Guidelines for using regional-scale earthquake fault information in Canterbury

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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.

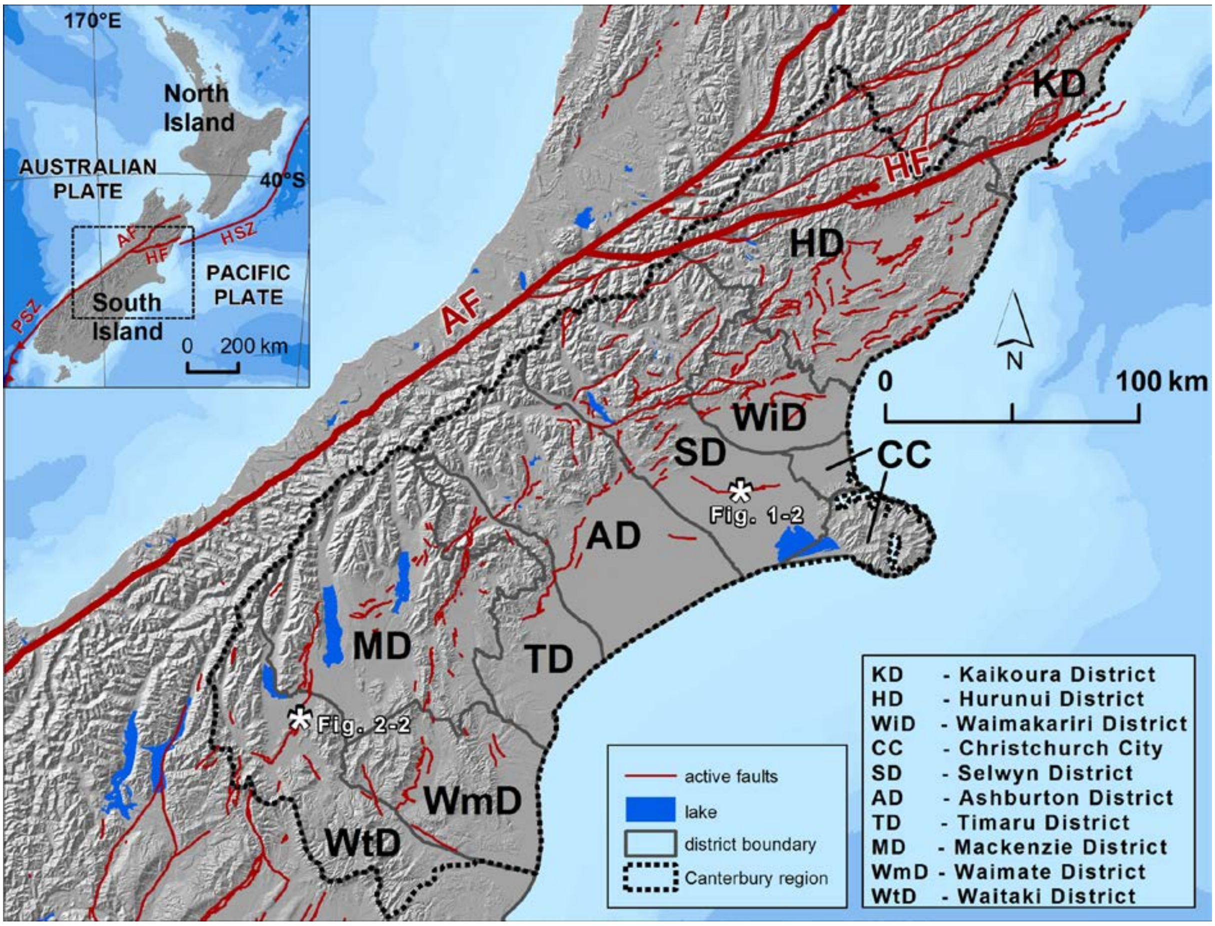

Figure 1.1 Location map of the Canterbury region and its territorial authority districts, along with active faults. Those within the Canterbury region are from the Environment Canterbury 1:250,000-scale district fault datasets, with the display showing active faults and monocline folds with 'certainty' 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.

