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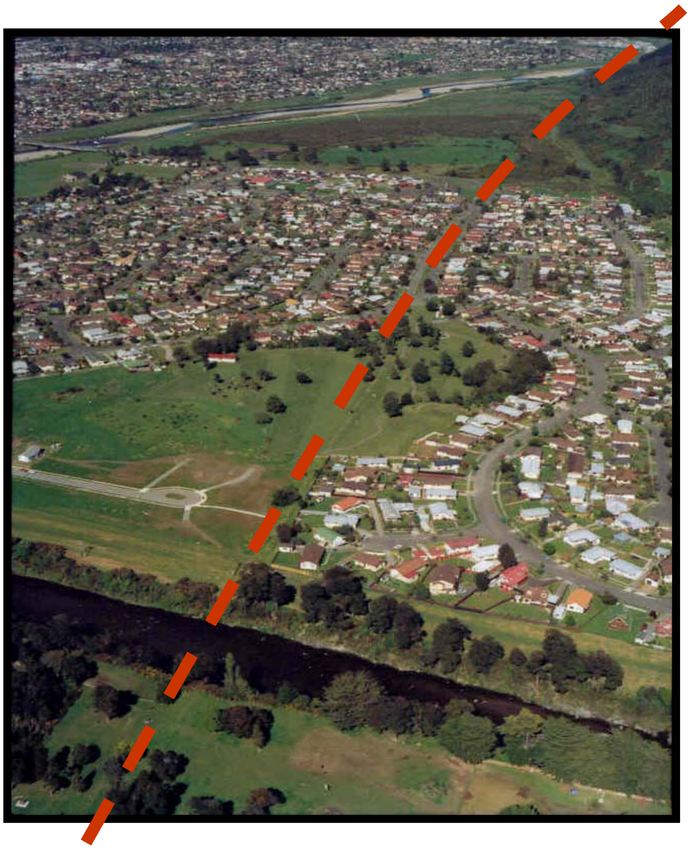
Planning for Development of Land on or Close to Active Faults



A guideline to assist resource management planners in New Zealand

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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.

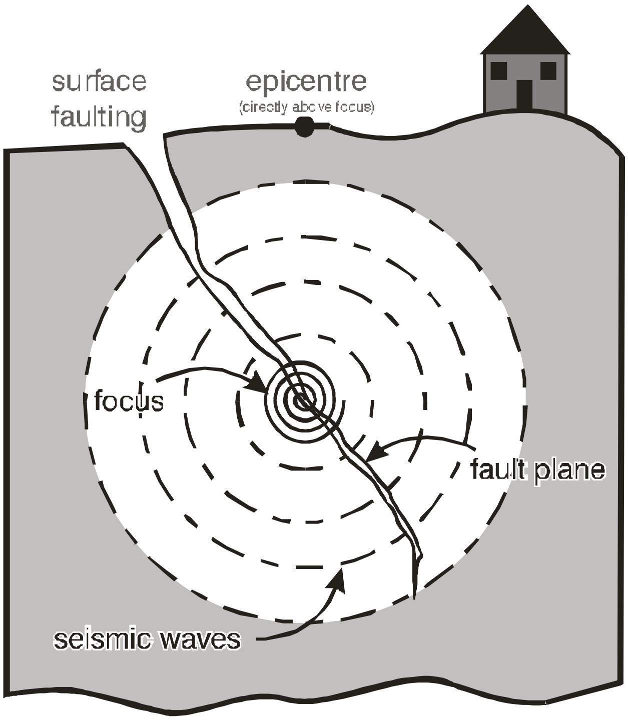
Non-regulatory approaches, such as hazard education programmes and incentives to retire at-risk land, would also ensure that landowners and building occupiers are made aware of the hazard, and the probability of future fault rupture.

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.

