaken by land owners or resource consent applicants should be supplied to Environment Canterbury so that the information can be added to the active fault datasets, as per Method 7 of Policy 11.3.3 of the Canterbury Regional Policy Statement. Rules should be included in the District Plan to ensure this.

5.0 LAND INFORMATION MEMORANDA (LIMS) AND PROPERTY INFORMATION MEMORANDA (PIMS)

The delineation of active faults, even at 1:250,000 scale, identifies a potential natural hazard and territorial authorities should provide information about such faults on Land Information Memoranda (LIMs) and Property Information Memoranda (PIMs), under section 44a(3) of the Local Government Official Information and Meetings Act 1987.

Fault Awareness Areas, as outlined in this guideline, give context to the possible extent and nature of a surface fault rupture hazard and it is recommended that appropriate information is provided on a LIM or PIM for any land parcel within a Fault Awareness Area. It is important to appreciate that in any district, Fault Awareness Areas will affect only a very small percentage of the land area of the district. Accordingly, relatively few applications for LIMs and PIMs are likely to fall within a Fault Awareness Area. For those that do, the presence of a Fault Awareness Area should be part of the information provided to the applicant.

Under the Local Government Official Information and Meetings Act 1987, if information about natural hazards is apparent from a District Plan then it does not need to be included in a LIM or PIM. However, it is recommended that information about Fault Awareness Areas be included in the District Plan as well as on LIMs and PIMs. The reasoning is that by providing people with information through more than one channel, it maximises their opportunities to make informed decisions.

Two approaches can be taken to providing fault information. The most complete approach is to provide full information on specific Fault Awareness Areas where they coincide with the land parcel(s) for which the LIM or PIM application has been made (*Property-specific details*). This is the recommended approach. A simpler approach is to include a note on all LIMs and PIMs, regardless of whether the property coincides with a Fault Awareness Area, that a fault report for the district is available (*General note*).

5.1 FAULT AWARENESS AREAS - PROPERTY-SPECIFIC DETAILS

This approach provides specific information about a Fault Awareness Area(s) in relation to the particular land parcel addressed in a LIM or PIM application. This approach is of greater use to applicants than a general note, and because of this it is the recommended approach. Information about a Fault Awareness Area needs to be carefully worded to be clear, fair and balanced, and should acknowledge limitations and uncertainties of the information. Key information to include is:

- that the Fault Awareness Area highlights that an earthquake fault is known or suspected to lie somewhere within the Fault Awareness Area. In most cases, that earthquake fault is likely to occupy a relatively narrow corridor within that area;
- whether the Fault Awareness Area is for a definite, likely, or possible fault (the Certainty);
- how well the fault is likely to be seen on the ground surface (the Surface Form);
- the estimated Recurrence Interval range for the fault, and that the lower (shorter) value is assumed to apply unless investigations are done to show otherwise;

- that the hazards associated with the earthquake fault include not only strong earthquake shaking should the fault move, but also breaking and buckling of land along and near the fault as land either side of the fault moves relative to the other;
- that in many cases the exact location of the fault should be able to be determined with more detailed investigations;
- that more information is available in the district fault report, and people can also contact Environment Canterbury for more information.

An example of wording is:

> The property is within a Fault Awareness Area, which is the indicative area within which a known or suspected active earthquake fault has been mapped at a regional-scale (1:250,000). The exact location of the fault is likely to occupy a relatively narrow corridor within the Fault Awareness Area and in most cases the location of the fault should be able to be determined with more detailed investigations.
>
> An earthquake fault is classified as active if it has suddenly fractured and moved at least once within the last 125.000 years. Movement on a fault can cause sudden fracturing and offset (faulting) of land along the line where the fault meets the ground surface and buckling or warping (folding) of the ground surface within many tens of metres of the fault line, in addition to earthquake shaking over a much wider area. This sudden breaking and warping of the ground surface can damage buildings and infrastructure that are on or close to the fault.
>
> The Fault Awareness Area on the property is for the XXX Fault.
>
> The certainty of the fault is identified here as (**select at least one definition and description and delete the others**) <*definite*, which means that the mapped feature is without a doubt an active fault><*likely*, which means that the mapped feature is probably an active fault but other explanations for its origin cannot be ruled out (for example, it could have been formed by river erosion)><*possible*, which means there is a possibility that the mapped feature is an active fault, but it is just as likely to have been formed by another process (for example, river erosion) or there is no direct evidence of movement at that location>.
>
> The surface form of the fault is identified here as (**select at least one definition and description and delete the others**) <*well expressed*, which means the mapped feature should be able to be located on the ground to better than ± 50 metres – it can be clearly seen on the ground><*moderately expressed*, which means the mapped feature should be able to be located on the ground to better than ± 100 metres – it is not so easily seen on the ground.><*not expressed*, which means the mapped feature cannot be seen at the ground surface and would require a detailed investigation to locate it (for example, it has been covered by river gravels since the last movement on the fault).><*unknown*, which means the surface form cannot be determined, for example where vegetation obscures the ground surface, or where no aerial photos are available for making an assessment.> The surface form information is primarily intended to aid any future detailed fault mapping or related investigations of the fault by indicating where a fault would be easy to locate and map in detail.
>
> The Recurrence Interval (RI) of the fault is an estimate of the long-term average time between earthquakes on the fault, and fracturing and warping of the ground at the fault.

> The RI of most active faults in Canterbury has not been determined in detail, but the RI of the XXX Fault is likely to be between XXX and XXX years. The lower (shorter) value is assumed to apply to this fault unless investigations are done to show otherwise. A very active fault in New Zealand would have a RI of a few hundred years (for example, the Hope Fault in North Canterbury) and a less active fault would have a RI of tens of thousands of years (for example, the Greendale Fault in Selwyn District).
>
> More information on this active earthquake fault can be found in a report titled *General Distribution and Characteristics of Active Faults and Folds in the XXX District*. That report is available online at www.ecan.govt.nz or in hard copy from Environment Canterbury or the XXX District Council. General information on active earthquake faults can also be found at www.ecan.govt.nz. Environment Canterbury may also hold more detailed information relevant to this Fault Awareness Area, and they should be contacted in the first instance for information.

The territorial authority may also wish to add any information about District Plan provisions for active faults.

5.2 FAULT AWARENESS AREAS - GENERAL NOTE

The approach of providing a generalised statement of information about faults, as described below, is not recommended as a satisfactory approach. This approach involves placing a note (i.e. under section 44A(3)) on all LIMs and PIMs, regardless of whether the property coincides with a Fault Awareness Area, that a fault report for the district is available. It is important to appreciate that the district fault reports do not contain information on Fault Awareness Areas. Fault Awareness Area information is addressed only in the present report. If choosing this approach, a territorial authority should direct an applicant to both the district fault report and to this report.

An example of wording is:

> Information on active earthquake faults in XXX district can be found in a report *General Distribution and Characteristics of Active Faults and Folds in the XXX District.* That report should be read in conjunction with a report *Guidelines for using regional-scale earthquake fault information in Canterbury*. Both reports can be viewed online at www.ecan.govt.nz or in hard copy from the XXX District Council or Environment Canterbury. Environment Canterbury may also hold more detailed fault information and they should be contacted in the first instance for information.

This approach is simple to apply. However, because this approach will not inform a LIM or PIM applicant whether the land is within a Fault Awareness Area or not, the applicant will need to obtain and read the two reports, whether or not they are relevant to the land parcel(s). Most of the land area in any district is not within Fault Awareness Areas, so most applicants will need to go to unnecessary effort to determine whether or not the land is subject to a possible surface fault rupture hazard, and in most cases find that it isn't. Conversely, there is also the possibility that applicants where the land parcel(s) do coincide with a Fault Awareness Area will not look at the reports, and therefore not be aware that there is a possible fault rupture hazard on the land. This approach falls short of the aim of providing LIM and PIM applicants with as much information as possible so that they can make an informed decision, and for that reason is not recommended.

5.3 OTHER CONSIDERATIONS

Where faults have been mapped in detail – the Hanmer Fault, Hope Fault Zone at Mt Lyford Village, Ashley Fault Zone, Ostler Fault Zone near Twizel, and the Greendale Fault – more specific LIM wording should be developed, because the location of the fault and associated ground deformation is better mapped and more is usually known about the RI of the fault.

Similar wording to the detailed LIM wording suggested above is used in Environment Canterbury Land Information Requests (LIRs). However, more detail can usually be provided because of the relatively low number of LIRs requested compared to LIMs and also because a LIR is not automatically generated but is written on a case-by-case basis by a geological hazard analyst.

6.0 OTHER USES FOR 1:250,000-SCALE FAULT INFORMATION

The location of earthquake faults should be taken into account in planning new infrastructure. This may be included in District Plans as provisions around critical infrastructure. It is also recommended that syncline and anticline folds be considered if major infrastructure is proposed within 2 km of a mapped syncline or anticline axis location. This is because tilting of the ground as a result of an earthquake on the fault that underlies the surface fold, while not posing a significant hazard to most types of land use, could render critical structures or major infrastructure unusable. The reason for this wide zone of awareness is that for anticline or syncline folds, what is mapped is the centreline (axis) of the fold, and the zone of potential ground tilt extends a considerable distance either side of that line.

The 1:250,000-scale fault information can also be used to apply Rule 5.181 condition 6(b) of the Canterbury Land and Water Regional Plan. This rule states that the storage of hazardous substances is not permitted within 250 metres of a known active fault that has a recurrence interval of less than 10,000 years, if the land is over an unconfined or semi-confined aquifer, or within 50 metres of a permanently or intermittently flowing river or lake.

The 1:250,000-scale fault information is also useful for emergency management planning and public education. The mapped fault locations highlight areas where there may be a surface fault rupture hazard and in a general way indicate likely sources of large earthquakes (if a fault has ruptured all the way to the ground surface, it is generally capable of generating an earthquake of magnitude 7.0 or larger).

All Fault Awareness Areas, as well as anticline and syncline folds, and any detailed fault mapping undertaken by Environment Canterbury, will be accessible on the Canterbury Maps website from the end of 2016.

7.0 ACKNOWLEDGEMENTS

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APPENDICES

A1.0 ROLES OF LOCAL GOVERNMENT

The responsibilities of local authorities in Canterbury, in regard to surface fault rupture and liquefaction hazards, are set out in the Canterbury Regional Policy Statement (CRPS). Relevant extracts from the CRPS are provided below. Methods for implementing the policy provisions relating to surface fault rupture are underlined.

Objective 11.2.1 - Avoid new subdivision, use and development of land that increases risks associated with natural hazards

New subdivision, use and development of land which increases the risk of natural hazards to people, property and infrastructure is avoided or, where avoidance is not possible, mitigation measures minimise such risks.

Policy 11.3.3 – Earthquake hazards

New subdivision, use and development of land on or close to an active earthquake fault trace, or in areas susceptible to liquefaction and lateral spreading, shall be managed in order to avoid or mitigate the adverse effects of fault rupture, liquefaction and lateral spreading.

Methods

The Canterbury Regional Council will:

1. Assist territorial authorities to delineate fault avoidance zones along known active fault traces.
2. Assist territorial authorities to delineate areas susceptible to liquefaction and lateral spreading.
3. Make available, upon request, any information that it holds about natural hazards.
4. Territorial authorities will:
5. Set out objectives and policies, and may include methods in district plans to manage new subdivision, use and development of land in areas on or adjacent to a known active earthquake fault trace.
6. Set out objectives and policies, and may include methods in district plans to manage new subdivision, use and development of land in areas known to be potentially susceptible to liquefaction and lateral spreading.
7. Ensure that the risk of earthquake fault rupture, liquefaction and lateral spreading hazards are assessed before any new areas are zoned or identified, in a district plan, in ways that enable intensification of use, or where development is likely to be damaged and/or cause adverse effects on the environment.

Territorial authorities should:

8. Supply information to the Regional Council captured at time of subdivision in relation to active earthquake fault trace, areas susceptible to liquefaction and lateral spreading.

A2.0 DISTRICT FAULT MAPPING REPORTS

All district fault mapping reports are accessible on the Environment Canterbury website www.ecan.govt.nz and we recommend visitors access them using the search term <earthquake fault information>. Note that there is no district fault mapping report for Christchurch City, because there are no known earthquake faults at the ground surface in the Christchurch City area (the faults that caused the February 2011 and later earthquakes are wholly underground and did not break the ground surface).

Barrell, D.J.A.; Strong, D.T. 2009. General distribution and characteristics of active faults and folds in the Ashburton District, mid-Canterbury. GNS Science Consultancy Report 2009/227; Environment Canterbury Report No. R09/72.

Barrell, D.J.A.; Strong, D.T. 2010. General distribution and characteristics of active faults and folds in the Mackenzie District, South Canterbury. GNS Science Consultancy Report 2010/147; Environment Canterbury Report No R10/44.

Barrell, D.J.A.; Townsend, D.B. 2012. General distribution and characteristics of active faults and folds in the Hurunui District, North Canterbury. GNS Science Consultancy Report 2012/113; Environment Canterbury Report No. R12/39.

Barrell, D.J.A. 2013. General distribution and characteristics of active faults and folds in the Selwyn District, North Canterbury. GNS Science Consultancy Report 2012/325; Environment Canterbury Report No. R13/27.

Barrell, D.J.A.; Begg, J.G. 2013. General distribution and characteristics of active faults and folds in the Waimakariri District, North Canterbury. GNS Science Consultancy Report 2012/326; Environment Canterbury Report No. R13/28.

Barrell, D.J.A. 2015. General distribution and characteristics of active faults and folds in the Kaikoura District, North Canterbury. GNS Science Consultancy Report 2014/210; Environment Canterbury Report No. R15/23.

Barrell, D.J.A. 2016. General distribution and characteristics of active faults and folds in the Timaru District, South Canterbury. GNS Science Consultancy Report 2014/308; Environment Canterbury Report No. R15/112.

Barrell, D.J.A. 2016. General distribution and characteristics of active faults and folds in the Waimate District and Waitaki District, South Canterbury and North Otago. GNS Science Consultancy Report 2015/166; Environment Canterbury Report No. R15/135.

A3.0 BUILDING IMPORTANCE AND FAULT AVOIDANCE ZONATION

The Ministry for the Environment (MfE) Guidelines for development of land on or close to active faults (Kerr & others 2003) define five Building Importance Categories (BIC1-5) (Table A3.1), with one of the categories, BIC 2, divided into a and b classes. These categories closely equate with Building Importance Level (BIL) defined in New Zealand legislation, most recently updated in the Building (Building Code: Fire Safety and Signs) Amendment Regulations 2012. The main difference is that BIL 2 is a single category in the regulations, not divided into 2a and 2b as is done in the BIC scheme. The rationale for making that distinction in the MfE Guidelines is that it allows typical timber-framed residential dwellings to be distinguished from more important structures such as multi-occupancy commercial buildings and public assembly buildings, for example.

When Building Importance Categories are taken into account with Recurrence Interval (RI), which is segregated into six classes, the Guidelines provide a risk-based methodology for planning for the development of land on or close to active faults (Table A3.2). The Guidelines make a distinction between previously subdivided and/or developed ‘brownfield’ sites, and undeveloped ‘greenfield’ sites, and allow for different conditions to apply to these two types of sites (Table A3.2).

Table A3.1 Building Importance Categories. This compilation is: a modified version of New Zealand Loading Standard classifications (from MfE Guidelines “Planning for development of land on or close to active faults”; Kerr & others 2003).

Building Importance Category (BIC)	Description	Examples
1	Temporary structures with low hazard to life and other property	• Structures with a floor area of <30m^2 • Farm buildings, fences • Towers in rural situations
2a	Timber-framed residential construction	• Timber framed single-story dwellings
2b	Normal structures and structures not in other categories	• Timber framed houses with area >300 m^2 • Houses outside the scope of NZS 3604 “Timber Framed Buildings” • Multi-occupancy residential, commercial, and industrial buildings accommodating <5000 people and <10,000 m^2 • Public assembly buildings, theatres and cinemas <1000 m^2 • Car parking buildings
3	Important structures that may contain people in crowds or contents of high value to the community or pose risks to people in crowds	• Emergency medical and other emergency facilities not designated as critical post disaster facilities • Airport terminals, principal railway stations, schools • Structures accommodating >5000 people • Public assembly buildings >1000 m^2 • Covered malls >10,000 m^2 • Museums and art galleries >1000 m^2 • Municipal buildings • Grandstands >10,000 people • Chemical storage facilities >500m^2
4	Critical structures with special post disaster functions	• Major infrastructure facilities • Air traffic control installations • Designated civilian emergency centres, medical emergency facilities, emergency vehicle garages, fire and police stations

Table A3.2 Relationships between fault Recurrence Interval Class and Building Importance Category (from MfE Guidelines "Planning for development of land on or close to active faults"; Kerr & others 2003). The MfE Guidelines recommend that 'non-allowable' buildings are unsuitable for lying on or close to an active fault of that RI Class.

<table>
<tr><th rowspan="2">Recurrence interval class</th><th rowspan="2">Average recurrence interval of surface rupture</th><th colspan="2">Building Importance Category (BIC) limitations (allowable buildings)</th></tr>
<tr><th>Previously subdivided or developed sites</th><th>'Greenfield' sites</th></tr>
<tr><td>I</td><td>≤2000 years</td><td>BIC 1
temporary buildings only</td><td rowspan="2">BIC 1
temporary buildings only</td></tr>
<tr><td>II</td><td>>2000 years to
≤3500 years</td><td>BIC 1& 2a
temporary & residential timber-framed buildings only</td></tr>
<tr><td>III</td><td>>3500 years to
≤5000 years</td><td>BIC 1, 2a, & 2b
temporary, residential timber-framed & normal structures</td><td>BIC 1& 2a
temporary & residential timber-framed buildings only</td></tr>
<tr><td>IV</td><td>>5000 years to
≤10,000 years</td><td rowspan="2">BIC 1, 2a, 2b & 3
temporary, residential timber-framed, normal & important structures
(but not critical post-disaster facilities)</td><td>BIC 1, 2a, & 2b
temporary, residential timber-framed & normal structures</td></tr>
<tr><td>V</td><td>>10,000 years to
≤20,000 years</td><td>BIC 1, 2a, 2b & 3
temporary, residential timber-framed, normal & important structures
(but not critical post-disaster facilities)</td></tr>
<tr><td>VI</td><td>>20,000 years to
≤125,000 years</td><td colspan="2">BIC 1, 2a, 2b, 3 & 4
critical post-disaster facilities cannot be built across an active fault with a recurrence interval ≤20,000 years</td></tr>
</table>

Note: Faults with average recurrence intervals >125,000 years are not considered active.

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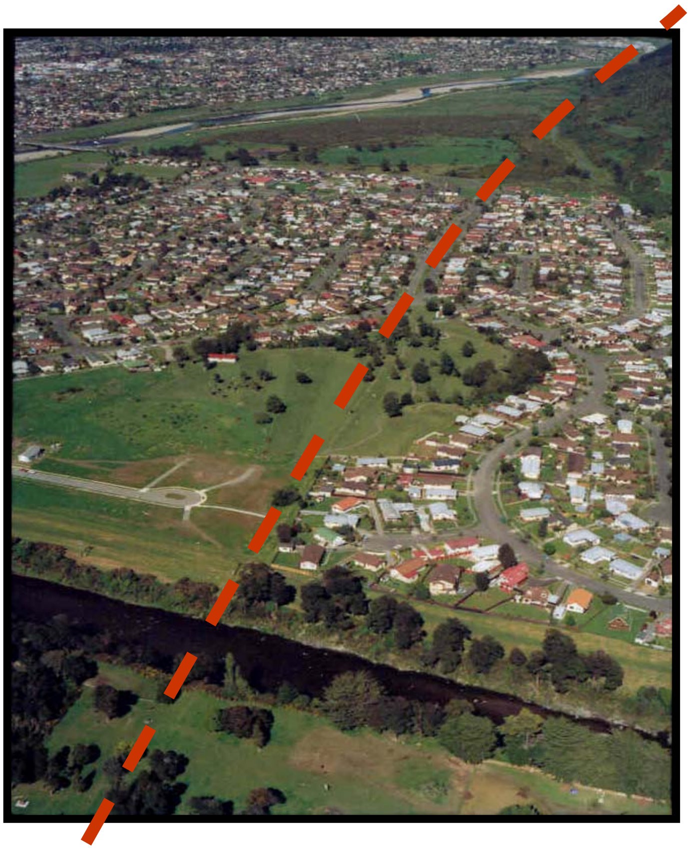
Appendix C

GNS – Planning for development of land on or close to active faults

Planning for Development of Land on or Close to Active Faults



A guideline to assist resource management planners in New Zealand

Report prepared for the Ministry for the Environment by
Janine Kerr, Simon Nathan, Russ Van Dissen, Peter Webb,
David Brunsdon and Andrew King

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Institute of Geological & Nuclear Sciences client report 2002/124
Project Number: 440W3301

The data presented in this report are available to GNS for other use from May 2003.

Titlepage photo: Totara Park suburb, Upper Hutt City. *A "greenfield" development that has mitigated the fault rupture hazard of the Class 1 Active Wellington fault (The photo dates from the late 1970's, before Totara Park was fully developed). The photo shows, in the distance, right of centre, the dual carriageway of California Drive leading into California Park, the large open space at centre. The Wellington fault underlies the median strip of California Drive, crosses California Park, through the centre of the photo, and continues to the lower left. It underlies a walkway between California Park and the Hutt River, just left of the leftmost group of houses nearest the camera, on the far bank of the Hutt River. The fault crosses into the river, at the leftmost of the trees aligned along the far riverbank. It continues to lower left, through Harcourt Park, another recreational reserve. Photo D.L. Homer, GNS CN18547/39*

Contents

1 Introduction

Controlling the development of land on or close to active faults is a Resource Management Act 1991 issue. These guidelines provide direction on land use planning approaches for land on or close to active faults. They aim to help local authorities minimise the hazard risk and the time it takes for individuals, communities, and the government to recover from fault rupture.