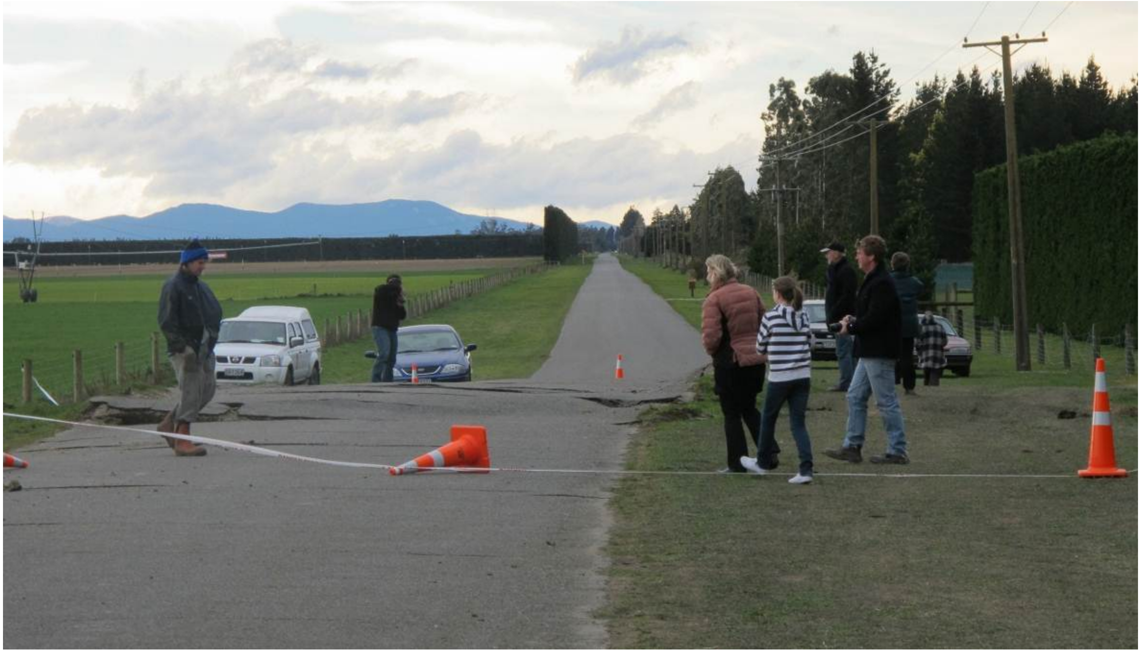

Figure 1.2 Surface fault rupture on the Greendale Fault at Highfield Road in Selwyn District (see Figure 1.1 for location) during the 4 September, 2010, Darfield (Canterbury) Earthquake. Before the earthquake, the road was straight and the ground was flat. At this location, surface fault rupture formed 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.

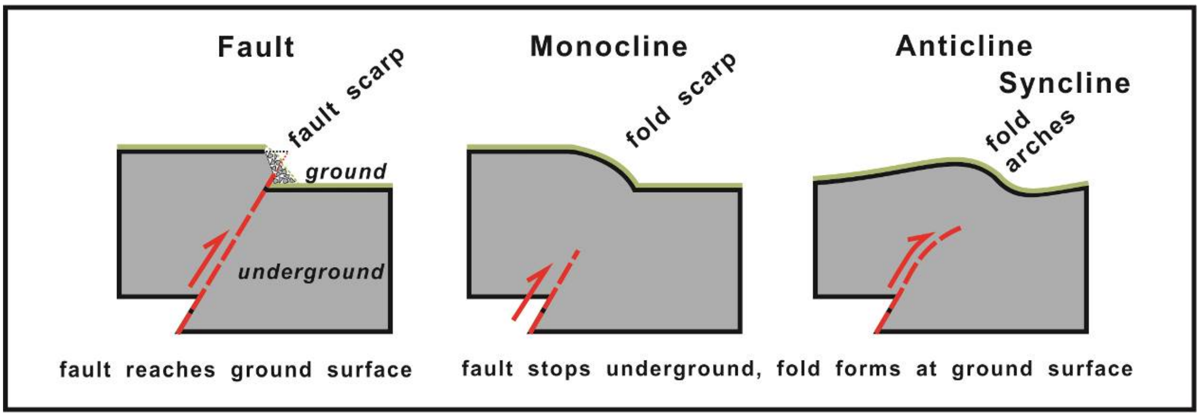

Figure 2.1 Cross-sections (diagrams looking from the side) illustrating the general character of active faults and folds. The diagrams show general concepts rather than actual details, and are not drawn to an exact scale.

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.

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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. <u>Assist territorial authorities to delineate fault avoidance zones along known active fault traces</u>.
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. <u>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</u>.
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. <u>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</u>.

Territorial authorities should:

8. <u>Supply information to the Regional Council captured at time of subdivision in relation to active earthquake fault trace</u>, 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.

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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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