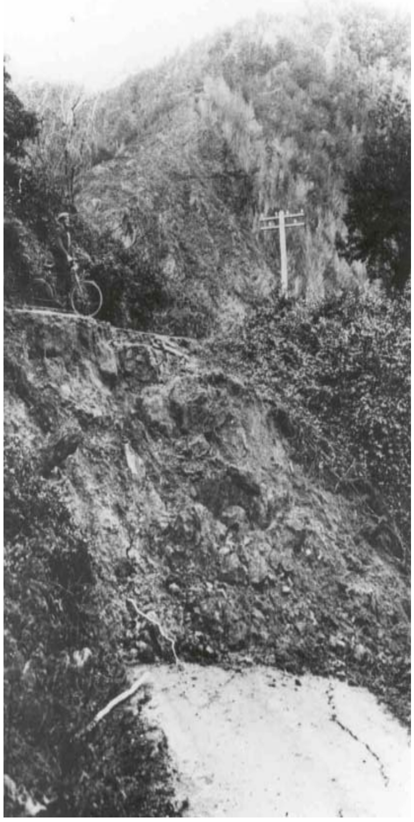
All buildings close to the epicentre of a large shallow earthquake will be strongly shaken, and this shaking causes most of the earthquake damage. Any building sited across a fault scarp is likely to suffer more damage, especially if the foundations are offset. It is unlikely that any building sited 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.*



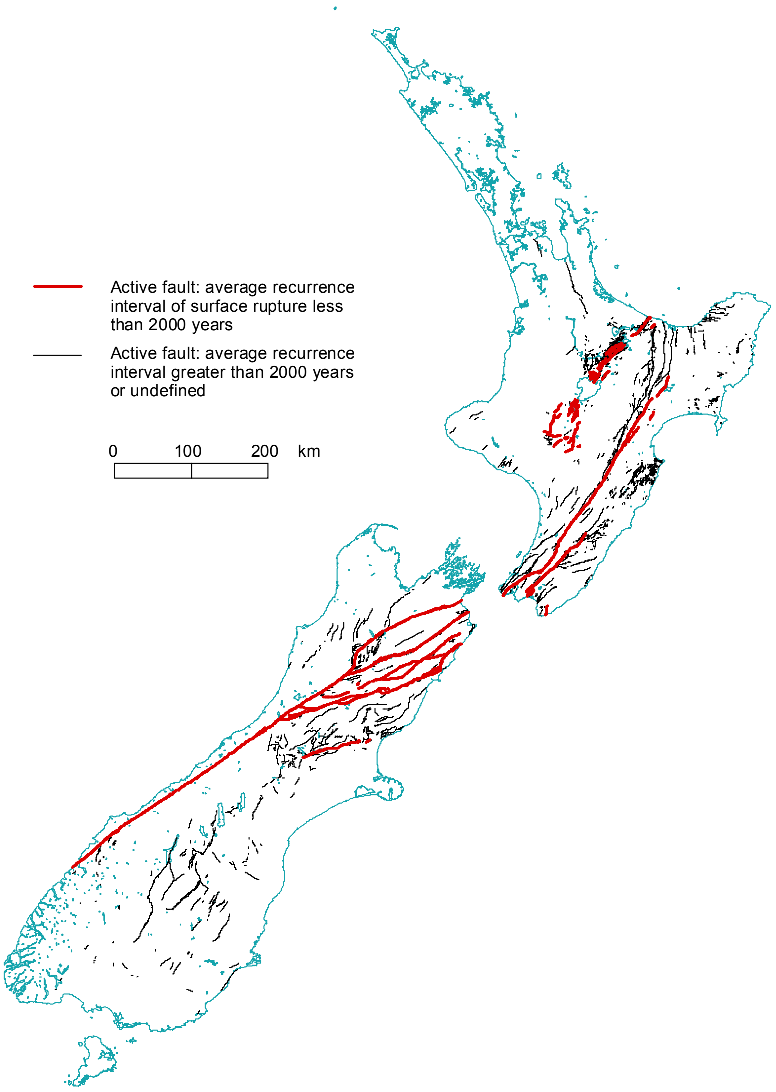
c) *Hope Fault – The 1888 earthquake on the Hope fault resulted in about 3 m of right lateral displacement of the ground surface at the fault. The offset fence-line shows the amount of displacement across the fault (Cowan 1991).*

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.