The guidelines aim to assist planners, emergency managers, earth scientists, and people in the building industry to avoid or mitigate the fault rupture hazard.

We hope that using these guidelines will help to avoid or mitigate the risks associated with building on or close to active faults. Different planning approaches are appropriate in different areas – councils can establish appropriate policies and criteria which are more or less restrictive than those represented here if necessary.

A working party of representatives from the Institute of Geological & Nuclear Sciences, Geological Society of New Zealand, New Zealand Society for Earthquake Engineering, BRANZ, Earthquake Commission and Ministry for the Environment developed these guidelines. Consultation took place with members from various local authorities. The collaborative approach drew together a range of expertise from professions that have an interest in land use issues and hazard risk reduction.

Note that these guidelines are only concerned with the avoidance and mitigation of risk arising from active fault rupture. They don't discuss other earthquake-related hazards, such as strong ground shaking, liquefaction, uplift, subsidence, landslide and tsunami.

1.1 Why we developed the guidelines

New Zealand's precarious location at the edge of two converging tectonic plates means we are subject to natural hazards like earthquake shaking, earthquake fault rupture, and land deformation. As these tectonic plates continue to move, New Zealand will continue to be subject to earthquake-related hazards.

In March 2001, the Parliamentary Commissioner for the Environment released the report *Building on the Edge – The Use and Development of Land On or Close to Fault Lines*. The Commissioner's investigation arose following public concern that local authorities were not able to adequately manage the use and development of land on or close to active faults.

The PCE report focused on the Building Act 1991 and the Resource Management Act 1991 (RMA). It reached a number of key conclusions.

- There is no technology to prevent earthquake damage to buildings built across faults.
- Few territorial authorities identify and plan for seismic hazards, despite their responsibilities for subdivision and land use.
- Practical guidelines are urgently needed to reduce the risks associated with fault rupture.

Recommendation 1 (below) of the PCE report was the catalyst for the development of these guidelines:

> *The Ministry for the Environment [is] working together with the Institute of Geological and Nuclear Sciences and other interested organisations with structural and geotechnical expertise to develop best practice guidelines for territorial authorities in avoiding or mitigating seismic hazard through the district plan process.*

We suggest that users of these guidelines also read the PCE report, to gain an overview of active fault and land use issues.

1.2 Summary of the contents

The first part of this guide (sections 2–9) focuses on the need for a risk-based approach to planning for land use on and near active faults. It recommends that councils:

- identify active faults in their district, with maps that are at the right scale for the purpose
- create fault hazard avoidance zones on their district planning maps
- evaluate the fault rupture hazard risk within each fault avoidance zone
- avoid building within fault hazard avoidance zones where possible
- mitigate the fault rupture hazard when building has taken place or will take place within a fault hazard avoidance zone.

The main elements of the risk-based approach are:

- the fault recurrence interval, which is an indicator of the likelihood of a fault rupturing in the near future
- the fault complexity, which establishes the distribution and deformation of land around a fault line
- the Building Importance Category, which indicates the acceptable level of risk of different types of buildings within a fault avoidance zone.

The second part of this report (sections 10–11) discuss the role of regional councils and territorial authorities in planning for fault rupture hazard. Section 11 describes how councils can take a risk-based approach to establishing resource consent categories for buildings within a fault hazard avoidance zone.

The appendices to the guide contain information that councils can use to begin identifying active faults in their districts.

2 Principles for Planning Approaches

The information in this guide is based on the four over-arching principles below. However, past planning decisions have not always taken that approach. The principles recognise that a different planning approach is needed for an area that has not been developed (a greenfield site) and an area that has been developed or subdivided, or where there exists an expectation to build. Defining a Greenfield site is something that each council needs to do. It may be an area where there is currently no expectation to build (e.g. no zoning for intensive development) or may be an undeveloped area of a certain defined size (e.g. < 20 acres).

2.1 Principle 1: Gather accurate active fault hazard information

Identifying and accurately locating hazards on planning maps is an essential step towards communicating hazard risk and mitigating hazards. Collecting information will often require specialised scientific knowledge and surveys. Maps showing the location of hazards around property boundaries must be developed at the right scale. Because the existence of a particular hazard may have a major effect on a decision to purchase or build on a property, all information on hazards should be as accurate as technology and resources permit.

2.2 Principle 2: Plan to avoid fault rupture hazard before development and subdivision

Building away from areas of fault rupture can avoid, or certainly mitigate, the fault hazard risk. For example, a new subdivision can be required to avoid building in an area of fault rupture (a *fault avoidance zone* in the district plan). This is the safest and most satisfactory long-term solution for current and later landowners and for the territorial authority. It can also be achieved for little or no extra cost (although we recognise that loss of development opportunities are a cost to the developer).

2.3 Principle 3: Take a risk-based approach in areas already developed or subdivided

If land has already been subdivided and sites have been purchased, there is an expectation that building on these sites will be allowed. Planning for land use in a fault avoidance zone helps to avoid or mitigate the hazard risks caused by land-use intensification (such as urban infill) and inappropriate building.

These guidelines propose a risk-based, approach, based on risk management standard AS/NZS 4360:1999. This standard takes into account the fault recurrence interval and fault complexity, and the Building Importance Category of the building proposed for the site.

This approach does not guarantee that a building will not suffer damage from fault rupture in an earthquake. It does establish that the risk of damage is sufficiently low to be generally accepted.

2.4 Principle 4: Communicate risk in built up areas subject to fault rupture

One of the most difficult problems concerning fault rupture hazard is dealing with urban areas where buildings have already been constructed on or close to an active fault. One of the clearest examples of this situation is the suburb of Thorndon in Wellington. Although the risk posed by building in such a location is obvious to us now, it was not clear when urban subdivision started in New Zealand in the 19th century.

The ideal approach in this situation would be to avoid further development in high-risk areas, to limit existing use rights to rebuild, and to limit the use of buildings.

The most realistic approach, however, is to accept the status quo whilst ensuring that:

- any further development and use of buildings is consistent with the level of risk posed
- district plan maps clearly show fault rupture hazard zones.

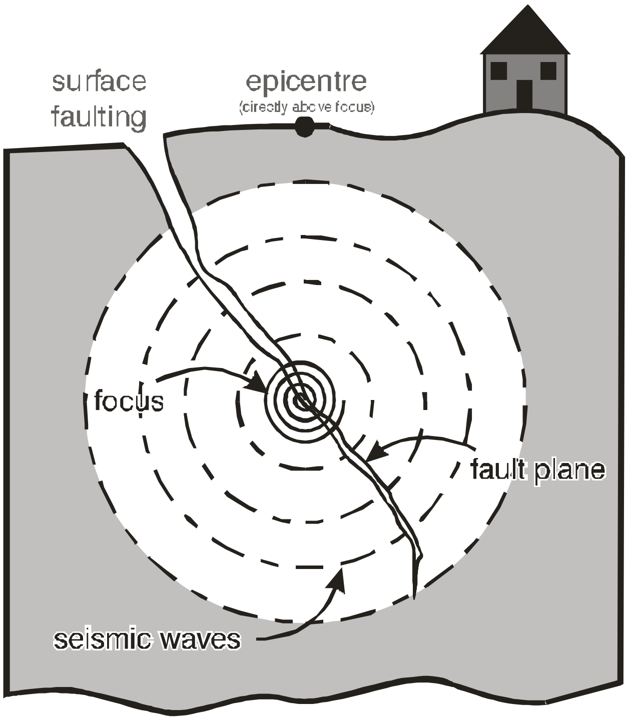
Non-regulatory approaches, such as hazard education programmes and incentives to retire at-risk land, would also ensure that landowners and building occupiers are made aware of the hazard, and the probability of future fault rupture.

3 Understanding Earthquakes and Active Faults

3.1 Definitions

A **fault** is a fracture in the Earth's crust. The opposite sides of the fracture are held together by pressure and friction, but as stress builds up a fault may suddenly rupture. In a large rupture, shock waves cause the earth to shake violently and produce an **earthquake**.

Figure 3.1: Relationship between faults and earthquakes



The point at which a fault plane starts to rupture is known as the focus or origin. The point on the surface directly above the focus is called the epicentre.

An **active fault** is a fault that has ruptured repeatedly in the past, and whose history indicates that it is likely to rupture again. An active fault creates a **fault hazard risk**. The level of that risk depends on the fault recurrence interval (section 7), fault complexity (section 8), and nature of development in the area.

New Zealand geological maps use a distinctive colour for faults that have moved in the last 120,000 years. This is generally regarded as the upper limit for a fault to be classified as active. Most of New Zealand's major active faults have been identified and mapped, at least on small-scale maps.

In a large earthquake, the fault rupture may extend up to the ground surface, and suddenly form a **fault scarp** (the disrupted land form created by the rupture). For example, in the 1987 Edgecumbe earthquake, a man climbing a tree felt the ground shaking and saw a fault scarp develop across the field on either side of him.

All buildings close to the epicentre of a large shallow earthquake will be strongly shaken, and this shaking causes most of the earthquake damage. Any building sited across a fault scarp is likely to suffer more damage, especially if the foundations are offset. It is unlikely that any building sited across the fault scarps in Figures 3.2(a)–3.2(c) would avoid major damage or collapse.

Figure 3.2: Examples of fault displacement

a) Edgecumbe Fault – The 1987 Edgecumbe earthquake resulted in about 7 km of surface rupture along the Edgecumbe fault, and up to about 2 m of vertical displacement of the ground surface at the fault (Beanland et al *1989). Arrows mark the location of surface fault rupture.*

Photo by DL Homer: CN 10115/37.

b) White Creek Fault – The 1929 Murchison earthquake resulted in over 4 m of vertical displacement of the ground surface at the White Creek fault (Berryman 1980). Note the cyclist standing on the upthrown side of road that is displaced by the fault.

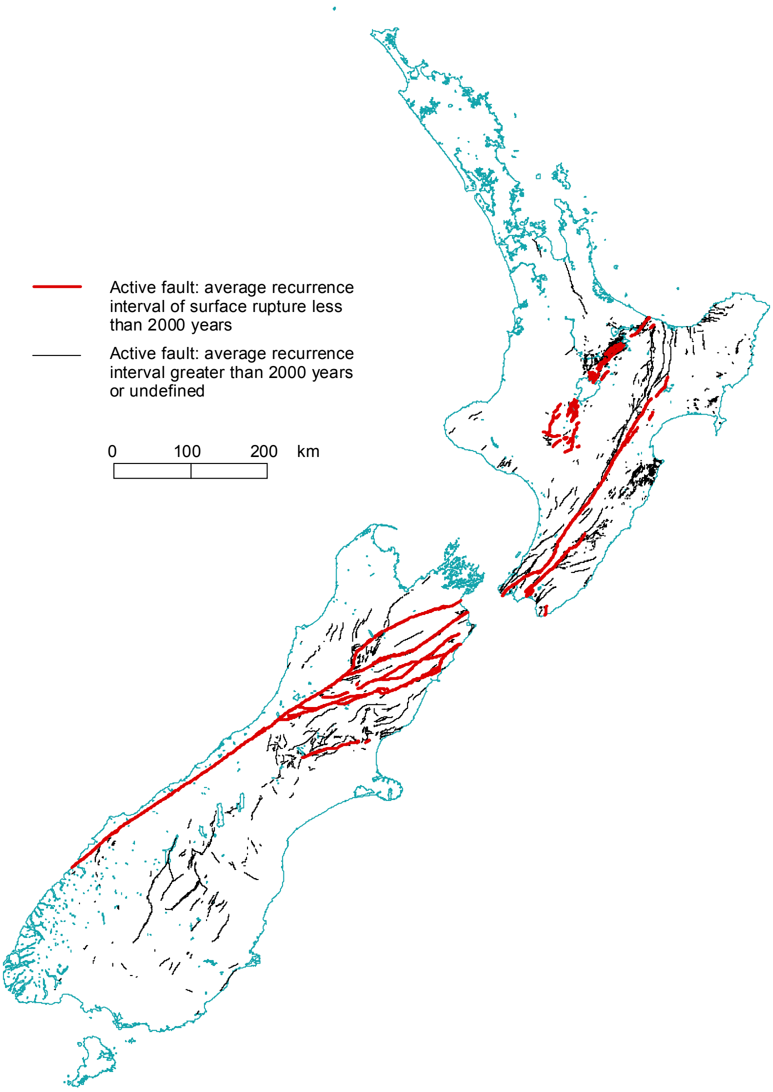
c) Hope Fault – The 1888 earthquake on the Hope fault resulted in about 3 m of right lateral displacement of the ground surface at the fault. The offset fence-line shows the amount of displacement across the fault (Cowan 1991).

Faults may show horizontal offset, vertical offset, or a combination of the two.

Table 3.1 Historic examples of surface fault rupture that have accompanied major earthquakes in New Zealand over the last 160 years

Year	Event	Approximate maximum surface offset (metres)	Sense of displacement	Photo in text
1848	Awatere Fault, Marlborough	7	Strike slip	Fig 5.5(c)
1855	Wairarapa Fault	13	Strike slip	Fig 5.3
1888	Hope Fault, North Canterbury (Glenn Wye)	3	Strike slip	Fig 5.2(c)
1929	White Creek Fault, Murchison	4	Reverse and strike slip	Fig 5.2(b)
1931	Napier	2	Reverse and strike slip	–
1934	Pahiatua	4	Reverse	–
1968	Inangahua	1	Reverse	–
1987	Edgecumbe	2	Normal	Fig 5.2(a)

Figure 3.3: Active faults map of New Zealand



4 Taking a Risk-based Approach

4.1 Using a risk management standard

We recommend that councils use this risk-based approach, based on risk management standard AS/NZS 4360:1999, when they develop provisions for their district plans. (AS/NZS 4360:1999 is set out fully in Appendix 1.)

This risk-based approach combines the key elements of fault recurrence interval (section 7), fault complexity (section 8), and Building Importance Category (section 9).

Key points to remember about the fault recurrence interval, fault complexity, and Building Importance Category are:

- **Fault Recurrence Interval:** The longer the recurrence interval of an active fault, the lower the risk that the fault will rupture in the near future.
- **Fault Complexity:** A fault rupture with a wide and distributed deformation is lower risk than a narrow, well-defined fault line.
- **Building Importance Category:** The Building Importance Category shows the need for an assessment of the suitability of a building in a fault avoidance zone.

4.2 Summary of the steps

Figure 4.1 summarises the steps involved in the recommended risk-based approach. Note that this approach depends upon accurate information and mapping of active faults. Identifying and mapping faults are part of the *Gathering information* stage of district plan preparation.

Figure 4.1: Risk-based planning approach

Step One: Identify active faults in your district

Where are the active faults in the district? (Refer to Appendices 2 and 3.)

↓

Step Two: Create fault avoidance zones around active faults

Is a fault avoidance zone in a greenfield site?

Is a fault avoidance zone in an area already subdivided or developed? Is there an existing expectation to build?

↓

Step Three: Identify the nature of the fault rupture hazard risk

What is the likelihood of fault rupture in the fault avoidance zone? *(Fault recurrence interval)*

What is the nature of the fault in the fault avoidance zone? (*Fault complexity*)

↓

Step Four: Analyse and evaluate the level of the risk to a subdivision or development

What is the proposed use of the site?

What is the construction type, and the nature of its response to fault rupture movement? *(Building importance category)*

↓

Step Five: Treat the risk

What action should be taken to avoid or mitigate the risk within the fault avoidance zone?

regulatory planning methods

non-regulatory methods

limiting the risk posed by the building

↓

Step Six: Monitor and review

Are we achieving our outcomes?

Is new information available?

Do we need to update our district plan?

5 Mapping Active Faults

5.1 The importance of mapping

Faults must be accurately located, and mapped at a scale appropriate for end use purposes, to enable planners to make decisions about land use on or close to active faults.

Geologists with particular experience of mapping faults are the most appropriate professionals to investigate, locate and assess active faults. Engineers with recognised qualifications and experience in geotechnical engineering are also able to investigate faults.

Active faults are complex and often have multiple breaks. A number of methods and evaluative tools need to be used in investigation.

Once a fault has been accurately located and assessed, the fault features should be clearly marked out (for example, pegged) so they can be surveyed onto cadastral maps.

5.2 Required scale of fault maps

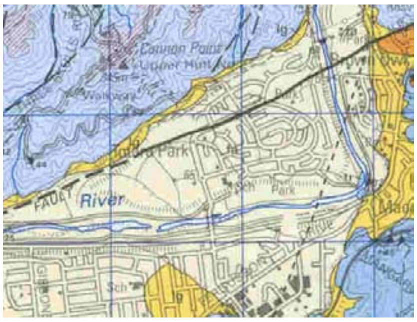
For planning purposes, faults should be mapped and classified at a minimum scale of 1:10,000. At present, few local authorities have mapped active faults to this scale, instead relying on existing fault maps for indicative purposes. This can create severe limitations for land use planning. (See Appendix 2 for an indication of faults in your district.)

Most of New Zealand's major active faults are mapped on small-scale geological maps (1:250,000 or 1:50,000 scale). This does not provide adequate detail for planning purposes, which requires detail to at least property boundary level. This is shown in Figure 5.1, and in more detail in Figure 5.2.

Figure 5.1: Example of fault mapping

Two recently published geological maps show the Wellington Fault, but neither is sufficiently accurate to be used for planning purposes.

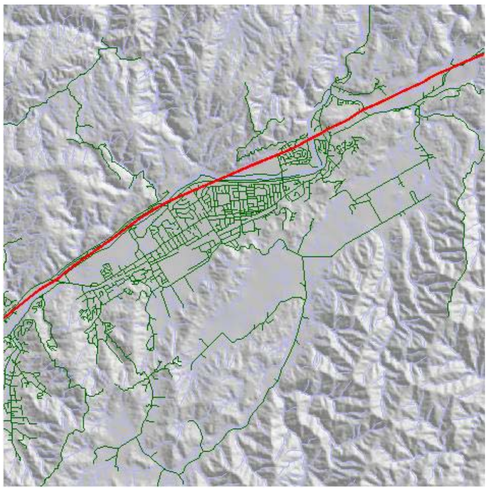
1: 250,000 scale



1: 50,000 scale

A map should only be interpreted at the scale it is compiled at. Figure 5.2 shows what happens when published maps are enlarged.

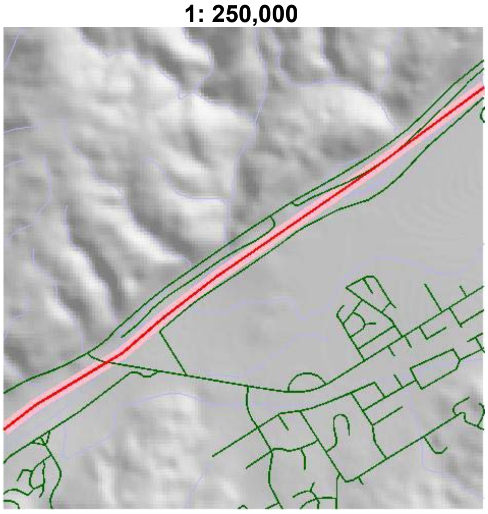
Figure 5.2: Interpreting fault maps



1: 250,000

1: 250,000 publication scale

Geological maps in New Zealand are often published at the 1:250,000 scale. The fault data is simplified for map clarity.

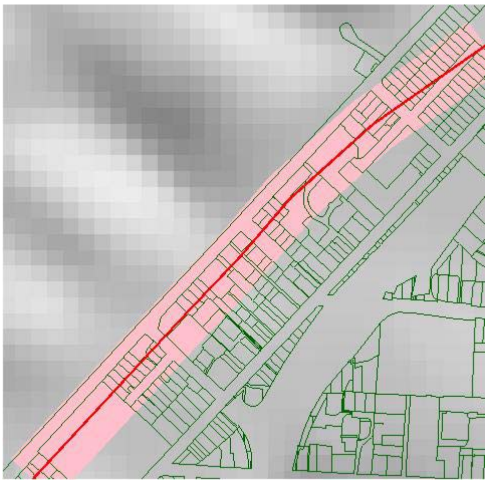


1: 50,000

1: 50,000 compilation scale

Fault data is drawn on maps at this scale when being compiled for 1: 250,000 scale presentation, but the data is then simplified for publication.

1: 10,000 scale



1: 10,000

If a 1: 250,000 scale map is enlarged to this degree (as it often is, especially on photocopiers) the fault will be inaccurately portrayed and its placement interpreted wrongly. A key mistake is thinking that a fault intersects a particular property when it does not.

On the 1: 10,000 scale map, the pink area represents the width of the line portraying the fault in the 1: 250,000 scale map. In reality, the fault is unlikely to be this wide, although the zone of deformation around the fault could be wider.

Faults shown on planning maps at 1: 10,000 scale must be compiled, and features located, at a scale consistent with end use.

Data should not be transferred from larger scale maps (1: 250,000) to typical district plan maps (1: 10,000), or used for detailed land use planning purposes.