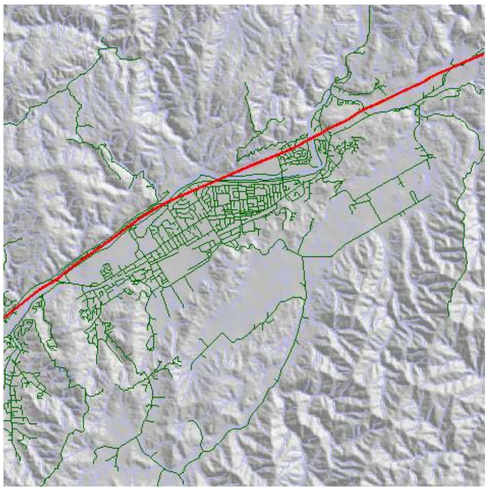
Figure 5.1: Example of fault mapping

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.

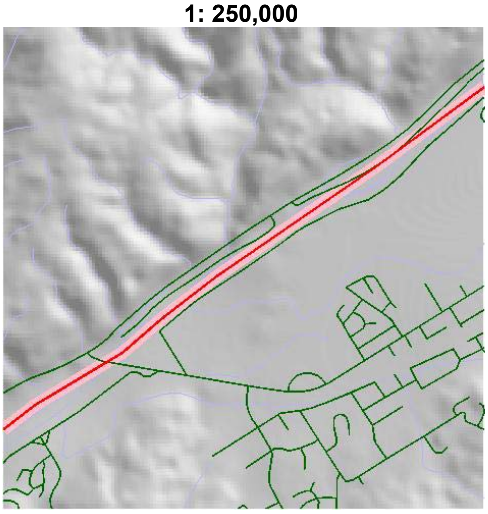
Figure 5.2: Interpreting fault maps



1: 250,000

1: 250,000 publication scale

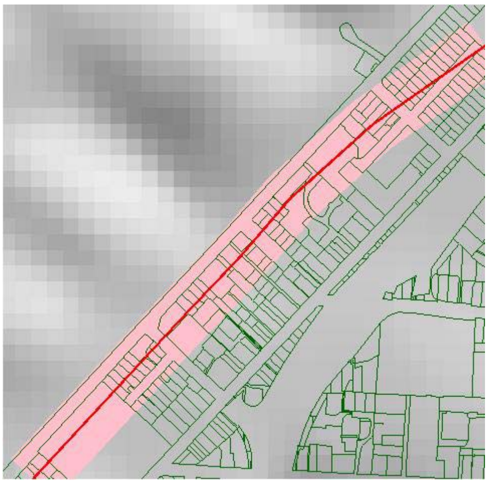
Geological maps in New Zealand are often published at the 1:250,000 scale. The fault data is simplified for map clarity.



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

1: 10,000 scale

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.