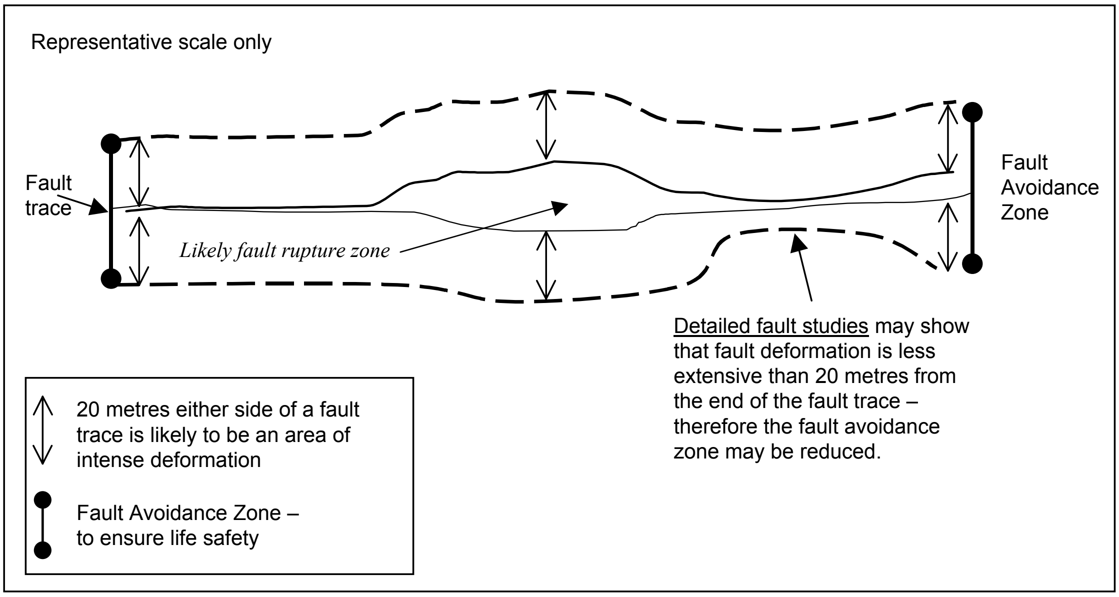
6 Fault Avoidance Zones

6.1 Definition

A fault avoidance zone is an area created by establishing a buffer zone either side of the known fault trace (or the identified likely fault rupture zone). These Guidelines recommend a minimum buffer zone of 20 metres either side of the known fault trace or likely fault rupture zone.

Twenty metres has been chosen because intense deformation and secondary ruptures are commonly experiences as a result of fault movement within this distance from the primary plane of the fault rupture. These effects can occur because near-surface weak materials deform instead of breaking cleanly, and structures built near an area of fault rupture can cause surface rupture to divert around them unpredictably. Twenty metres also represents a precautionary approach to ensure a level of life safety.

Figure 6.1: A fault avoidance zone on a district planning map



Defining a fault avoidance zone on district planning maps, which is supported by policies and methods (including rules) will allow a council to:

- restrict development within the fault avoidance zone
- take a risk-based approach to development in built-up areas.

The determination of the extent of a fault avoidance zone is closely related to fault complexity (refer section 8). A wide and complex likely fault rupture zone is likely to have a significant fault avoidance zone.

Displacement across a fault usually decreases with its distance from the fault trace. The fault avoidance zone can be reduced if a detailed fault study shows that the zone of intense deformation and secondary rupture is less than 20 metres from the likely fault rupture zone.

7 Fault Recurrence Interval

7.1 Definition

The fault recurrence interval is the average time between surface ruptures on a fault. We consider it is the best measure to use when evaluating the hazard risk of an active fault.

Historic and geological evidence shows that faults rupture repeatedly along the same narrow fracture. For example, there is evidence of two major fault ruptures on the Wellington Fault within the last 700 years, each with a horizontal offset of about four metres. There is also evidence of a total offset of almost one kilometre on the Wellington Fault in the last 140,000 years, indicating at least 200 major earthquake ruptures during this time. Along the Wairarapa Fault, up to 130 metres has been displaced along the same fault scarp that first ruptured in 1855. This indicates that multiple surface ruptures have occurred in the same location along the same fault scarp.

Figure 7.1: Wairarapa Fault – repeated rupture on same fault

Faults with short recurrence intervals are generally more likely to rupture in the near future than faults with a longer recurrence interval. It is important to remember that this is a statistical measurement only, and may not be an accurate predictor of future movement on a fault. For example, although the White Creek Fault has a long recurrence interval of more than 20,000 years, it actually ruptured in the 1929 Murchison earthquake.

Detailed investigation, usually involving trenching, is needed to determine the fault recurrence interval.

Recurrence intervals of surface rupture on New Zealand faults range from several hundred years (for example, the Hope and Alpine faults) to tens of thousands of years (for example, the Waverly, Whitemans and White Creek faults).

Table 7.1 groups together fault recurrence interval classes.

Table 7.1: Fault recurrence interval classes

Recurrence interval class	Average fault recurrence interval of surface rupture
I	≤2000 years
II	>2000 years to ≤3500 years
III	>3500 years to ≤5000 years
IV	>5000 years to ≤10,000 years
V	>10,000 years to ≤20,000 years
VI	>20,000 years to ≤125,000 years

The fault recurrence interval measure can also be related to accepted levels of risk in the current Building Code. Appendix 3 gives details of most of New Zealand's known active faults, and indicates which regional council jurisdictions these faults fall within. It also gives a confidence rating of these faults' average recurrence intervals.

8 Fault Complexity

8.1 Definition

Fault complexity refers to the width and distribution of the deformed land around the fault trace.

Many faults appear to be a simple linear feature on the ground surface, with a narrow zone of deformation only a few metres wide, as shown in Figures 8.1(a)–8.1(c).

Others have a complex and distributed zone of deformation, as shown in Figures 8.2(a)–8.2(c).

Figure 8.1: Examples of simple linear fault features

a) Wellington Fault at Totara Park.

Photo by D.L. Homer; CN 14444/10.

b) Wairau Fault. The most recent rupture along the well-defined trace of the Wairau section of the Alpine fault in Marlborough resulted in about 3–5 m of right lateral displacement at the fault (Lensen 1976, Zachariasen et al. *2001).*

Photo by D.L. Homer;
CN 17871/24.

c) The 1848 earthquake on the eastern section of the Awatere fault resulted in over 100 km of surface rupture along the fault, and as much as about 7 m of right-lateral displacement of the ground surface at the fault (Grapes et al*. 1998, Benson* et al*. 2001).*

Photo by D.L. Homer; CN 3940/12

Figure 8.2: Examples of complex deformation on the Ostler fault trace

These photos show the complex trace of the Ostler fault where surface rupture deformation, though concentrated at the fault, is also distributed over a relatively broad region on either side of the fault (Van Dissen et al. *1994). Arrows mark the location of surface fault rupture.*

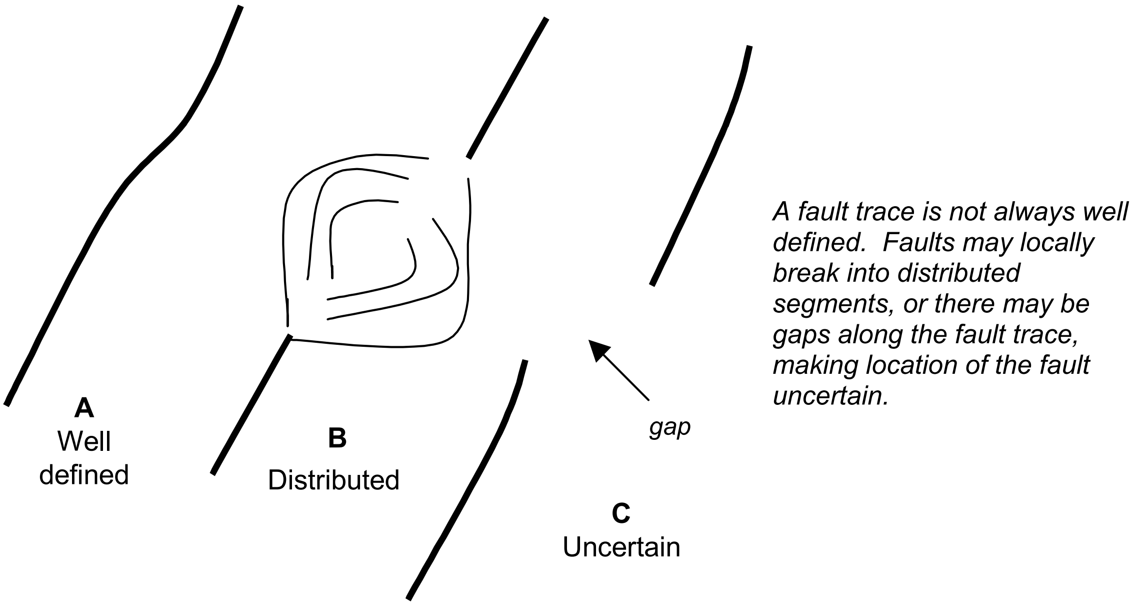
Photos by D.L. Homer, CN 3418/a, 576/b and 6435/23 respectively.

Table 8.1 proposes a three-fold classification for fault complexity: well defined, distributed or uncertain.

Table 8.1: Defining fault complexity types

A **Well defined**	**A well defined** fault trace of limited geographic width Typically metres to tens of metres wide
B **Distributed**	Deformation is **distributed** over a relatively broad geographic width Typically tens to hundreds of metres wide Usually comprises multiple fault traces and/or folds
C **Uncertain**	The location of fault trace(s) is **uncertain** as it either has not been mapped in detail or it cannot be identified. This is typically a result of gaps in the trace(s), or erosion or coverage of the trace(s)

Figure 8.3: View of fault complexity types



Recent fault location studies have shown (refer case studies Section 12) that certain faults can demonstrate all three levels of fault complexity at different parts of the fault. Variations on the three types of complexities discussed above may therefore be warranted.

9 Building Importance Category

9.1 Definition

It is not always possible to avoid building within a fault avoidance zone. Past planning decisions may have resulted in buildings being within a fault avoidance zone, or people may have an expectation to build there now. Also, where the level of certainty is low regarding the fault location, its complexity and recurrence interval, it may be difficult to justify rules that limit any building in these areas.

Buildings within a fault avoidance zone, particularly buildings crossing active faults, are very likely to be damaged in a fault rupture. A Building Importance Category states the relative importance of assessing the suitability of a building within, or proposed for, a fault avoidance zone.

The categories are based on risk levels for building collapse according to the building type, use and occupancy. Category one is least importance; category four is most importance.

Councils can use Building Importance Categories to make decisions about resource consents (Section 11), and to require conditions on buildings within fault avoidance zones.

Table 9.1: Building Importance Categories: a modified version of New Zealand Loading Standard classifications

Building Importance Category (BIC)	Description	Examples
1	Structures presenting a low degree of hazard to life and other property	Structures with a total floor area of les than $30m^2$ Farm buildings, isolated structures, towers in rural situations Fences, masts, walls, in-ground swimming pools
2a	Residential timber-framed construction	Timber framed single-story dwellings
2b	Normal structures and structures not in other categories	Timber framed houses of plan area of more than 300 m^2 Houses outside the scope of NZS 3604 "Timber Framed Buildings" Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate less than 5000 people and also those less than 10,000 m^2 gross area. Public assembly buildings, theatres and cinemas of less than 1000 m^2 Car parking buildings
3	Structures that, **as a whole, may** contain people in crowds or contents of high value to the community or pose **risks to people in crowds**	Emergency medical and other emergency facilities not designated as post disaster facilities Buildings where more than 300 people can congregate in one area Buildings and facilities with primary school, secondary school or day care facilities with capacity greater than 250 Buildings and facilities with capacity greater than 500 for colleges or adult education facilities Health care facilities with a capacity of 50 or more residents but not having surgery or emergency treatment facilities Airport terminals, principal railway stations, with a capacity of more than 250 people Any occupancy with an occupancy load greater than 5000 Power generating facilities, water treatment and waste water treatment facilities and other public utilities not included in Importance Category 4 Buildings and facilities not included in Importance Category 4 containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries
4	**Structures with special post disaster functions**	Buildings and facilities designated as essential facilities Buildings and facilities with special post-disaster function Medical emergency or surgical facilities Emergency service facilities such as fire, police stations and emergency vehicle garages Utilities required as backup for buildings and facilities of importance level 4 Designated emergency shelters Designated emergency centres and ancillary facilities Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond the property boundaries.

Table 9.2 shows the relationship between the fault recurrence interval and Building Importance Category in previously subdivided or developed areas, and in greenfield sites.

It shows which Building Importance Categories are acceptable in a fault avoidance zone with a particular fault recurrence interval.

Table 9.2: Relationship between fault recurrence interval and Building Importance Category

Recurrence interval class	Fault recurrence interval	Building importance category (BIC) limitations* (allowable buildings)	
		Previously subdivided or developed sites	"Greenfield" sites
I	≤2000 years	BIC 1	BIC 1
II	>2000 years to ≤3500 years	BIC 1 and 2a	
III	>3500 years to ≤5000 years	BIC 1, 2a and 2b	BIC 1 and 2a
IV	>5000 years to ≤10,000 years	BIC 1, 2a, 2b and 3	BIC 1, 2a, and 2b
V	>10,000 years to ≤20,000 years		BIC 1, 2a, 2b and 3
VI	>20,000 years to ≤125,000 years	BI Category 1, 2a, 2b, 3 and 4	

Note: Faults with average recurrence intervals >125,000 years are not considered active.

10 Planning for Fault Rupture Hazard

10.1 The RMA and the Building Act

Councils need to make a planned response to fault rupture hazard in regional policy statements and district plans. A combination of controls through the RMA and the Building Act can avoid or mitigate the effects of fault rupture hazard.

The RMA concerns land use issues such as the location of a building and the effects of its intended use, while the Building Act concerns a building's construction and the safety and integrity of the structure.

Under the Building Act, all building work must comply with the mandatory Building Code 1992. The Building Code sets out a series of minimum performance criteria for buildings. The council must be satisfied that the criteria of Clause B1 of the Building Code will be met before it issues a building consent. However:

- no guidance is available to councils to help them decide whether a design will comply with Clause B1
- no existing technology will prevent damage to buildings sited across a fault, meaning significant damage can occur even if the Building Code is complied with.

Therefore, relying solely on the Building Act to address the adverse effects of fault rupture is not effective. Councils need to consider and develop a policy response in their district plans, with the Building Act being one of the methods that can avoid or mitigate the risk.

Using controls under the RMA and Building Act are just part of a council's response to managing hazards. Protecting essential infrastructure and undertaking civil defence emergency management planning are also required under other Acts, such as the Civil Defence Emergency Management Act 2002.

10.2 Responsibilities under the RMA

Under the RMA, both regional councils and territorial authorities have responsibilities for natural hazards. Sections 30 and 31 reflect the fact that some natural hazards are best managed at a regional council level, and others at a territorial authority level.

Section 30 of the RMA lists the functions of **regional councils**. They include "the control of the use of land for the purpose of… the avoidance or mitigation of natural hazards". Regional councils are required to:

- prepare a **regional policy statement**, which helps to set the direction for the management of all resources across the region
- produce **regional plans** where appropriate

- co-ordinate investigations into natural hazards, and maintain information about hazards of regional significance
- integrate the approaches to manage the risk posed by fault rupture, and work with the territorial authorities as to who will do what.

Section 31 of the RMA says that **territorial authorities** are responsible for, among other things, "the control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards ...".

Territorial authorities are required to:

- prepare a **district plan**, the primary document for setting out district wide policies and controls on what people can and can't do on their land
- gather information on hazards associated with land use.

Generally, provisions in the regional policy statement should set out what approach the district plan will take. The district plan should contain the specific policies to address hazard risk, and any controls concerning land use and fault rupture.

10.3 Agreement among councils

Regional councils and territorial authorities must agree on their respective responsibilities for managing hazards under the RMA. It is not effective for councils in the same region and subject to the same hazards to work independently.

The way that councils work together to reach agreement will depend on the issues and resources within each district in a region. Councils can reach agreement:

- during the regional policy statement development process
- by consulting during plan or policy statement preparation
- through a Memoranda of Understanding.

The issues that need to be agreed on include:

- who will be the key information provider (and what this information is)
- who will identify and map hazards
- who will carry out education and communication campaigns
- who will be responsible for planning and responding to hazards (under the RMA as well as a Civil Defence response)
- who will develop and implement specific hazard mitigation plans for particular hazards
- who will be responsible for writing objectives, policies, and rules in plans.

Section 62(1)(i)(i) of the RMA says that a regional policy statement must state "the local authority responsible in the whole or any part of the region for specifying the objectives, policies, and methods for the control of the use of land to avoid or mitigate natural hazards or any group of hazards". If the regional policy statement does not clarify these responsibilities, then they default to the regional council.

However, territorial authorities issues building consents, and control the subdivision of land and most land uses. District plans are usually the best place to control land use to avoid or mitigate fault rupture hazard.

10.4 Role of the regional policy statement

A key purpose of the regional policy statement is to identify the regional council's and territorial authority's agreed responsibilities for planning for fault hazards.

The regional policy statement should therefore:

- state clearly which council (regional or district) has the primary responsibility for dealing with fault rupture
- be quite specific as to what each will do.

For example: the regional council will co-ordinate hazard investigation, and the district councils will develop objectives, policies and methods to control use of land to avoid or mitigate fault rupture hazard.

Environment Waikato actually recognises in one of its objectives the need for the regional and district councils to agree on their roles.

> *"The roles of all relevant agencies for the management of natural hazards in the Waikato Region clearly identified and their responsibilities consistently implemented"* (Waikato Regional Policy Statement)

The Wellington Regional Council spells out the division of responsibilities in a table.

	Responsibilities for developing objectives	Responsibilities for developing policies	Responsibilities for developing rules
Coastal marine area	WRC	WRC	WRC
Beds of lakes and rivers	WRC	WRC	WRC
Other land	WRC*	WRC	WRC
	TA	TA	TA*

WRC = Wellington Regional Council, TA = territorial authorities, * = primary responsibility

Source: Wellington Regional Policy Statement

10.5 Provisions in the regional policy statement

The regional policy statement also:

- provides an overview of the resource management **issues** facing the region
- sets region-wide **objectives** and **policies**
- identifies the **methods** to be used across the region to address the objectives and implement the policies.

Regional policy statement provisions tend to be reasonably generic (for example, by considering all natural hazards within the same objective or policy). However, a regional council can be more specific if it wishes, and can set a clear policy direction for the districts to follow. The regional policy statement can identify fault rupture hazard as an issue across the region, and then state the objectives and policies that explain how the issue will be addressed.

Regional policy statements also tend to have similar **objectives**. The objective is usually to avoid or mitigate the adverse effects of natural hazards on life, property and the environment.

For example:

> *"To avoid or mitigate the adverse effects of natural hazards upon human life, infrastructure and property, and the natural environment"* (horizons.mw Regional Policy Statement)
>
> *"Any adverse effects of natural hazards on the environment of the Wellington Region are reduced to an acceptable level"* (Wellington Regional Policy Statement)
>
> *"To avoid or mitigate natural hazards within the Taranaki region by minimising the nett costs or risks of natural hazards to people, property and the environment of the region"* (Taranaki Regional Policy Statement)

Environment Waikato also seeks to increase public resilience to natural hazards:

> *"The adverse effects associated with natural hazards minimised, the resilience of the community and public awareness of the causes and potential effects of natural hazards events increased"*

Policies in regional policy statements vary, but can be grouped into the following categories:

- raising awareness
- improving knowledge
- imposing planning controls, especially with respect to high risk areas
- preparing for hazard events and Civil Defence response.

10.6 Role of the district plan

The district plan should contain the specific policies to address fault rupture hazard risk, and any controls concerning land use and fault rupture.

Section 75(2)(b) of the RMA states that a district plan must "not be inconsistent" with the regional policy statement.

Before developing and adopting objectives, policies, and methods for the district plan, councils needs to:

- gather information about fault rupture hazards
- assess the risk of fault rupture hazard
- identify and assess earthquake and fault rupture issues.

Plan provisions need to be appropriate to the community's circumstances. No one policy response to fault rupture hazard will work for all communities within New Zealand. The issues and objectives between districts affected by active faults may be similar, but the methods (or mix of methods) used to address the risk will often be different.

10.7 Gathering information

The first step is to determine whether there are any active faults in the district.

Information can be gathered from:

- the regional council, especially hazard information and hazard maps (the territorial authority might create more detailed maps after assessing the active faults in the district)
- geotechnical information provided as part of resource consent applications
- data gathered from site-specific investigations
- Crown Research Institutes, such as the Institute of Geological and Nuclear Sciences
- private companies involved in the geology, earthquake engineering, and geotechnical professions.

The data may be very general in nature, incomplete, or contain conflicting conclusions. Initial information gathering may show the need for further studies. Data also needs to be kept up to date: section 35(5)(j) of the RMA requires councils to keep records of natural hazards that are sufficient for the local authority to discharge its functions effectively.

The cost of obtaining fault data can be expensive, and prohibitive for smaller councils. Cost sharing between neighbouring councils and agreements with the regional council may help.

The most hazardous faults in the district need to be accurately located, surveyed and mapped in enough detail to provide accuracy at property boundary level (a scale of 1: 5000 to 1: 10,000). This enables the development of appropriate objectives, policies, and methods.

It is not feasible to map all faults in the district, and not always possible to know where they are. Highest priority needs to be given to faults with recurrence intervals of less than 5000 years, and faults closest to urban areas or set aside for future urban development.

10.8 Assessing the risk

Having identified active faults in its district, the council needs to define a fault avoidance zone around each active fault in the district planning maps. It then needs to assess the fault hazard risk within each fault avoidance zone.

As outlined in Figure 4.1, the main elements that determine the risk of fault hazard are the fault recurrence interval and the fault complexity.

The likely displacement along active faults is also important. Vertical and horizontal displacement along the fault plane will result in more damage during a fault rupture.

In assessing the fault hazard risk, the council should also take account of:

- community values and expectations (what the community wants and what it does not want)
- which areas of the district are, or are likely to be, under pressure for development
- what infrastructure already exists near faults (buildings, network utilities etc) and the value of that infrastructure
- what level of risk the community is prepared to accept or not accept (in practice, it is easier to define what the community will not accept).

Risk assessment requires an understanding of the likely magnitude or consequences of events, and the risks of injury or loss of life and damage to property and investment. It also requires consideration of the cost of clean-up or repair or replacement of damaged property or services after the event.

10.9 Identifying the issues

Gathering information and assessing the risk will determine whether the risk is a significant issue that the community wants addressed. If so, the issue needs to be included in the district plan, and a policy response developed (objectives, policies, and methods, including rules, to address the issue) to help to avoid or mitigate the fault hazard risk.

10.10 Developing objectives and policies

Many district councils take an 'all-hazards' approach to developing hazard-related objectives and policies in their plans. This provides simplicity and may be acceptable for an overall hazard objective and some policies. However, a hazard-specific approach is likely to be more effective and easier to implement.