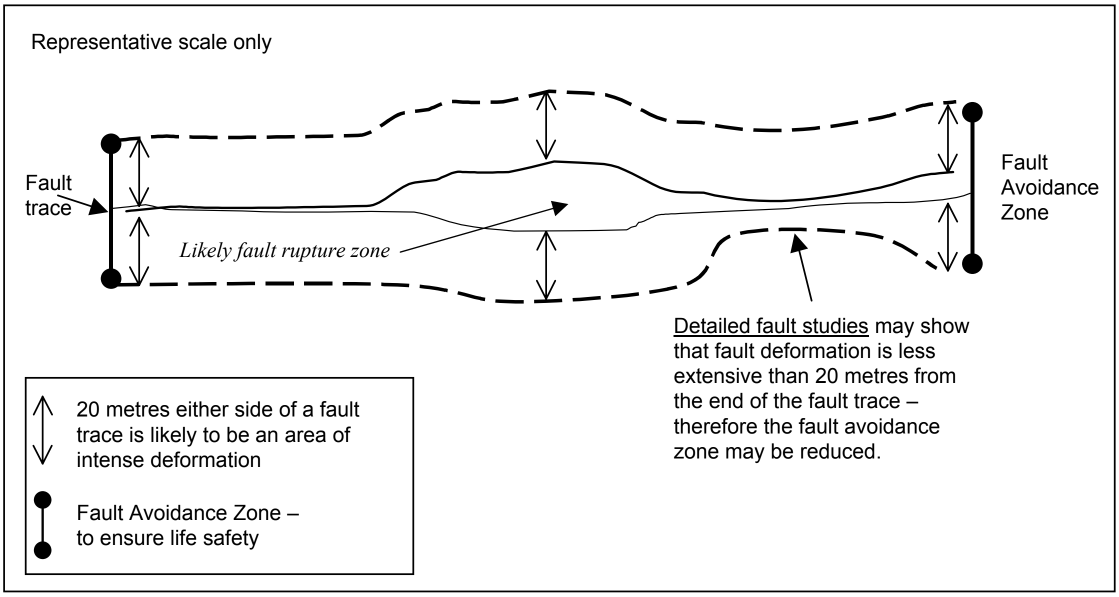
6 Fault Avoidance Zones

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.*

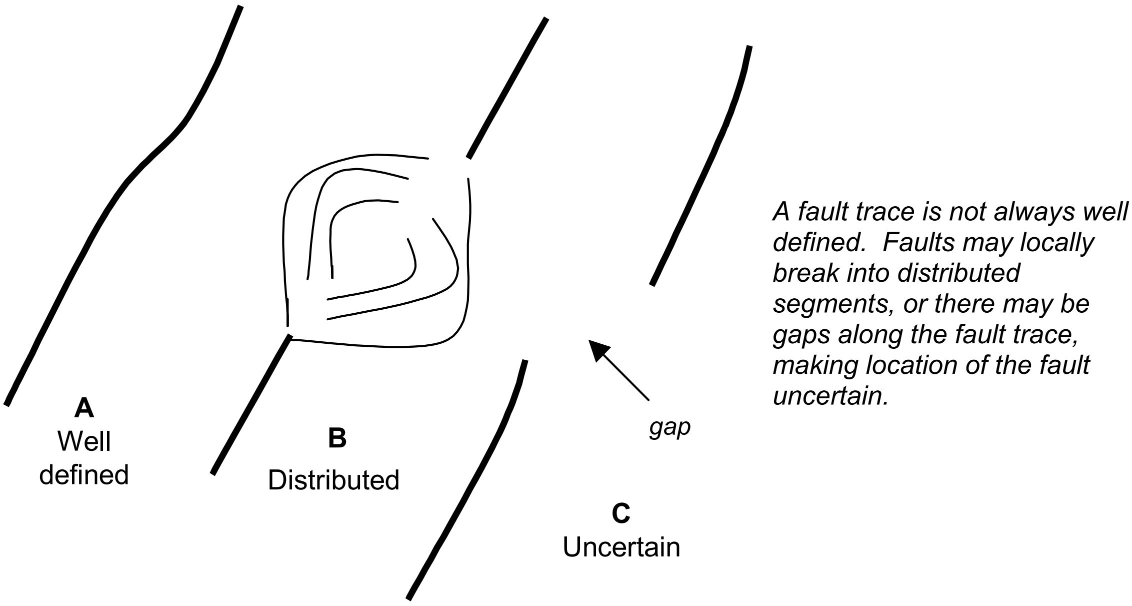
Photos by D.L. Homer, CN 3418/a, 576/b and 6435/23 respectively.

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

<table>
<tr><th rowspan="2">Recurrence interval class</th><th rowspan="2">Fault recurrence interval</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</td><td rowspan="2">BIC 1</td></tr>
<tr><td>II</td><td>>2000 years to ≤3500 years</td><td>BIC 1 and 2a</td></tr>
<tr><td>III</td><td>>3500 years to ≤5000 years</td><td>BIC 1, 2a and 2b</td><td>BIC 1 and 2a</td></tr>
<tr><td>IV</td><td>>5000 years to ≤10,000 years</td><td rowspan="2">BIC 1, 2a, 2b and 3</td><td>BIC 1, 2a, and 2b</td></tr>
<tr><td>V</td><td>>10,000 years to ≤20,000 years</td><td>BIC 1, 2a, 2b and 3</td></tr>
<tr><td>VI</td><td>>20,000 years to ≤125,000 years</td><td colspan="2">BI Category 1, 2a, 2b, 3 and 4</td></tr>
</table>

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.