When formulating policies, it is important to focus on the effects that need to be addressed to achieve the objective, and to state how those effects are going to be dealt with.

As in regional policy statements, **objectives** in district plans tend to relate to the territorial authority's statutory function for natural hazards prescribed in section 31 of the RMA: to avoid or mitigate adverse effects of the use of land for the purpose of avoiding or mitigating natural hazards.

For example:

> *"The avoidance, remedying or mitigation of the adverse effects of natural hazards on the environment"* (Objective 14.3.1 of the Upper Hutt District Plan)
>
> *"To avoid or reduce the risk to people and their property from natural hazards associated with seismic action, landslides, flooding and coastal hazards"* (Objective in Section 14H 1.1.1 of the Hutt City Proposed District Plan)
>
> *"To avoid or mitigate the adverse effects of natural and technological hazards on people, property and the environment"* (Objective 4.2.7 of the Wellington City District Plan)

The Tasman District Council takes a different approach. Its objective (subject to appeal) is:

> *"Management of areas subject to natural hazard, particularly flooding, instability, coastal and river erosion, inundation and earthquake hazard to ensure that development is avoided or mitigated, depending on risk"* (Objective 13.1.0 of the Tasman Proposed Resource Management Plan)

A less common objective seeks to ensure that land use activities do not increase or worsen the effects of the natural hazard:

> *"Activities and development do not create, accelerate, displace, or increase the effects of a natural hazard"* (Objective 31.2.2 of the Taupo Proposed District Plan)
>
> *"Safe land use practices which do not increase the risk of adverse effects from natural hazards on the environment, people and their property"* (Objective 11.2.3 of the South Waikato District Plan)

The use of a specific earthquake objective is rare. Examples include:

> *"To minimise the risk from earthquakes to the wellbeing and safety of the community"* (Objective C12.1 of the Porirua City District Plan)
>
> *"To minimise the risks of earthquakes affecting people and property in the District as far as practicable"* (Objective 5 in Section 3.2 of the Matamata Piako Proposed District Plan)

In low-risk areas, the objective may instead seek to improve knowledge of potential risk:

> *"Increase Council and community understanding of the earthquake risk and associated natural hazard"* (Objective 8.3.1 of the Waimakariri Proposed District Plan)

Policies in district plans generally fall into the same groupings as in regional policy statements, but are at a more detailed level. Essentially, policies specify:

- collection of information, development of a hazards register or database, and identification of at-risk areas
- provision of information and advice, to raise public awareness and to encourage good practices
- inclusion of controls in plans, so that activities are located and designed to avoid or mitigate adverse effects in at-risk areas
- required standards for emergency responses and essential services following an earthquake event.

For example:

> *"To develop a database on natural hazards including implementing a hazards identification system for risk assessment"* (Policy 15.2 of the Masterton District Plan)
>
> *"Promote community awareness of natural hazards to encourage avoidance of adverse effects of hazards"* (Policy 5 in Section C.15.1 of the Kapiti Coast District Plan)

"In areas of known susceptibility to natural hazards, activities and buildings are to be designed and located to avoid, remedy, or mitigate, where practicable, adverse effects of natural hazards on people, property and the environment" (Policy 14.4.2 of the Upper Hutt District Plan)

"To provide warnings and emergency response systems for areas at risk from or affected by natural hazards" (Policy 13.1.6 of the Tasman Resource Management Plan)

Hutt City has a policy specific to fault rupture in its plan:

"That the area at risk from fault rupture causing permanent ground deformation along the Wellington Fault be managed by the Wellington Fault Special Study Area to address the effects of subdivision and development on the safety of people and their property"

South Waikato realises the importance of working with the regional council on hazard issues:

"To work with Environment Waikato to develop measures to ensure that land use practices do not cause or promote natural hazards" (Policy 11.3.6 of the South Waikato District Plan)

10.11 Developing methods

Although it is not practical or possible to eliminate fault rupture hazard risk completely, doing nothing is not an option. Methods should be developed specifically to address the effects of fault rupture.

The plan needs to contain methods that address different aspects of the risk: what is the likelihood of the hazard occurring? What are the consequences? Does the risk need treating?

District plan rules are not necessarily the only option: a mixture of rules and other methods can be adopted. The exact makeup will vary, depending on the level of risk and the outcome of the section 32 analysis (see below).

Methods can become more permissive as the risk of fault rupture decreases, by, for example:

- allowing a greater range of buildings to be located in an area of fault rupture
- allocating a less restrictive consent activity category
- relying more on the Building Act for controls
- relying more on non-regulatory approaches such as education and advocacy.

10.12 Non-regulatory methods

Non-regulatory methods are good for encouraging people to avoid putting themselves at risk. One of the more important things a council can do is communicate the risk to the community.

Some of the non-regulatory methods available to councils include:

- purchasing at-risk land for passive recreational purposes
- exchanging at-risk land with land that can be put to some other purpose
- allowing greater development rights if land is retired or covenanted
- taking at-risk land as a condition of subdivision consent (reserves contribution)
- using financial incentives (for example, rates relief on at-risk land if it isn't built upon)
- promoting and helping fund the use of covenants (privately or through the QEII National Trust) for the voluntary protection from development of open space on private land
- educating to raise awareness of the risk and to encourage people to locate buildings away from the fault rupture hazard
- using the Building Act to ensure that structures are safe and will remain intact throughout the life of the building.
- including fault hazard information in LIM and PIM reports.

Fault avoidance zones still need to be clearly identified on district plan maps if non-regulatory methods are used. This ensures that risk is communicated, and that landowners and building occupiers can be made aware of the hazard.

10.13 Regulatory methods (rules)

Building within a fault avoidance zone should be discouraged wherever possible. Even when a fault has a long recurrence interval, the chance exists that the fault may move during the lifetime of a building.

Rules in the district plan can allow development in a fault avoidance zone only if resource consent is granted. This approach is suitable for well-defined faults, or distributed faults that have been accurately located. Section 11 describes how the fault recurrence interval, fault complexity, and Building Importance Category can be used to establish resource consent categories.

Rules need to be based upon risk. The approach used in built-up areas should differ from the approach used in a greenfields area. In greenfields areas it is much easier to require a subdivision to be planned around the likely fault rupture zone and buffer zone (i.e. the fault avoidance zone). In built-up areas, buildings may have been established without the knowledge of the risk posed by fault rupture. The community may have an expectation to continue living there and be prepared to live with the risk despite the potential for damage.

Existing use rights under the RMA also mean that when an existing building over a fault is damaged or burnt down, or requires rebuilding for whatever reason, it can be rebuilt, even once the risk has been realised.

The district plan may have to include provisions to ensure that the risk is not increased by intensified land use (such as urban infill) or by new building on sites not already occupied. It can also require geotechnical investigations and appropriate earthquake-resistant design where appropriate.

Some councils have taken a precautionary approach to fault rupture.

For example:

> *"To take a precautionary approach to development in suspected risk areas until further information on the extent and nature of earthquake risk becomes available"*
> (Policy P1 in Section 3.2.2.5 of the Matamata Piako Proposed District Plan)

The council can also require a report, including certification from an appropriately qualified person, stating that the land is suitable for the activities anticipated.

Nelson City Council has the following rule:

> *"Construction or alteration of a building within the Fault Hazard Overlay is permitted if:*
>
> *a) in the case of any site where a fault trace is identified and can be precisely located by reference to the Council conditions book, subdivision files, site files, or GIS database, buildings are set back 5 metres from the fault trace"*
> (Rule REr.71.1 of the Nelson Proposed Resource Management Plan)

The faults identified in Nelson City have low activity and long recurrence intervals. However, Nelson City considered that it was best to design new subdivisions to avoid building on them.

10.14 Section 32 analysis

Before a council adopts any objective, policy, rule, or other method, it has a duty under section 32 of the RMA to consider alternatives.

Essentially, the council is required to evaluate the costs and benefits of its proposed objective, policy, or method.

Section 32 ensures that the proposed provisions are necessary, and that accurate data has been used to carry out the evaluation.

It means that a council cannot simply adopt the approach of a neighbouring council – it must first justify its reasoning. Any response the council chooses to take has to be supported by the community and backed up by a section 32 analysis.

10.15 Cross-boundary issues

Natural hazards do not stop at local authority boundaries. It is important to consider how the plan will co-ordinate with the plans of territorial authorities that share the same hazards, to ensure that provisions are integrated across councils.

10.16 Monitoring

The plan needs to specify measurable outcomes that will ensure that issues are addressed, and objectives and policies achieved.

These can be measured by looking at:

- number of houses being built on at-risk land
- type of houses being built (construction and use)
- land subject to active faults being set aside/purchased
- the level of awareness of the community and their acceptance of risk-based plan provisions.

If monitoring shows that the provisions aren't reducing fault rupture hazard risk, councils need to revise the provisions. If new information becomes available, councils need to review the level of acceptable risk, and revise the provisions.

Advances in scientific information and technology will affect existing data held by councils, and create new data that needs to be considered for incorporation into planning policy. Councils need to identify new information should happen on an ongoing basis, to ensure plan provisions are kept up to date, and ensure decisions based on the most accurate data.

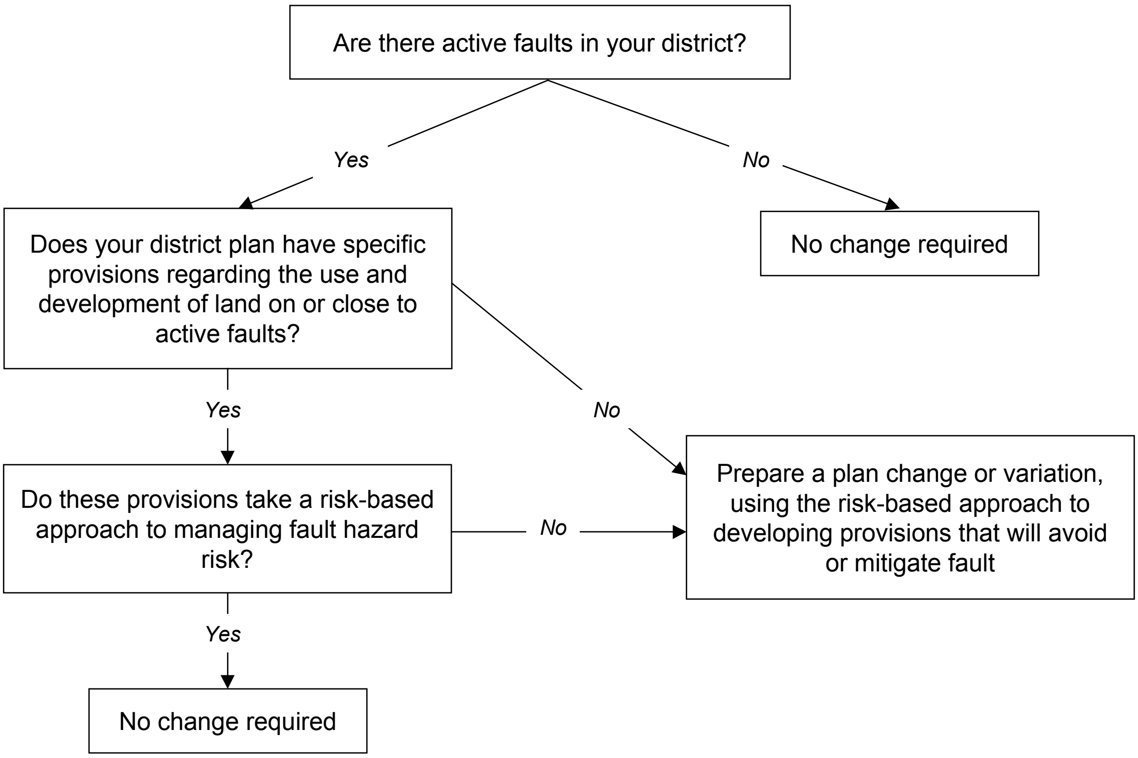
Regional and district plan reviews are a good time to consider new information and data relating to active faults. A programme of consultation should accompany any changes to hazard information gained by the council.

To measure the effectiveness of policies and methods contained in plans, section 35(2A) of the RMA requires that the results of plan monitoring be made available to the public every five years. Keeping communities informed about the hazards they face, and changes to existing fault knowledge is important because it not only lets them know what is going on in terms of plans development, but raises awareness of hazards in the community.

10.17 Does your district plan need amending?

The following flow chart can help councils determine whether the district plan needs amending.

Figure 10.1: Clarifying whether a district plan needs amending



Note: information on the location and type of faults to be found in New Zealand is contained on the website: http://data.gns.cri.nz/af/index.jsp

11 Taking a Risk-based Approach to Resource Consent

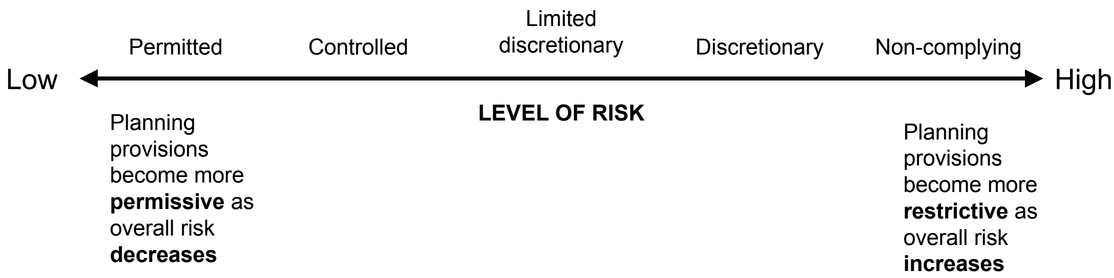
11.1 Determining consent categories

Determining consent categories for buildings within a fault avoidance zone involves evaluating the fault recurrence interval, fault complexity, and Building Importance Category alongside the risk the community is prepared to accept.

Differing types of buildings will be placed into different resource consent activity categories, based upon the risk. The council needs to be satisfied that the risk isn't significant, or that appropriate mitigation measures have been taken, before granting resource consent.

Clearly, as the risk increases, the consent category should become more restrictive, and the range of matters the council needs to consider will increase. The council needs to set requirements for the bulk, location and foundations of any structure, so it can impose the consent conditions that will avoid or mitigate the adverse effects of fault rupture.

Figure 11.1: Scale of risk and relationship to planning provisions



A rule may require resource consent for a new building, but with a requirement that a geotechnical report be included with the application (confirming that the building will be located at least 20 metres from an area subject to fault rupture, or that necessary engineering precautions have been taken).

For example:

> *"For all structures and buildings, an engineering report will be required to confirm that the Wellington Fault is not within 20.0m of any proposed structure or building; or that the necessary engineering precautions have been taken"* (Standard 14H 2.1.1.2 to Rule 14H 2.1 of the Hutt Proposed District Plan)

Each council will want to apply the resource consent activity status categories that suits its own circumstances. *The key is to ensure that the council has the ability to address the fault rupture hazard risk properly when assessing a resource consent application.* The matters over which the council can reserve control or restrict its discretion include:

- the proposed use of the building
- site layout, including building setback and separation distance
- building height and design

- construction type (for resource management purposes)
- financial contributions (for example, reserves contributions).

Tables 11.1 and **11.2** show an example of resource consent activity status for proposed buildings within a fault hazard avoidance area. The activity status will depend on the Building Importance Category, the fault recurrence interval, and the fault complexity.

Table 11.1: Resource consent activity status for greenfield sites

Building importance category	**1**	**2a**	**2b**	**3**	**4**
Fault complexity	**Activity status**				
Fault recurrence interval class I less than or equal to 2000 years					
A – Well defined	Permitted	*Non-complying*	*Non-complying*	*Non-complying*	Prohibited
B – Distributed	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
C – Uncertain†	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
Fault recurrence interval class II greater than 2000 but less than or equal to 3500 years					
A – Well defined	Permitted	*Non-complying*	*Non-complying*	*Non-complying*	Prohibited
B – Distributed	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
C – Uncertain †	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
Fault recurrence interval class III greater than 3500 to but less than or equal to 5000 years					
A – Well defined	Permitted	Permitted*	*Non-complying*	*Non-complying*	Non-complying
B – Distributed	Permitted	Permitted	*Discretionary*	*Discretionary*	Non-complying
C – Uncertain †	Permitted	Permitted	*Discretionary*	*Discretionary*	Non-complying
Fault recurrence interval class IV greater than 5000 but less than or equal to 10,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	*Non-complying*	Non-complying
B – Distributed	Permitted	Permitted	Permitted	*Discretionary*	Non-complying
C – Uncertain †	Permitted	Permitted	Permitted	*Discretionary*	Non-complying
Fault recurrence interval class V greater than 10,000 but less than or equal to 20,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	Permitted*	Non-complying
B – Distributed	Permitted	Permitted	Permitted	Permitted	Non-complying
C – Uncertain †	Permitted	Permitted	Permitted	Permitted	Non-complying
Fault recurrence interval class VI greater than 20,000 but less than or equal to 125,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	Permitted*	Permitted*
B – Distributed	Permitted	Permitted	Permitted	Permitted	Permitted**
C – Uncertain †	Permitted	Permitted	Permitted	Permitted	Permitted**

Note: Faults with a recurrence interval of greater than125,000 years are not considered active.

* The activity status is permitted, but could be controlled or discretionary because the fault location is well defined.

** Although the activity status is permitted, care should be taken in locating BIC 4 structures on or near known active faults. Controlled or discretionary activity status may be more suitable.

† Where the fault trace is uncertain, specific fault studies may provide more certainty on the location of the fault. Moving the fault into the distributed or well defined category would allow a reclassification of the activity status and fewer assessment criteria.

Italics show that the activity status is more flexible. For example, where *discretionary* is indicated, controlled activity status may be considered more suitable.

Table 11.2: Resource consent activity status for developed and already subdivided sites

Building importance category	1	2a	2b	3	4
Fault complexity	**Activity status**				
Recurrence interval class I less than or equal to 2000 years					
A – Well defined	Permitted	*Non-complying*	*Non-complying*	*Non-complying*	Non-complying
B – Distributed	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
C – Uncertain †	Permitted	*Discretionary*	*Non-complying*	*Non-complying*	Non-complying
Recurrence interval class II greater 2000 but less than or equal to 3500 years					
A – Well defined	Permitted	Permitted*	*Non-complying*	*Non-complying*	Non-complying
B – Distributed	Permitted	Permitted	*Discretionary*	*Non-complying*	Non-complying
C – Uncertain †	Permitted	Permitted	*Discretionary*	*Non-complying*	Non-complying
Recurrence interval class III greater than 3500 but less than or equal to 5000 years					
A – Well defined	Permitted	Permitted*	Permitted*	*Non-complying*	Non-complying
B – Distributed	Permitted	Permitted	Permitted	*Discretionary*	Non-complying
C – Uncertain †	Permitted	Permitted	Permitted	*Discretionary*	Non-complying
Recurrence interval class IV greater than 5000 but less than or equal to 10,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	Permitted*	Non-complying
B – Distributed	Permitted	Permitted	Permitted	Permitted	Non-complying
C – Uncertain †	Permitted	Permitted	Permitted	Permitted	Non-complying
Recurrence interval class V greater than 10,000 but less than or equal to 20,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	Permitted*	Non-complying
B – Distributed	Permitted	Permitted	Permitted	Permitted	Non-complying
C – Uncertain †	Permitted	Permitted	Permitted	Permitted	Non-complying
Fault recurrence interval class VI greater than 20,000 but less than or equal to 125,000 years					
A – Well defined	Permitted	Permitted*	Permitted*	Permitted*	Permitted*
B – Distributed	Permitted	Permitted	Permitted	Permitted	Permitted**
C – Uncertain †	Permitted	Permitted	Permitted	Permitted	Permitted**

Note: Faults with a recurrence interval of greater than 125,000 years are not considered active.

* The activity status is permitted, but could be controlled or discretionary because the fault location is well defined.

** Although the activity status is permitted, care should be taken in locating BIC 4 structures on or near known active faults. Controlled or discretionary activity status may be more suitable.

† Where the fault trace is Uncertain, specific fault studies may provide more certainty on the location of the fault. Moving the fault into the Distributed or Well Defined category would allow a reclassification of the activity status and fewer assessment criteria.

Italics – show that the activity status is more flexible. For example, where *discretionary* is indicated, controlled activity status may be considered more suitable.

Note that the (restricted) discretionary category has not been shown in Tables 11.1 and 11.2 but may be considered more effective than the non-complying activity status as it allows for targeted assessment criteria to be developed.

11.2 Exercises

Example 1

A developer with a *Greenfield site* proposes to build a *Building Importance Category* 2a structure (a typical New Zealand wood-framed house) within a fault avoidance zone). The fault through this zone has a *Fault Recurrence Interval Class* of III (>3500 to ≤5000 years) and the *Fault Complexity* is A (well defined).

Q: What type of resource consent would have to be applied for?

A: ____[1]

Example 2

A philanthropist decides to make use of a spare plot of land she owns to build an art gallery to display local work. The site is located within a densely built-up inner city suburb in a fault avoidance zone. The proposed art gallery will have a floor area of 700m2 (refer to Table 7.1 to determine the *Building Importance Category*). The *Fault Recurrence Interval Class* is III and the *Fault Complexity* is B.

Q: What type of resource consent would have to be applied for?

A: ____[2]

Example 3

The philanthropist decides to move the proposed gallery to the country, where she owns 20 hectares of undeveloped rural land. The proposed location is within a fault avoidance zone where the *Fault Recurrence Interval Class* is II and the *Fault Complexity* is C?

Q: What type of resource consent would have to be applied for?

A: ____[3]

Example 4

A local health care facility is proposed that will accommodate up 60 elderly patients who will live at the facility (refer to table xx for the Building Importance Category). The proposed site is in a rural area that has recently been subdivided into five-acre blocks, and is within a fault avoidance zone. A well-defined active fault with a 4000-year fault recurrence interval runs through the site.

Q: What type of resource consent would have to be applied for?

A: ____[4]

11.3 Answers

1 Permitted* activity (but a district plan may want to make this activity controlled or discretionary given that the *Fault Complexity* is well defined).

2 Permitted. The building is a *BIC* 2b structure (defined as either a retail building less than 10,000 m^2, or a public assembly building less than 1000 m^2) to be located where the *Fault Recurrence Interval* is >3500 to ≤5000 (Class III) and the *Fault Complexity* is distributed (B).

3 Non-complying activity. The activity is proposed where the *Fault Recurrence Interval* is <2000 to ≥35,000 years (Class II), the *Fault Complexity* is uncertain (C) and the building is a *BIC* 2b structure (defined as either a retail building less than 10,000 m^2, or a public assembly building less than 1000 m^2). The activity is classed Non complying as the site allows for alternative siting of the gallery outside the fault avoidance zone – which would reduce the risk to life and property.

4 Non-complying activity. The *Fault Recurrence Interval Class* is III (>3000 to ≤5000 years), the *Fault Complexity* is A (well defined) and the building is a *BIC* 3 (a health care facility with a capacity of 50 or more residents but does not have surgery or emergency treatment facilities).

11.4 Assessment criteria

Where there are rules in a district plan limiting development in a Fault Avoidance Zone, the district plan needs to include assessment criteria that make clear what the council will consider when assessing resource consents. Matters may include:

- the risk to life, property and the environment posed by the natural hazard
- the likely frequency and magnitude of movement
- the type, scale and distribution of any potential effects from the natural hazard
- the effects of ground shaking and ground displacement caused by earthquakes
- the distance of any proposed structure from the fault (as shown on either the district plan map, or from a site-specific study locating the fault trace)
- the degree to which the building, structural or design work to be undertaken can avoid or mitigate the effects of the natural hazard
- the accuracy and reliability of any engineering and geotechnical information (e.g. the extent to which such a report shows how the risk of building failure following fault rupture can be reduced to minimise the effects of the fault rupture on the safety of occupants and neighbours).

If the council has not located the fault trace, and the developer does not wish to locate it, the developer needs to prove that the building is resilient enough to withstand fault rupture.

11.5 AEE requirements

An applicant lodging a resource consent application to build on or near an active fault is required by section 88 of the RMA to provide an adequate AEE with any application. The district plan needs to spell out what is required of the resource consent applicants.

An AEE should:

- consider alternatives
- provide a risk analysis
- identify the hazard
- show mitigation measures.

12 Case Studies – Implementing the Guidelines

In this section we examine how two territorial authorities within the Wellington Region, Wellington City Council (WCC) and Kapiti Coast District Council (KCDC), have used these Guidelines when reviewing active fault hazard provisions in their district plans. The case studies are preceded by an explanation of the unique tectonic setting in the Wellington region to help explain the fault rupture hazard.

12.1 The Wellington Region's Tectonic Environment

Both WCC and KCDC sit within the Wellington region; the jurisdiction of Greater Wellington – The Regional Council. The tectonic environment within the Wellington region is very active given its location astride the constantly moving Pacific and Australian plates. As a result, a large number of active faults of varying complexity and recurrence interval classifications are present within the region (refer Figure 1).

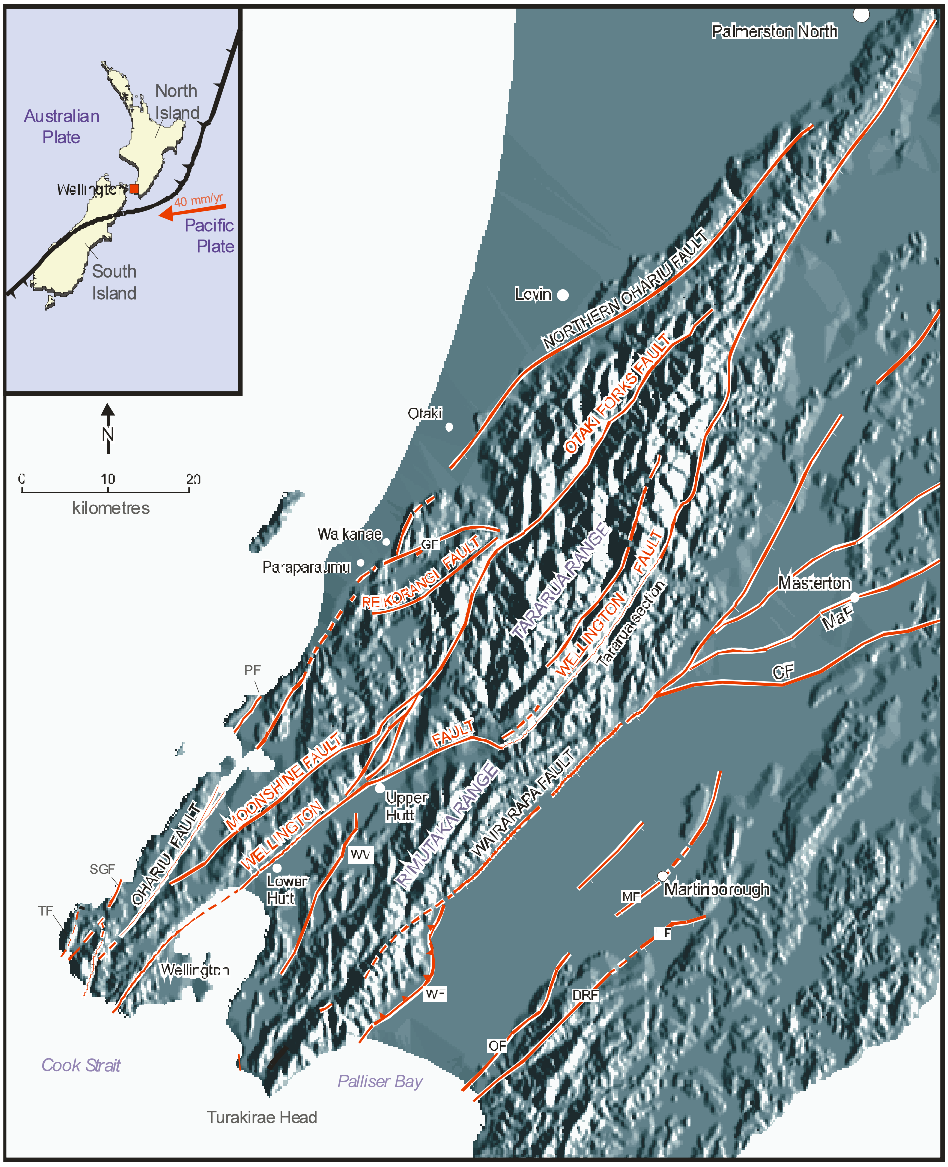


Figure 1: Schematic Representation of Major Faults in the Wellington Region. Adapted from: Begg. J.G and Van Dissen. R.J. (2000).

The most active fault in the region (i.e., the one with the shortest recurrence interval) is the **Wellington Fault** which extends northwards from the Cook Strait (its most southernmost known location) past the south Wellington shoreline, through Wellington and the Hutt Valley and through the Tararua Range to the Manawatu River. At this point, the name of the Fault changes but continues north to the Bay of Plenty coastline.

The **Wairarapa Fault**, the source of the great 1855 Wairarapa earthquake, extends northeastward along the base of the eastern flank of the Tararua Ranges. With a recurrence interval of about 1500 years, it is a Class 1 active fault. Its average slip rate of just under 10mm/year means it is moving faster than the Wellington Fault. Past surface rupturing earthquakes on the Wairarapa Faults have resulted in up to 10 metres or more of lateral slip at the fault trace, with regional uplift and tilting east of the Fault.

The **Ohariu Fault** extends approximately 70km north-northeastward from offshore of the Wellington south coast, through Porirua to Waikanae (Heron *et al*. 1998, Begg & Johnston 2000) and probably continues a further 60 km northwards as the **Northern Ohariu Fault** to just south of Palmerston North (e.g. Van Dissen *et al*. 1999, Palmer and Van Dissen. 2002). The **Gibbs Fault** is less constrained than the Ohariu and Northern Ohariu faults, but is thought to branch off the Ohariu Fault near MacKays Crossing and extend 30km north north-east to within 3-4 kms of the **Otaki Forks Fault** which passes through Kapiti Coast District hill country to the east for about 10-15 kms. Little is known about the **Southeast Reikorangi Fault** which most likely extends from the Gibbs Faults about 20km in the hills east of Kapiti Coast (Van Dissen *et al*. 2003).

12.1.1 Fault Rupture in the Region

In the Wellington region, the Wairarapa fault in the only fault that has ruptured in historical times (during the 1855 Magnitude (M) 8 Wairarapa earthquake). The most known recent surface fault rupture on the Wellington Fault occurred about 400 years ago (Van Dissen and Berryman, 1996) and on the Ohariu Fault about 1000 years ago (Litchfield *et al.* 2004).

It is estimated that the Wellington Fault is capable of generating earthquakes in the order of M 7.5 with a 10 percent probability of it rupturing in the next 50 years**.** Such a rupture could move the ground along the fault horizontally by 4-5 metres and vertically by about 1 metre (Froggatt & Rhodes 1996, Van Dissen & Berryman 1996).

The Ohariu fault is capable of an earthquake about M 7.5 with expected fault rupture of 3-5 metres of right-lateral displacement at the ground surface with lesser and more variable vertical displacement. (Heron *et al.* 1998). The Northern Ohariu Fault, Gibbs Fault and Otaki Forks Fault are all capable of generating earthquakes M7+ and metre-scale surface rupture displacements ((Litchfield *et al.* 2004, Van Dissen *et al*, 2003).

The region's most active faults (Wellington, Wairarapa and Ohariu) all have varying *fault complexity* at stages along the fault meaning that while parts of these faults are well-defined, other parts are distributed or the location is uncertain. Finding the fault location can be difficult in some areas due to two key reasons: fault traces have been removed by natural processes (landslide, weather, and coastal); and/or the intensity of urban development has obscured the fault trace.

12.2 The Wellington City Council

Wellington City Council's District Plan Change 22 amended the Hazard (Fault Line) Area for the Wellington Fault on district plan maps, and amended a number of district plan provisions relating to the fault hazard.

12.2.1 Background

In 2001, the Wellington Emergency Management Office (WEMO) engaged the Institute of Geological & Nuclear Sciences (GNS) to assess the impact on property from an earthquake along the Wellington fault. The work by GNS uncovered the fact that the Wellington City district plan maps depicting the Wellington Fault did not reflect GNS's understanding of the fault location.

The district plan team engaged GNS to undertake a Wellington Fault location review to provide up-to-date information on the location of the urban section of the Wellington Fault from Aotea Quay to the lower Karori Reservoir to include the Port, Railways Yards and the parts of the suburbs Thorndon, Northland, Kelburn and Karori. WCC decided to concentrate the fault location investigation solely on the Wellington Fault (although they were also aware of the other active faults in the district these were not considered as high risk as the Wellington Fault). The findings of the GNS report highlighted inaccuracies in the existing Hazard (Fault Line) Area as shown on district plan maps and as a result identified two new updated fault hazard zones:

1. **Likely fault rupture hazard zone:** The area containing the likely position of the Wellington Fault, and the zone within which the fault is likely to rupture (but not across its entire width). The width of the zone varies from approximately 10 to 50 metres.
2. **Recommended fault rupture hazard zone:** The width of this zone ranges from 50 to 90 metres as it includes the recommended (as per the Guidelines) 20 metre buffer zone either side of the *likely fault rupture hazard zone.* In its report, GNS recommended that this *recommended fault rupture hazard zone* be used for district planning purposes as it accommodates uncertainties in the location and width of the *likely fault rupture hazard zone*.

12.2.2 Properties Affected

The Wellington Fault location review identified **665 properties** within the new *recommended fault rupture hazard zone* (some properties straddle both the *likely fault rupture zone* and the r*ecommended fault rupture hazard zone* or buffer zone). Of these 665 properties, there were **244 more properties** than currently identified on the planning maps. Approximately **35 properties** were removed from the fault rupture hazard zone.

12.2.3 Justification for Plan Change

In light of the new information from the Wellington Fault location review, the WCC decided to look at whether a district plan change was justified to reflect the findings.

In addition to learning that the planning maps depicted the Wellington Fault in the wrong location, the district plan team recognised that the current district plan fault hazard zone provisions were not proving effective. A review of the existing plan provisions (which has been developed as part of the district plan review in 1999) showed that they were not achieving their intention (e.g. multiple unit developments had been approved and built in areas identified in the district plan as active fault zones). Although the district plan policies reflected the intention to limit development in these areas, the rules were not explicit enough and the planning team decided they were in need of updating.

Clearer information requirements for developers were also needed and planners needed to have better assessment criteria to use when assessing resource consent applications for development in the fault rupture hazard zone.

12.2.4 Public Information Process

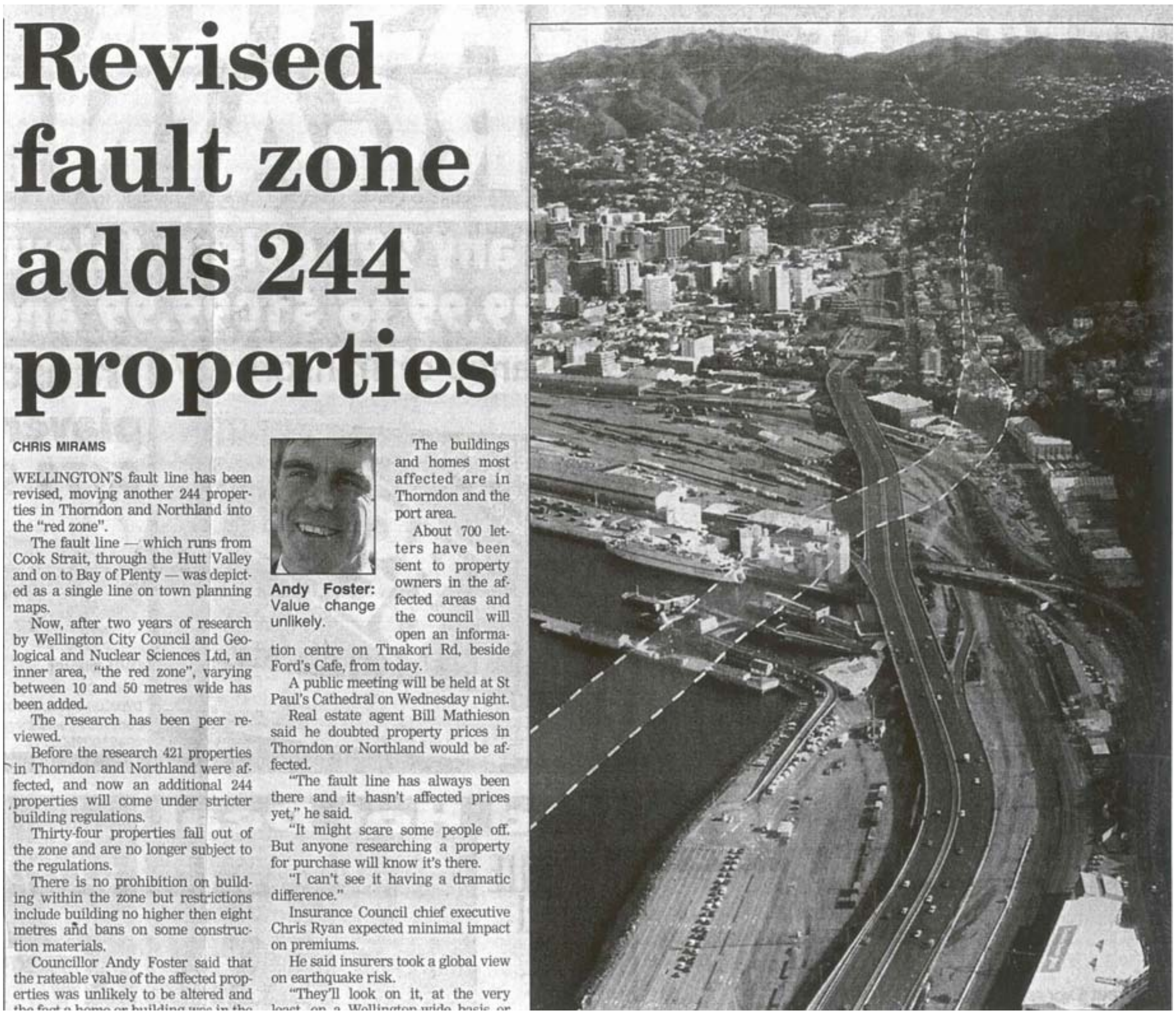
Prior to initiating Plan Change 22, the WCC undertook an extensive **public consultation campaign** to clearly communicate the findings of the Wellington Fault location review. Affected property owners and occupiers were targeted to gauge initial responses. Less than two weeks after receiving the final GNS report WCC undertook the following:

- letters were sent to over 700 property owners affected by the fault rupture hazard zones
- an information centre was established on Tinakori Road (i.e. close to the affected properties)
- a public meeting was held.

Over 70 people dropped into the information centre during its three days of opening, and about 65 people attended the public meeting. The GNS scientists who worked on the Wellington Fault location review attended the public meeting along with WCC staff. GNS's role was to explain the science behind the hazard zones, and WCC staff outlined the plan change process. A facilitator was used to help manage the questions that followed the main presentations.

Key issues raised by the public at the information centre and public meeting related to:

- the 20m buffer zone and whether there was scope to change this
- the nature of information included on Land Information Memorandums
- requests that no new significant buildings be built in the fault hazard area, whereas others were concerned about the level of existing regulation in the Plan.
- the impact on house values, insurance premiums and council rates
- expectations about compensation where the fault hazard zone now covered a property
- whether or not property owners were now required to strengthen their homes.



Revised fault zone adds 244 properties

CHRIS MIRAMS

WELLINGTON'S fault line has been revised, moving another 244 properties in Thorndon and Northland into the "red zone".

The fault line — which runs from Cook Strait, through the Hutt Valley and on to Bay of Plenty — was depicted as a single line on town planning maps.

Now, after two years of research by Wellington City Council and Geological and Nuclear Sciences Ltd, an inner area, "the red zone", varying between 10 and 50 metres wide has been added.

The research has been peer reviewed.

Before the research 421 properties in Thorndon and Northland were affected, and now an additional 244 properties will come under stricter building regulations.

Thirty-four properties fall out of the zone and are no longer subject to the regulations.

There is no prohibition on building within the zone but restrictions include building no higher then eight metres and bans on some construction materials.

Councillor Andy Foster said that the rateable value of the affected properties was unlikely to be altered and

Andy Foster: Value change unlikely.

The buildings and homes most affected are in Thorndon and the port area.

About 700 letters have been sent to property owners in the affected areas and the council will open an information centre on Tinakori Rd, beside Ford's Cafe, from today.

A public meeting will be held at St Paul's Cathedral on Wednesday night.

Real estate agent Bill Mathieson said he doubted property prices in Thorndon or Northland would be affected.

"The fault line has always been there and it hasn't affected prices yet," he said.

"It might scare some people off. But anyone researching a property for purchase will know it's there.

"I can't see it having a dramatic difference."

Insurance Council chief executive Chris Ryan expected minimal impact on premiums.

He said insurers took a global view on earthquake risk.

"They'll look on it, at the very

Figure 2 Newspaper article showing the line of the newly mapped Wellington Fault (looking south). The photo does not show the Fault Rupture Hazard Zone with the buffer. The article reflects effective communication between the WCC and the Dominion Post which has reported positively and discussed key issues such as building restrictions, valuations, public consultation and insurance.
Source: Dominion Post, Wellington, 5 April 2003

12.2.5 The Plan Change

A number of options were considered when recommending the final Plan Change 22 which included "do nothing" and reducing the buffer zone around the likely fault rupture hazard zone. The final recommendations included:

- Amend the existing planning maps to re-align the Hazard (Fault Line) Area to reflect the GNS recommendations which suggested a 20 metre buffer area either side of the *likely fault rupture hazard zone*

- Delete reference to NZS4203:1992 and replace with definitions of 'light roof' and 'light wall cladding' (from NZS 3604:19999 (Timber Framed Buildings)

- Allow for only one residential unit as a Permitted Activity in the Hazard (Fault Line) Area

- Provide for multi-unit developments to be assessed as a Discretionary (Unrestricted) Activity (this would have the effect of allowing appropriate assessment criteria to be developed for use by resource consent planners unlike a Non-Complying Activity status).

- Amend the explanation of the hazard policies to include specific reference to earthquake hazards, and that the damage caused by such hazards can be reduced with mitigation measures.

- Provide assessment criteria to give planners more scope when determining the effects to a specific site from fault rupture including the opportunity to obtain geotechnical and engineering information.

- Provide for geotechnical reports and engineering design reports to be supplied as part of any resource consent in the hazard area.

- Changes to other associated rules in the plan.

12.2.6 Issues raised by submitters

Following notification, Plan Change 22 received eleven submissions and four further submissions, with the majority of the submitters opposing aspects of the Plan Change or seeking amendments. Issues raised by submitters included:

a) The width of the 20m buffer zone.
b) Whether a whole property was affected by the hazard zone rules, or only land within the Hazard (Fault Line) Area.
c) The requirement to provide geotechnical and engineering design reports with any resource consent in the Hazard (Fault Line) Area
d) The proposed change to reduce the number of permitted residential units to one per site
e) The impact of this information on property values, insurance premiums and compensation

Of these, the first two points were considered the most significant but all are discussed below:

a) The width of the 20m buffer zone

Both the Guidelines and the GNS report recommend a minimum 20 metre buffer zone. Public concerns were mostly related to this additional 20 metre zone rather than the narrower *likely fault rupture hazard zone* - suggesting that residents accepted the risk of living on the fault. Those residents not within the *likely fault rupture hazard zone* however, questioned the necessity of their inclusion within the buffer zone.