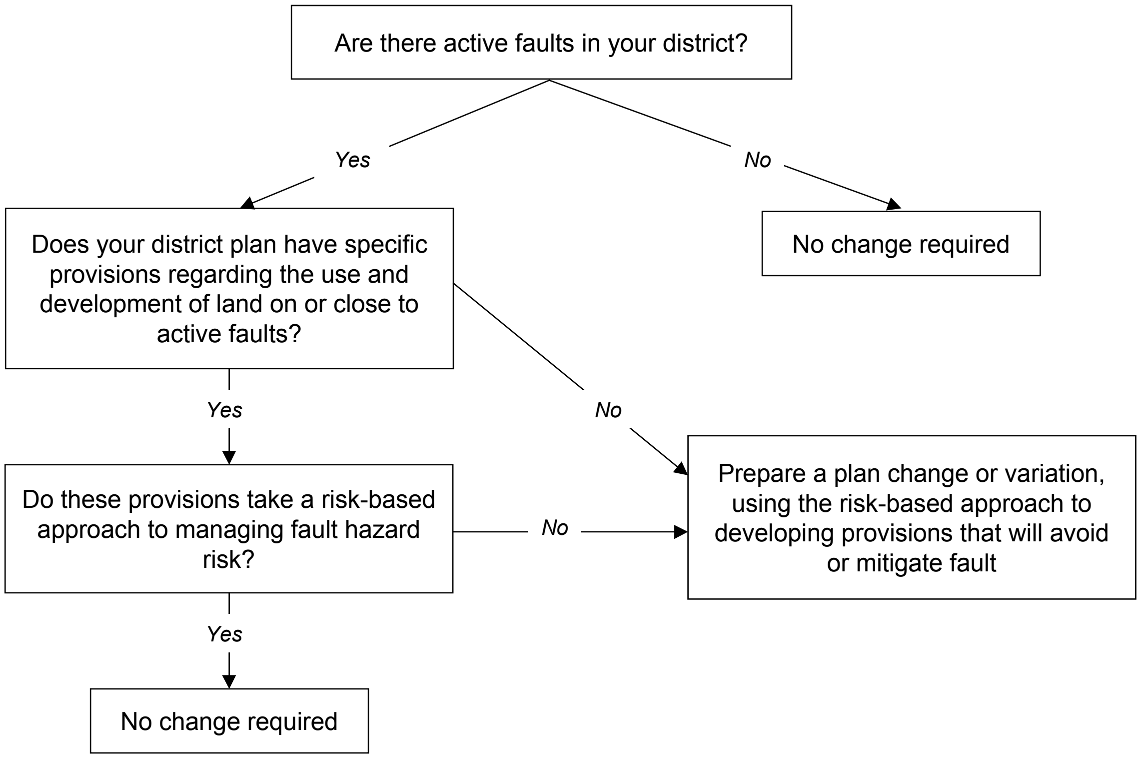
Regional and district plan reviews are a good time to consider new information and data relating to active faults. A programme of consultation should accompany any changes to hazard information gained by the council.

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

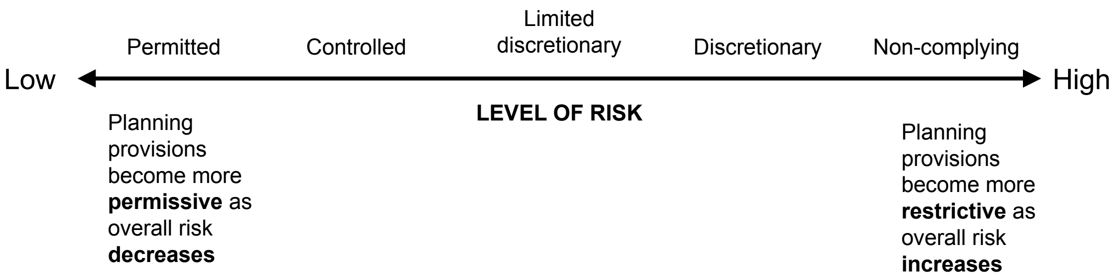
11.1 Determining consent categories

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).