It was decided, that if a smaller buffer zone (i.e. less than 20 metres) was put in place it would not resolve the fundamental problem that there would always be some properties *just within the zone* that would argue to be taken out of the zone. WCC acknowledged that the science of accurately locating fault rupture areas will continue to improve new technology, and better understanding of the hazard itself. If relevant information became known as site specific geotechnical investigations were carried out this may allow WCC to narrow the fault rupture hazard zone even further.

b) Whether a whole property was affected by the hazard zone rules, or only land within the Hazard (Fault Line) Area.

As with any type of zoning that does not strictly adhere to property boundaries, issues arose over interpretation of properties that i) had a boundary aligned with a line of the hazard zone, ii) were partially within the hazard zone, iii) had a right of way or similar within the fault rupture hazard zone (Figure 3):

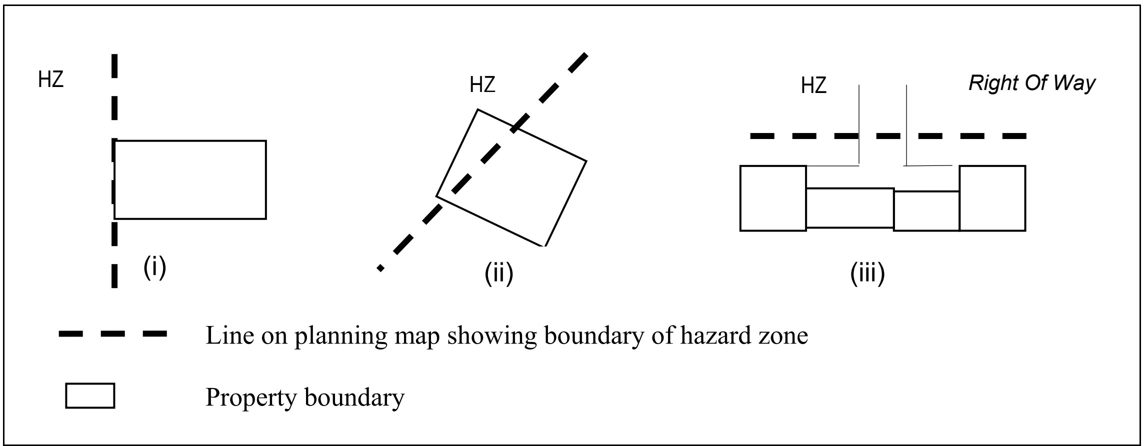


Figure 3 Interpreting fault rupture hazard zone lines

The WCC was required to make decisions on these situations in relation to whether or not the hazard information would be included in a LIM report; however the interpretations could easily apply to resource consent decisions. In scenario (i) planning staff assessed this property as being *out* of the hazard zone. In scenario (ii) the hazard information had to be included in a LIM, but the rules in the plan only apply to that portion of the land covered by the hazard area. Likewise with scenario (iii), the information had to be included in a LIM, but an extra note was included on that LIM explaining it was only the ROW affected by the hazard area and not the building itself.

Notes were put on **property files** for those properties where interpretation of the fault rupture hazard zone lines was unclear (as in the scenarios above) to provide clarity for property owners and planners assessing development proposals. In most cases, the planner will be able to interpret whether or not a property is in the hazard zone from the planning maps.

c) Requirement to provide geotechnical & engineering reports

The requirement for geotechnical and engineering reports as part of a resource consent application was objected to by a utility company on the grounds that such structures were designed to withstand ground-shaking events, that the structures are small in comparison to other structures (such as houses) and the potential environmental impacts are minor.

The requirement for geotechnical and engineering reports were part of Plan Change 22 as they allow for ground conditions (which can vary from site to site) to be assessed and also provide WCC with information about how a fault rupture event may affect a certain development. It was agreed that as the focus of the rules was on structures where people live, work and play and therefore no need for utility structures to be subject to the requirement to provide geotechnical and engineering reports.

d) Limiting residential units to one per site

Although the district plan already permitted only one residential unit per site in most of the area covered by the hazard zone (i.e. Thorndon), other areas of Wellington that were currently permitted two units per site, were affected by a rule in the Plan Change.

The rule does not prevent landowners from building more than one dwelling on a site but outlines what is permitted as of right without requiring resource consent. The assessment criteria, geotechnical and engineering requirements, developed as part of Plan Change 22, will allow WCC the opportunity to gather the information needed to assess any proposals in the hazard area that require a resource consent.

e) Property values, Insurance Premiums and Compensation

While some property owners accepted the hazard risk by living in the area, others were concerned about the impact of a hazard zone on property values and insurance premiums.

Although difficult to accurately confirm, there has been no evidence to suggest that the fault hazard zone has affected property prices in the past; similarly insurance premiums have not reflected any increase due to the risk identified in the fault rupture hazard zone. Even if it had been proven that property values decreased as a direct result of the fault hazard zone, WCC had not prohibited any development along the fault allowing people to still make reasonable use of their land. No compensation would be required.

12.2.7 Council hearing and decision-making process

The hearing for Plan Change 22 was held in February 2004 and attended by three submitters. The hearing was notable for the level of detail that the Hearings Committee went into in order to establish the appropriateness of the hazard zone in areas that were contested by submitters. One submitter bought along their own geotechnical advisor, which helped to raise the level of the debate about the accuracy of the hazard zones. The Committee found itself in a position of weighing the evidence from its District Planning Team geotechnical advisors against the expert bought in by the submitter. As a consequence of this debate between the experts, the Committee decided that there was enough evidence to narrow the fault rupture hazard area at two specific locations as argued by the submitter's expert. The Committee considered that it was ultimately better to narrow the *fault rupture hazard area* based on good quality information, rather than to reduce the 20m buffer area to appease submitters. Upon reflection, these changes were agreeable to GNS also, and consequently the hazard zones were revised for the decision.

Some changes were made to clarify some of the rules.

In June 2004, Plan Change 22 has received no appeals at the close of the appeal period.

Plan Change 22 resulted in planning map inaccuracies being fixed with properties that were no longer within the fault rupture hazard zone removed from the zone and no longer be subject to the rules for the Hazard (Fault Line) Area. Similarly, properties not currently within the fault rupture hazard area, but included in the fault rupture hazard zone recommended by GNS became subject to the Hazard (Fault Line) Area rules.

12.2.8 Key lessons

- Once WCC had the findings of the GNS report they **acted quickly by initiating an extensive public consultation campaign** that included the information centre, a public meeting and media liaison. A lot of questions the public had related to science and geotechnical issues which were able to be answered by the GNS staff who attended the meeting, and who had written the Wellington Fault location review report. As a result, **very few written submissions were received** on the proposed Plan Change 22. Of those that were received, they were all very focused and did not generally cover issues that could not be resolved in the plan change process. WCC considered that because of their well executed public campaign the submissions received were far more manageable than anticipated.

- The **information requirements**, developed as part of the plan change for inclusion within the district plan, needed to be explained clearly for both the planner (to request the right information) and the developer (to provide the right information). The cost of these requirements needed to be considered and should be met by the developer.

- If a council requires **geotechnical and engineering information** then it is important to have staff who can explain what is needed and interpret the information when it is received. The WCC now have a geotechnical staff member.

- It is important for **assessment criteria** to be very clear as it gives the consent planner a good basis when assessing an application and reasoning to refuse consent if necessary.

12.3 The Kapiti Coast District Council

The Kapiti Coast District is the fastest growing area in the Wellington Region (approximately 2% population increase per year) and is traversed by five known active faults – Ohariu, Northern Ohairu, Gibbs, Otaki Forks and South East Reikorangi. The Ohairu and Northern Ohariu faults are two of the more significant earthquake generating faults in the Wellington Region, and they both pass through areas of urban, semi-urban and rural development.

Following a comprehensive review of all the known fault traces in the district, the Kapiti Coast District Council (KCDC) is now in the process of reviewing and updating its district plan provisions for the development and subdivision of land on or close to active faults.

Plan Change 64 (Fault traces), while not yet complete, will seek to update the GIS and District Plan maps by more accurately depicting the locations of faults traces, as well as amending the supporting package of objectives, policies, rules and standards in the district plan.

12.3.1 Background

In November 2000, KCDC notified a Proposed Plan Change that sought better planning and management of development on or close to the active faults in the district. The plan change however, was withdrawn after submissions highlighted that further research was needed to more accurately define the fault trace locations in the district.

In 2003 KCDC, along with Greater Wellington – the Regional Council, commissioned GNS to carry out a comprehensive study of the known active fault traces in Kapiti.

Although KCDC already had some data regarding the location and type of fault generated features for some parts of the district, the information had been gathered in a piecemeal and site specific manner, and was basically confined to small sections of the Ohariu and Gibbs faults only. In addition, the accuracy of the information was in some cases limited to +/- 100 metres. A fault trace study was therefore necessary to improve the existing information held by KCDC and improve the detail and accuracy of fault trace locations on the district plan maps.

12.3.2 Current planning for fault rupture

The Kapiti Coast District Plan currently contains provisions in the rural and residential zones restricting the construction of buildings within 20 metres of an earthquake fault trace shown on district plan maps. Any building proposal falling within 20 metres of a fault trace requires Controlled Activity resource consent and conditions are usually applied to ensure appropriate engineering requirements are included in the building design in order to avoid, remedy or mitigate any adverse effects resulting from ground rupture.

12.3.3. Findings

The GNS report presented a comprehensive study of all known active fault traces in Kapiti. The locations were mapped into GIS to allow for incorporation into the Council's GIS system and onto the district plan planning maps. The findings were presented in a way compatible with the process set out in the Guidelines.

GNS established Fault Avoidance Zones (this is the same as the terminology in the Guidelines, whereas WCC used the term *fault rupture hazard zone*) based on fault locations and complexity (*well defined, distributed,* and *uncertain*). A Fault Avoidance Zone includes the fault rupture hazard zone, and the buffer zone.

Due to the particular fault trace complexities in Kapiti, GNS found it necessary to expand upon these categories to include:

- *Well defined*– fault rupture is well defined and of limited geographic width
- *Well defined – extended* – a well defined fault had either been buried or eroded over short distances but its position is tightly constrained
- *Distributed* – fault rupture can be constrained to lie within a relatively board geographic width (tens to hundreds of metres) typically as multiple fault traces and/or folds.
- *Uncertain – constrained* - areas where the location of the fault rupture is uncertain because evidence has been eroded or buried but where the location can be constrained to within a reasonable geographic extent (e.g. $\leq$ to 300 metres)
- *Uncertain – poorly constrained* where the fault trace was uncertain to be within 300 metres usually because deformation has been buried or eroded or the fault features are widely spaced and/or very broad.

Fault Avoidance Zones are defined along all the faults based on the rupture complexity of the particular fault, and the precision to which its location can be constrained. The Fault Avoidance Zones identified range in width from about 40m (*well defined*) to greater than 300m (*uncertain-poorly constrained*).

The GNS report also provided examples of resource consent activity classes appropriate to different Fault Avoidance Zones based on the fault *recurrence interval, fault complexity* and *building importance category*. This approach is consistent with the Guidelines and was included in order to provide assistance in drafting the district plan rules relating to fault traces.

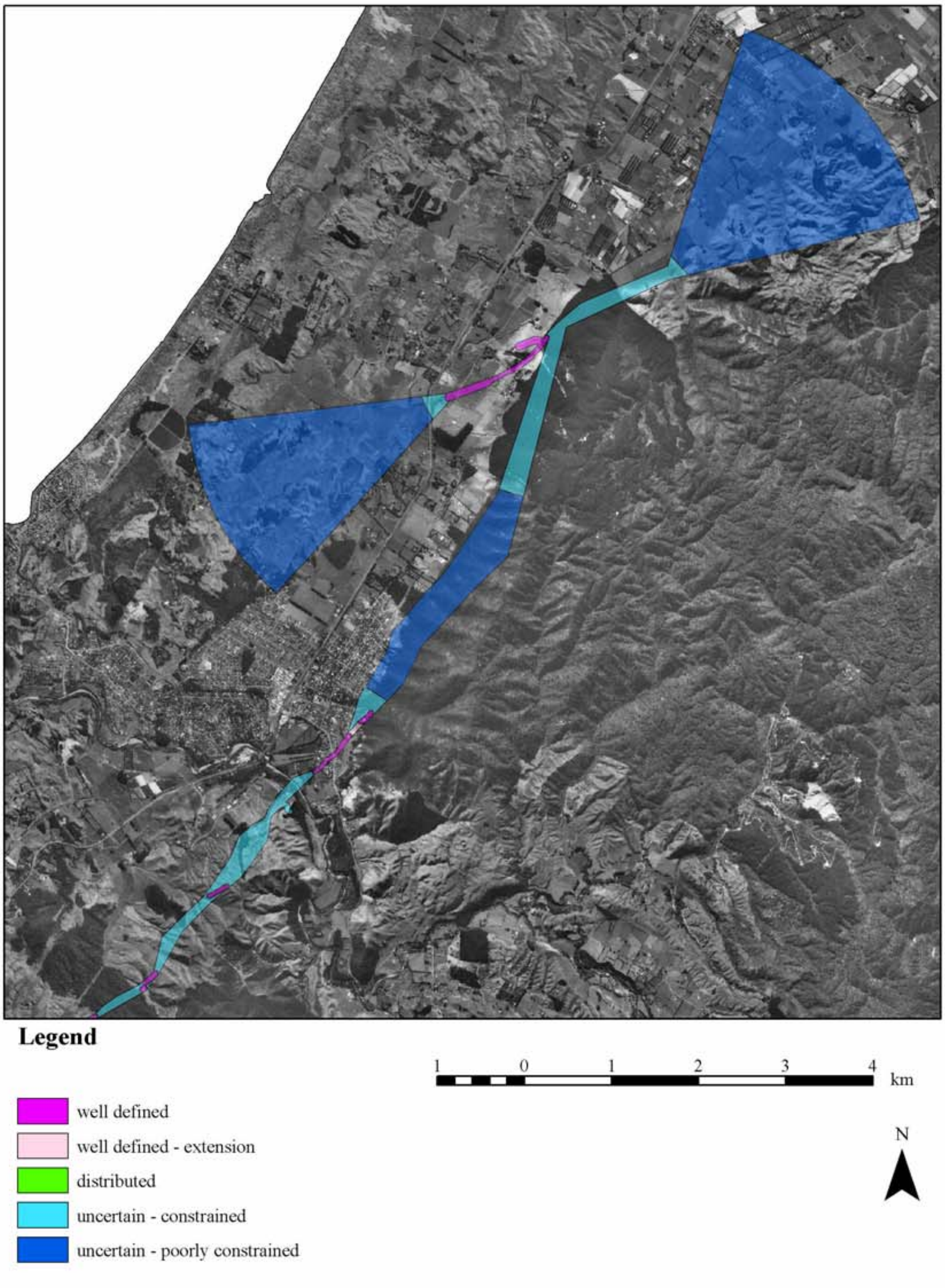


Figure 4. The Ohariu fault (northern end) showing Fault Avoidance Zones.

Figure 4 The Ohariu Fault (northern end) showing Fault Avoidance Zone. An example of the complex nature of faulting in the Kapiti district. Van Dissen. R., and Heron. D (2003).

12.3.4 Public consultation

As soon as KCDC received the GNS report and considered its findings, planning staff set about putting into action a public consultation process that would advise landowners affected by the report findings and seek feedback to assist the council with preparing a plan change.

Letters were sent to all landowners in September 2003, along with an Information Sheet summarising the fault trace study results and the implications. A large number of responses were received, including 32 written comments, which raised a raft of concerns including:

- The effect of the new information on property value, insurance premiums and insurance policy coverage
- The nature and extent of fault trace information included on Land Information Memorandums
- Expectations for compensation where the fault trace hazard now covers a property, as well as a reduction in council rates
- Concerns regarding existing houses built on or very close to a fault – what can landowners do to reduce risk and damage? Should owners be strengthening their homes?
- Greenfield areas should not be treated any differently to areas that are already developed
- The approach proposed is overly conservative and risk adverse, especially in areas where risk is uncertain (i.e. *uncertain-unconstrained* areas)
- The building importance categories identified are defective (no provision for 2-3 story timber framed houses within scope of NZS 3604)
- Concerns regarding the accuracy of information – How was it gathered? How accurate is it? Why did KCDC not already have accurate information for the whole of the district?

12.3.5 Towards a Plan Change

KCDC is currently dealing with the concerns raised by submitters and deciding on the scope and content of Plan Change 64. District plan maps will be updated with the new fault trace information supplied by GNS and amendments made to the supporting objectives, policies, rules and standards in the district plan, for example:

- Amending the relevant objectives and policies within the Natural Hazards chapter to include specific reference to earthquake fault trace hazards
- Including the opportunity within the rules and standards to obtain geotechnical and engineering information as part of any resource consent within a Fault Avoidance Zone
- Amending other relevant rules and standards in the plan.

The plan change will reflect the GNS report findings and the approach set out in the Guidelines, but will be adapted to the Kapiti Coast situation, and to the District Plan structure. The comments already received from landowners will also be taken into account in the drafting of new provisions.

The **complexity of the nature of faults** in Kapiti raises issues in terms of the provisions to be included in the District Plan. The challenge includes drafting provisions which cover:

- five different faults, all with slightly different faulting characteristics

- five different Fault Avoidance Zones reflecting different levels of certainty
- greenfield vs already developed land
- the different types of structure/building that could be erected (temporary structures, single or multiple-storied timber dwellings, through to more significant structures and buildings)
- and because of these differences, the potential for several different categories of resource consent.

The emphasis is on making the district plan provisions, particularly the rules and standards, as straightforward as possible to aid understanding by landowners, developers and decision makers.

In order to facilitate robust decision-making whilst the plan change is being developed, and to ensure the Council meets its obligations in terms of providing the most up-to-date information available, the GIS layer supplied by GNS as part of the study has been incorporated into the Council's GIS system.

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- Simon Nathan, Geological Society of New Zealand
- Russ Van Dissen, Institute of Geological and Nuclear Sciences
- Peter Webb, Ministry for the Environment
- David Brunsdon, New Zealand Society of Earthquake Engineering
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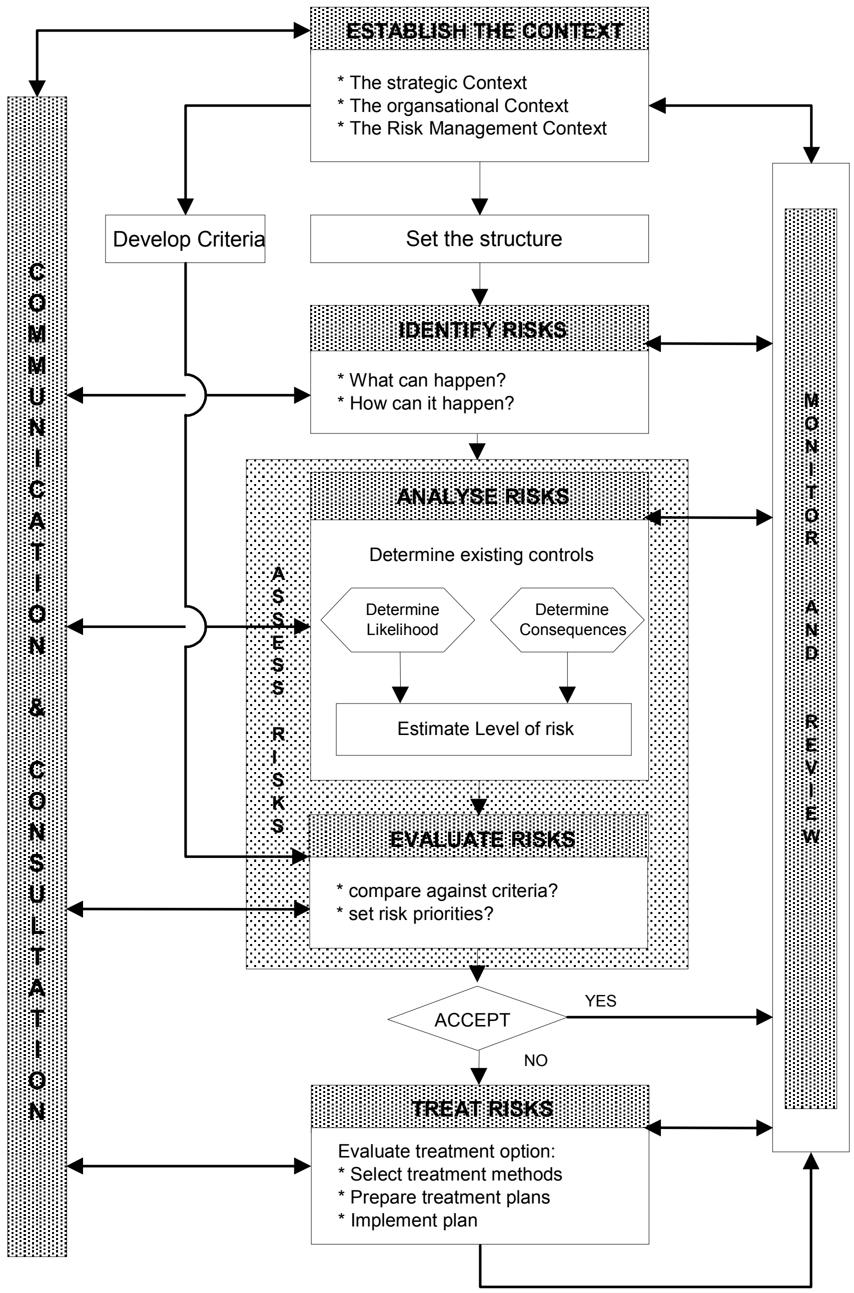
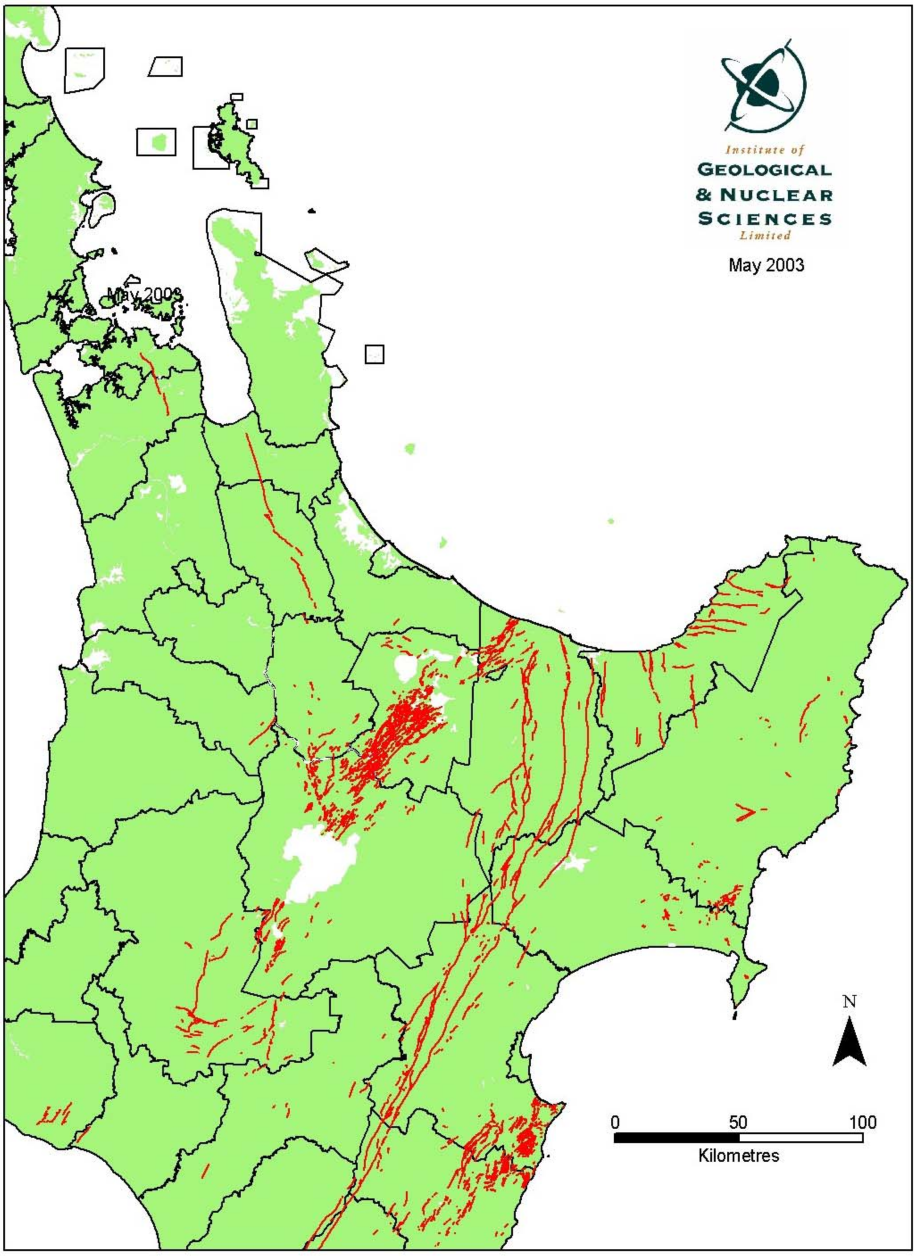
Appendix 1: AS/NZ 4360:1999

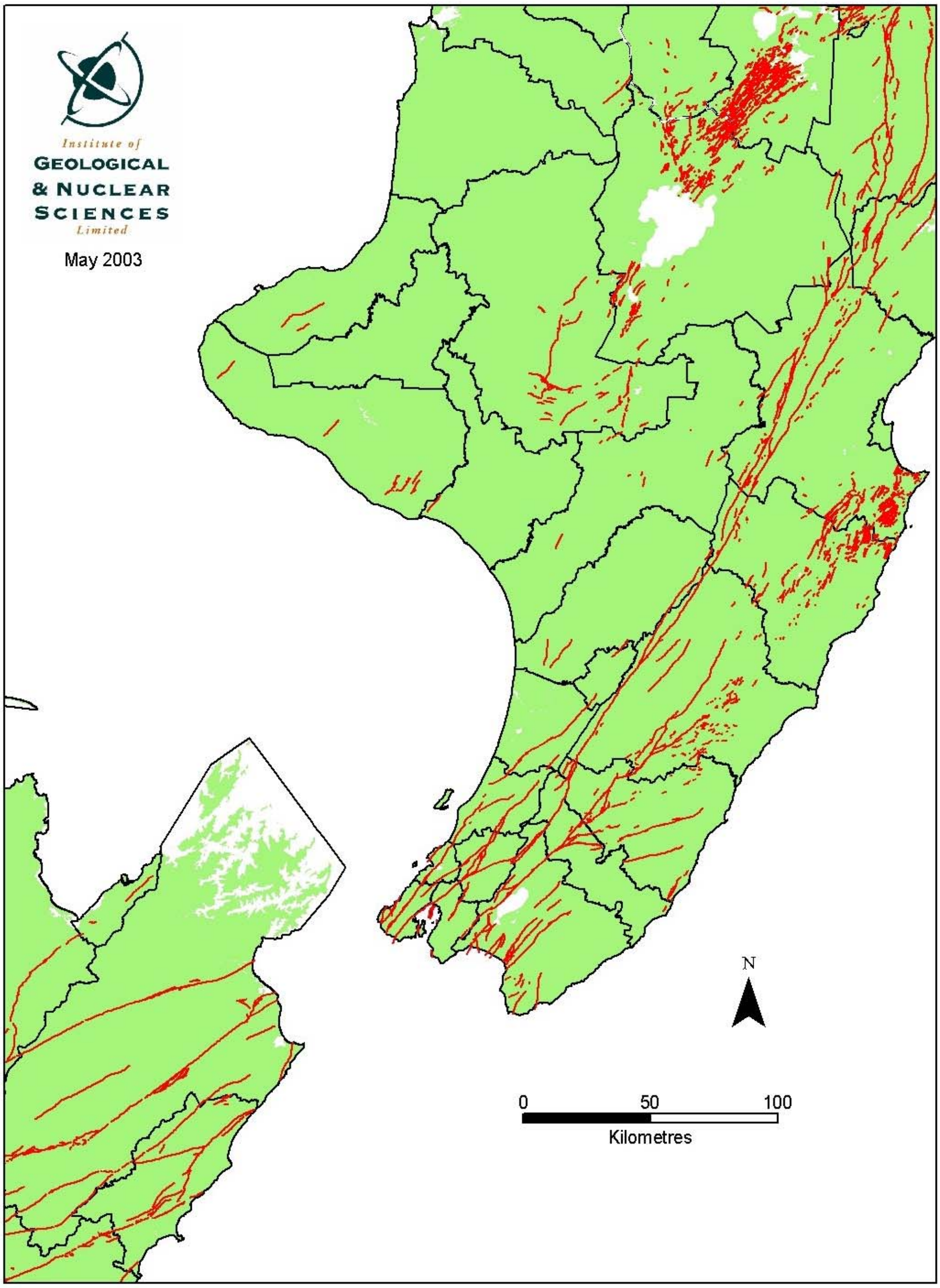
Figure A1.1: Stylised risk management process (after AS/NZS 4360:1999)



Appendix 2: Maps of Active Faults

The following maps show New Zealand's active faults within current territorial authority boundaries. *Note:* the purpose of these maps is to raise awareness of active faults and should be used for indicative purposes only.

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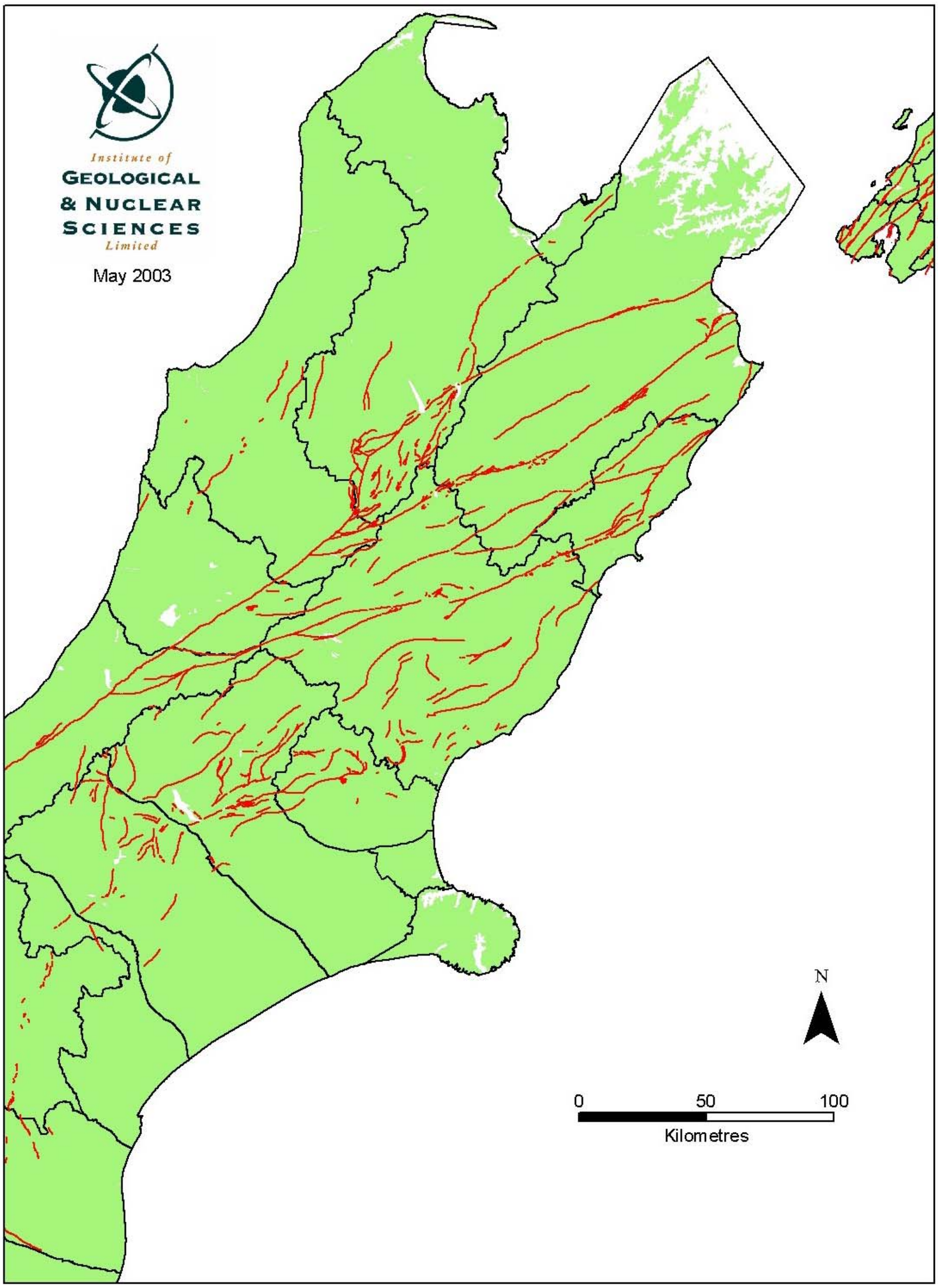
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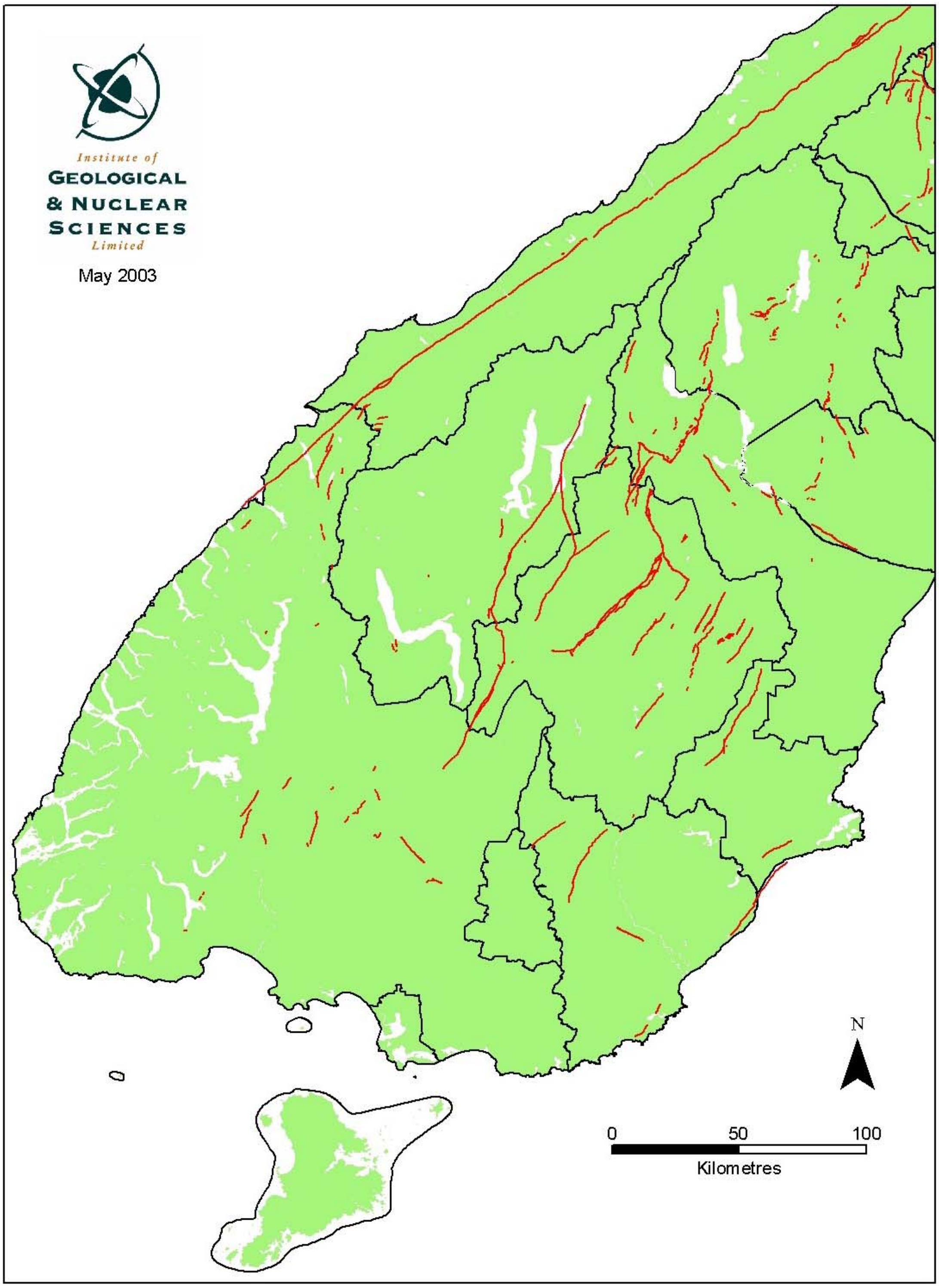
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Appendix 3: Classification of Faults

This table provides an interim classification of most of New Zealand's on-land active faults, based on fault recurrence interval.

Fault-avoidance recurrence interval class	Fault name*	Affected regional councils**	Confidence of classification[#]	Method of recurrence interval estimation[##]
≤ 2000 years (RI Class I)	Alfredton	Wgtn, M-W	M	1, 2, 3
	Alpine	S, WC, Tas	H	1, 2, 3
	Amberley	C	M	2, 3
	Aorangi–Ngapotiki	Wgtn	M	3
	Aratiatia	W	M	3
	Awatere	WC, C, M	H	1, 2, 3
	Braemar	BP	L	4
	Clarence	WC, C, M	H	1, 2, 3
	Dreyers Rock	Wgtn, M-W	L	4
	Edgecumbe	BP	H	1, 3
	Fyffe	C	L	4
	Hanmer	C	L	3, 4
	Highlands	W, BP	M	3
	Hope	WC, C	H	1, 2, 3
	Jordan Thrust	C	M	1, 4
	Kaiapo	W	M	3
	Kakapo	C	H	3
	Karioi	M-W	M	3, 4
	Kekerengu	C	H	3
	Kelly	C	L	4
	Kowhia	C	L	4
	Lake Ohakuri	W	L	4
	Maleme (including Rehi fault)	W	H	3
	Matata	BP	M	1, 4
	Mohaka	M-W, HB	M	1, 3
	Mt Grey	C	M	1, 4
	National Park	M-W	L	4
	Ngangiho	W	M	3
	Ohakune	M-W	M	1, 2, 3
	Orakeikorako	W	L	4
	Paeroa	W, BP	H	1, 2, 3
	Patoka	HB	L	4
	Porters Pass	C	M	1, 2, 3
	Poutu	W	M	l, 3, 4
	Puketerata	W	L	4
	Rangiora	HB	H	1, 2
	Rangipo	M-W, W	M	1, 2, 3
	Raurimu	M-W	M	3
	Rotoitipakau	BP	H	1
	Shawcroft Road	M-W	L	3, 4
	Snowgrass	M-W	L	1, 4
	Tumunui	W, BP	L	4
	Waihi	M-W, W	M	3, 4
	Waipukaka	M-W	M	1
	Wairarapa	Wgtn, M-W	H	1, 2, 3
	Wairau	Tas, M	M	1, 2, 3
	Wellington	Wgtn, M-W	H	1, 2, 3
	West Whangamata	W	L	4
	Whakaipo	W	M	3
	Whakatane (south)	BP	L	3, 4
	Whangamata	W	M	3
	Wharekauhau	W	L	4
	Whirinaki	W	M	3

Fault-avoidance recurrence interval class	Fault name*	Affected regional councils**	Confidence of classification#	Method of recurrence interval estimation##
> 2000 years to ≤ 3500 years (RI Class II)	Akatore	O	M	1, 3
	Ashley–Cust	C	L	1, 4
	Awaiti	BP	L	4
	Barber	W	L	3
	Carterton	Wgtn	M	3
	Cross Creek	Wgtn	L	4
	Elliott	C, M	M	3, 4
	Fidget	C	L	4
	Fowlers	C	L	3, 4
	Fox’s Peak	C	L	3
	Hihitahi	M-W	L	4
	Irishman’s Creek	C	M	1, 3
	Kerepehi	W	H	1, 2, 3
	Lake Heron	C	M	3
	Little Rough Ridge	O	L	4
	Long Valley	O	M	3
	Makuri	M-W	L	4
	Masterton	Wgtn	L	3, 4
	Mokonui	Wgtn	L	3, 4
	Mt Hutt – Mt Peel	C	L	3
	Northern Ohariu	Wgtn, M-W	L	2, 3, 4
	Ngapouri	M-W, BP	M	3
	Oaonui	T	M	1
	Ohariu	Wgtn	L	1, 2, 3
	Omeheu	BP	L	4
	Onepu	BP	M	1, 4
	Orakonui	W	M	3
	Ostler	C	M	1, 2
	Otakiri	BP	L	4
	Pa Valley	M-W	L	4
	Raetihi	M-W	L	4
	Raggedy Range	O	L	4
	Ranfurly	O	L	4
	Rotohauhau	W, BP	M	1, 3
	Ruahine	M-W, HB	L	3, 4
	Saunders Road	M-W	L	4
	Silver Range	HB	L	4
	Te Teko	BP	L	4
	Te Weta	W	M	3
	Thorpe-Poplar	W	M	3
	Torlesse	C	L	4
	Vernon	M	L	3, 4
	Waikaremoana	HB, BP	L	4
	Waimana	BP	M	3
	Waiohau	BP	M	1, 3
	Waipiata	O	L	4
	Weber	M-W	L	4

Fault-avoidance recurrence interval class	Fault name*	Affected regional councils**	Confidence of classification#	Method of recurrence interval estimation##
> 3500 years to ≤ 5000 years (RI Class III)	Akatarawa	Wgtn	L	3, 4
	Blue Lake	O	L	3
	Cheeseman	C	L	4
	Dry River	Wgtn	M	3, 4
	Gibbs	Wgtn	L	4
	Glendevon	HB	L	4
	Hossack Road	W	L	1, 3
	Huangarua	Wgtn	M	1, 3
	Hundalee	C	L	4
	Inglewood	T	M	1
	Kaiwara	C	L	4
	Kaweka	HB	L	4
	Kidnappers (east)	HB	M	3
	Kidnappers (west)	HB	M	3
	Lees Valley	C	M	1, 4
	Lindis Pass	C, O	L	4
	London Hill	M	L	4
	Martinborough	Wgtn	M	3
	Maunga	M-W	L	4
	Moumahaki	T	L	3
	Mt Thomas	C	L	4
	Ngakuru	W	M	1, 3
	Norfolk	T	L	4
	North Rough Ridge	O	L	4
	Omihi	C	L	4
	Oruawharo	HB, M-W	L	4
	Otaraia	Wgtn	L	3, 4
	Poulter	C, WC	L	4
	Pukerua	Wgtn	L	3, 4
	Raukumara (many different faults)	G	L	4?
	Ruataniwha	HB	L	4
	Shepherds Gully	Wgtn	L	2, 3
	Tukituki	HB	L	3
	Waimea–Flaxmere	N, Tas	L	4?
	Waipukurau–Poukawa	HB	M	1, 3
	Waitawhiti	M-W	L	4
	Whakatane (north)	BP	L	1, 4

Fault-avoidance recurrence interval class	Fault name*	Affected regional councils**	Confidence of classification[#]	Method of recurrence interval estimation[##]
> 5000 years to ≤ 10,000 years (RI Class IV)	Awahokomo	C	L	4
	Bidwill	Wgtn	L	3, 4
	Big River	WC	L	4
	Blackball	WC	L	4
	Cardrona	O	M	1, 3
	Dalgety	C	L	4
	Dunstan	O	M	1, 2, 3
	Esk	C	L	4
	Fern Gully	C	M	1, 2, 3
	Fernside	G	L	3, 4
	Giles Creek	WC	L	4
	Hog Swamp	M	L	4
	Horohoro	W, BP	H	1, 3
	Hyde	O	L	4
	Kirkliston	C	L	1, 3
	Lowry Peak	C	L	4
	Mangaoranga	Wgtn, M-W	L	4
	Mangatete	W	M	3
	Moonlight	S, O	L	4
	Nevis	O	M	1, 3, 4
	Nukumaru	T	L	3
	Paparoa Range	WC	L	3, 4
	Poukawa (north)	HB	M	1
	Punaruku	W, BP	M	1, 3
	Quartz Creek	C	L	4
	Rostreivor	C	L	4
	Rotokohu	WC	L	4
	Rough Creek	WC	L	4
	Southland (several different faults)	S	L	4?
	Springbank	C	L	4
	Waitotara	T	L	3
	West Culverden	C	L	4

* Faults are listed alphabetically within each fault-avoidance recurrence interval class.

** Regional councils: BP, Bay of Plenty; C, Canterbury; G, Gisborne; HB, Hawke's Bay: M, Marlborough; M-W, Manawatu-Wanganui; N, Nelson; O, Otago; T, Taranaki; Tas, Tasman; S, Southland; W, Waikato; WC, West Coast; Wgtn, Wellington.

[#] Relative confidence that the fault can be assigned to a specific fault-avoidance recurrence interval class.

H High – fault has a well constrained recurrence interval (usually based on fault-specific data) that is well within a specific fault-avoidance class, or fault has such a high slip rate that it can be confidently placed within the ≤ 2000 year fault-avoidance class.

M Medium – uncertainty in average recurrence interval embraces a significant portion (> ~25%) of two fault-avoidance classes; the mean of the uncertainty range typically determines into which class the fault is placed.

L Low – uncertainty in recurrence interval embraces a significant portion of three or more fault-avoidance classes, or there are no fault-specific data (i.e. fault-avoidance recurrence interval class is assigned based only on subjective comparison with other faults).

[##] Method by which recurrence interval was determined/constrained.

1 Fault-specific sequence of dated surface ruptures. The longer the sequence of dated surface ruptures, the more preference we give this method with respect to constraining average recurrence interval, and assigning fault-avoidance recurrence interval class.

2 Fault-specific slip rate and single-event displacement, and the use of Equation 1. The better the constraints on slip rate and single-event displacement, the more preference we give this method with respect to constraining average recurrence interval.

3 Indicative determination of recurrence interval based on fault-specific slip rate constraints, rupture length estimates, and Figures 1 and 2; however, well constrained recurrence interval estimates based on methods 1 and 2 above, take precedence over this method.

4 Based on comparisons with other, similar, faults.

Appendix D

Hand Auger & Dynamic Cone Penetrometer Results

INVESTIGATION LOG

HOLE NO.: TP01

SITE LOCATION: 131 Main Street,Oxford

PROJECT: Geotechnical Investigation

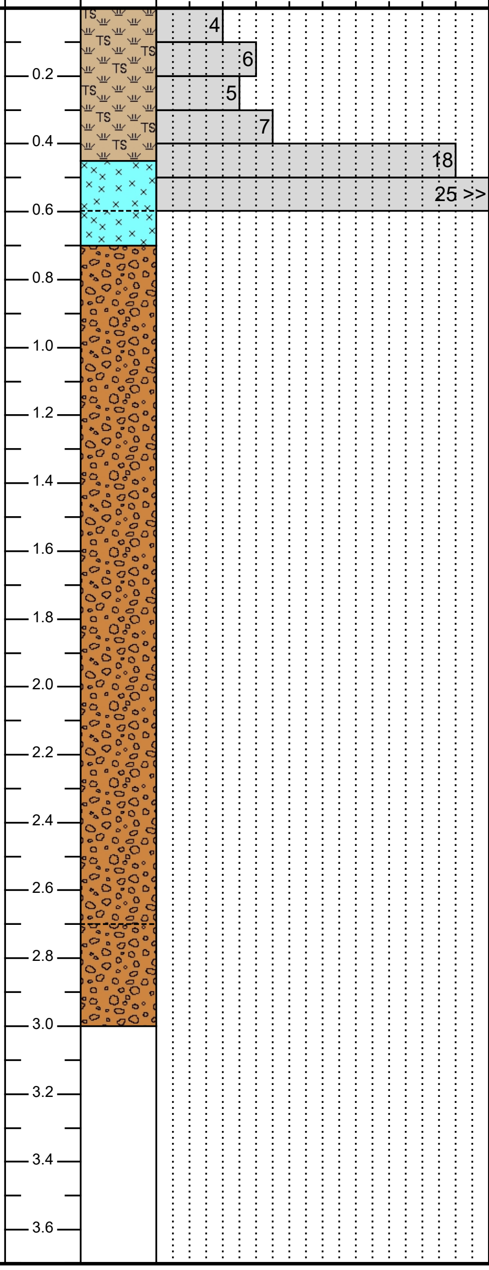
JOB NO.: 086

CLIENT: Waghorn Builders Limited

RIG: TP
DRILLER: NZGCL
LOGGED BY: JF

START DATE: 12/05/2022
END DATE: 12/05/2022
LOGGED: 12/05/2022

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	HAND SHEAR VANE (Uncorrected)	WATER
TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist,low-plasticity.						Groundwater Not Encountered
Firm,light brown SILT with minor fine to coarse gravel,moist,low plasticity-moderate plasticity.						
Becomes with some fine to coarse gravel,minor cobbles.						
Dense light brown fine to coarse GRAVEL with minor cobbles and fine to coarse sand,moist.						
Becomes wet.						
End of Hole at 3.00m-Target Depth Reached.						



PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 3.00m-Target Depth Reached. No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

GEOTECHNICAL CONSULTANTS	**INVESTIGATION LOG**	**HOLE NO.:** TP02
	SITE LOCATION: 131 Main Street,Oxford **PROJECT:** Geotechnical Investigation	**JOB NO.:** 086

CLIENT: Waghorn Builders Limited

RIG:	TP	**START DATE:**	12/05/2022
DRILLER:	NZGCL	**END DATE:**	12/05/2022
LOGGED BY:	JF	**LOGGED:**	12/05/2022

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details) | **SAMPLES** | **DEPTH (m)** | **LEGEND** | **SCALA PENETROMETER** (Blows / 100mm) | **HAND SHEAR VANE** (Uncorrected) | **WATER**

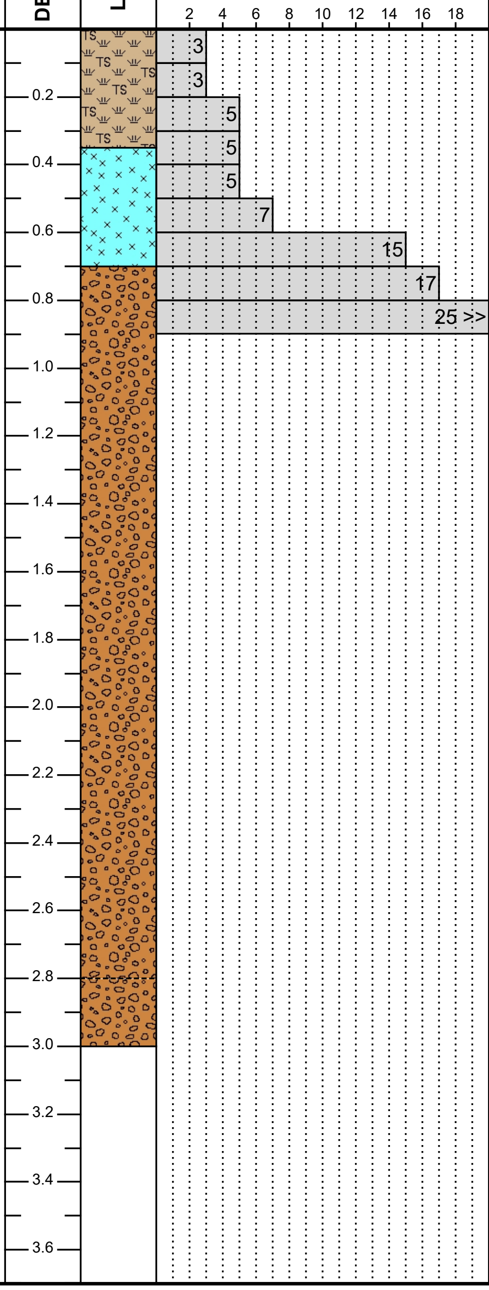
TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist,low-plasticity.

Firm,light brown SILT with some fine to coarse gravel,trace cobbles,moist,low plasticity.

Dense,light brown fine to coarse GRAVEL with some cobbles and fine to coarse sand,moist.

Becomes wet.

End of Hole at 3.00m-Target Depth Reached.



Groundwater Not Encountered

PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 3.00m-Target Depth Reached.No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

INVESTIGATION LOG

GEOTECHNICAL CONSULTANTS

HOLE NO.: TP03

JOB NO.: 086

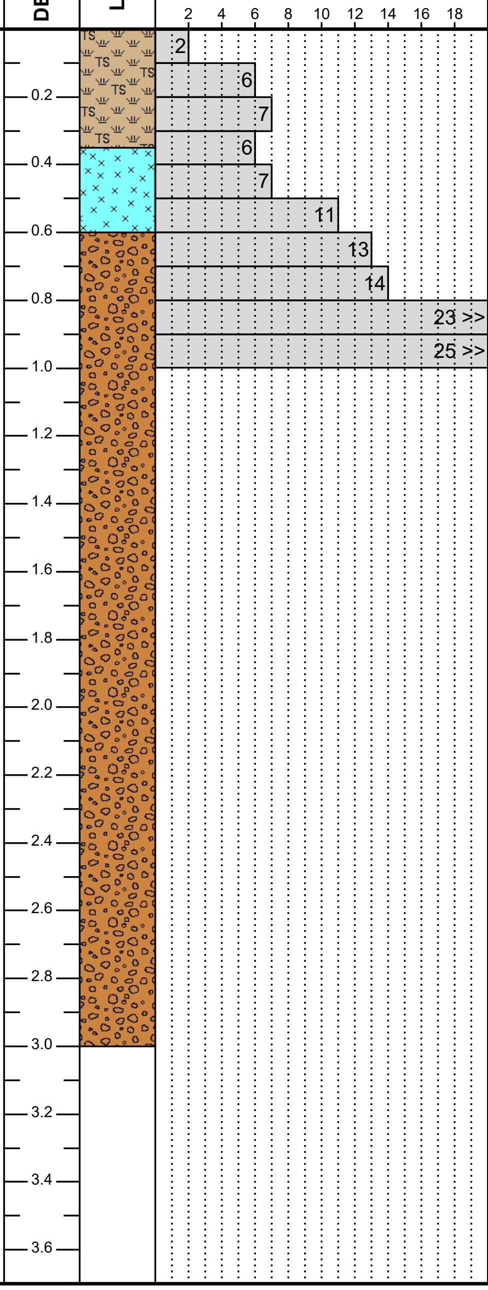
SITE LOCATION: 131 Main Street,Oxford

PROJECT: Geotechnical Investigation

CLIENT: Waghorn Builders Limited

RIG:	TP	**START DATE:**	12/05/2022
DRILLER:	NZGCL	**END DATE:**	12/05/2022
LOGGED BY:	JF	**LOGGED:**	12/05/2022

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	HAND SHEAR VANE (Uncorrected)	WATER
TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist,low-plasticity.		0.0–0.35	TS	2, 6, 7		Groundwater Not Encountered
Firm,light brown SILT with some fine to coarse gravel,moist,low-plasticity.		0.35–0.6		6, 7, 11		
Dense,light brown fine to coarse GRAVEL with some cobbles and fine to coarse sand,moist.		0.6–3.0		13, 14, 23 >>, 25 >>		
End of Hole at 3.00m-Target Depth Reached.		3.0				



PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 3.00m-Target Depth Reached.No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala bar-new1 - 17/05/2022 1:56:02 pm

INVESTIGATION LOG

HOLE NO.: TP04

JOB NO.: 086

SITE LOCATION: 131 Main Street,Oxford

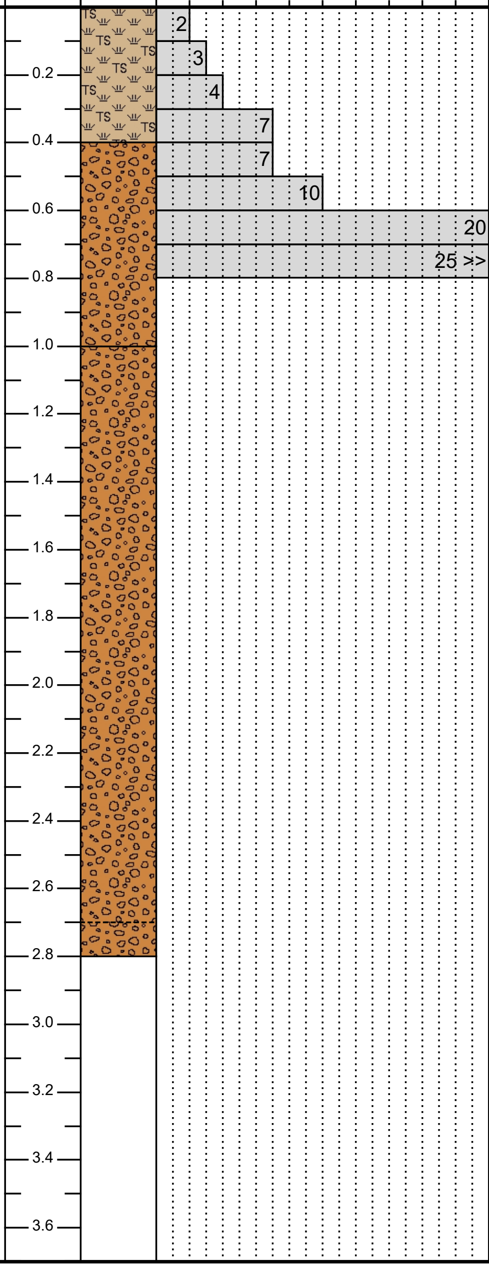
PROJECT: Geotechnical Investigation

CLIENT: Waghorn Builders Limited

RIG: TP
DRILLER: NZGCL
LOGGED BY: JF

START DATE: 12/05/2022
END DATE: 12/05/2022
LOGGED: 12/05/2022

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	HAND SHEAR VANE (Uncorrected)	WATER
TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist,low-plasticity.		0.0–0.4				Groundwater Not Encountered
FILL-Loose,dark grey fine to coarse GRAVEL with metal and organics including tree stumps.		0.4–1.0				
Dense,light brown fine to coarse GRAVEL with some cobbles and fine to coarse sand,moist.		1.0–2.8				
Becomes wet.						
End of Hole at 2.80m-Target Depth Reached.		2.8				



PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 2.80m-Target Depth Reached.No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

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INVESTIGATION LOG

GEOTECHNICAL CONSULTANTS

HOLE NO.: TP1/01

SITE LOCATION: 131 Main Street,Oxford

PROJECT: Geotechnical Consultants

JOB NO.: 086-1

CLIENT: Waghorn Builders Limited

RIG: TP
DRILLER: NZGCL
LOGGED BY: JF

START DATE: 22/03/2023
END DATE: 22/03/2023
LOGGED: 22/03/2023

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

SAMPLES | **DEPTH (m)** | **LEGEND**

SCALA PENETROMETER
(Blows / 100mm)

HAND SHEAR VANE
(Uncorrected)

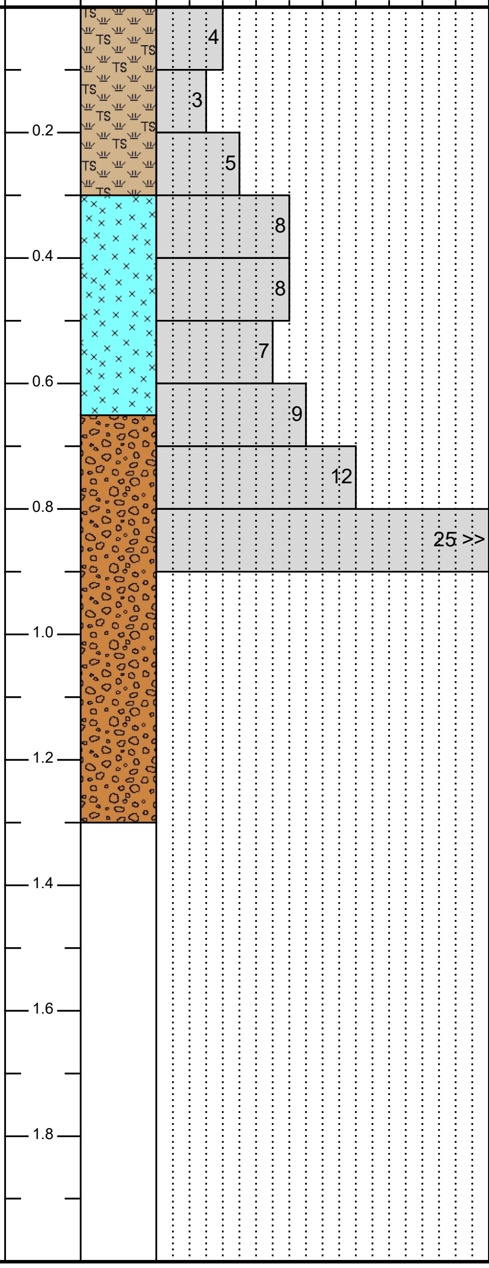
WATER

TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist.

Firm,light brown SILT with minor fine to coarse gravel,moist,low plasticity-moderate plasticity.

Dense,light brown fine to coarse GRAVEL with some fine to coarse sand,minor cobbles,moist.

End of Hole at 1.40m-Target Depth Reached.



Groundwater Not Encountered

PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 1.40m-Target Depth Reached.No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala bar-new1 - 22/03/2023 3:00:17 pm

INVESTIGATION LOG

GEOTECHNICAL CONSULTANTS

HOLE NO.: TP1/02

SITE LOCATION: 131 Main Street,Oxford
PROJECT: Geotechnical Consultants

JOB NO.: 086-1

CLIENT: Waghorn Builders Limited

RIG: TP
DRILLER: NZGCL
LOGGED BY: JF

START DATE: 22/03/2023
END DATE: 22/03/2023
LOGGED: 22/03/2023

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND
TOPSOIL-Firm,dark brown SILT with minor fine to coarse gravel,trace roots,moist,low plasticity.		0.0 – 0.3	TS
Firm,light brown SILT with minor fine to coarse gravel,moist,low plasticity-medium plasticity.		0.3 – 0.8	
Dense,light brown,fine to coarse GRAVEL with minor/some cobbles and minor fine to coarse SAND,moist.		0.8 – 1.2	
End of Hole at 1.20m-Target Depth Reached.			

SCALA PENETROMETER (Blows / 100mm)

Depth (m)	Blows / 100mm
0.0 – 0.1	3
0.1 – 0.2	5
0.2 – 0.3	7
0.3 – 0.4	6
0.4 – 0.5	7
0.5 – 0.6	12
0.6 – 0.7	13
0.7 – 0.8	25 >>

HAND SHEAR VANE (Uncorrected)

WATER

Groundwater Not Encountered

PHOTO(S)

LINKED POINT-IDs

REMARKS

End of Hole at 1.20m-Target Depth Reached.No Groundwater Encountered.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- ☐ Hand Auger
- ☑ Test Pit

Appendix E

Ultimate Bearing Capacity Graph

DYNAMIC CONE PENETROMETER - RESULT SHEET AS1289.6.3.2

Client: Waghorn Builders Limited
Project: Geotechnical Investigation
Location: 131 Main Street, Oxford
Operator: JF
Date: 12/05/2022

Appendix F

Statement of Professional Opinion

Statement of Professional Opinion on the Suitability of Land for Subdivision

(Appendix I to the Infrastructure Design Standard)

Issued by: NZ Geotechnical Consultants Limited
(Geotechnical engineering firm or suitably qualified engineer)

To: Waghorn Builders Limited
(Owner/Developer)

To be supplied to: Waimakariri District Council
(Territorial authority)

In respect of: Proposed Subdivision
(Description of proposed infrastructure/land development)

At: 131 Main road, Oxford, Canterbury (Lot 1 DP 80871 BLK VIII OXFORD SD)
(Address)

I Martinus Haryono *(Geotechnical engineer)* on behalf of NZ Geotechnical Consultants Limited *(Geotechnical engineering firm)*

hereby confirm:

1. I am a suitably qualified and experienced geotechnical engineer and was retained by the owner/developer as the geotechnical engineer on the above proposed development.

2. My/the geotechnical assessment report, dated 18/04/2023 has been carried out in accordance with the Department of Building and Housing *Guidelines for geotechnical investigation and assessment of subdivisions* and includes:
   - (i) Details of and the results of my/the site investigations.
   - (ii) A liquefaction assessment.
   - (iii) An assessment of rockfall and slippage, including hazards resulting from seismic activity.
   - (iv) An assessment of the slope stability and ground bearing capacity confirming the location and appropriateness of building sites.
   - (v) Recommendations proposing measures to avoid, remedy or mitigate any potential hazards on the land subject to the application, in accordance with the provisions of Section 106 of the Resource Management Act 1991.

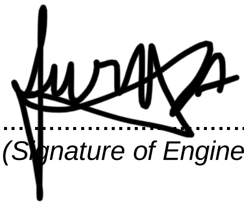
3. In my professional opinion, I consider that Council is justified in granting consent incorporating the following conditions:

   No further conditions to those outlined in the Geotechnical Report (NZGCL Geotechnical Investigation Report, Dated: 22/06/2022)

4. This professional opinion is furnished to the territorial authority and the owner/developer for their purposes alone, on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.

5. This certificate shall be read in conjunction with my/the geotechnical report referred to in Clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

6. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity insurance of no less than $ 1 Million
(Minimum amount of insurance shall be commensurate with the current amounts recommended by IPENZ, ACENZ, TNZ, INGENIUM.)



.... Date: 18/04/2023

(Signature of Engineer)

Qualifications and experience:

CMEngNZ, IntPE(NZ)/APEC Engineer, CPEng, Senior Geotechnical Engineer