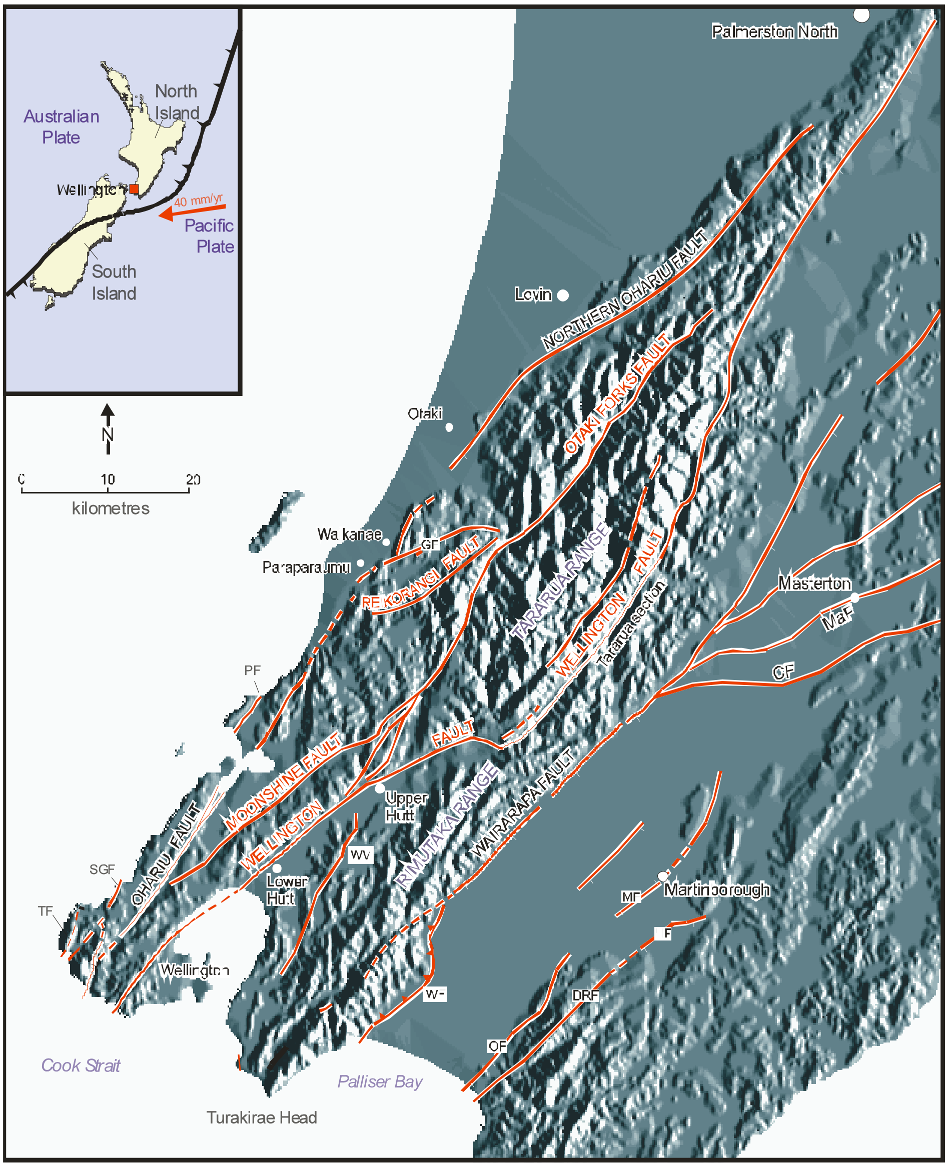


Figure 1: Schematic Representation of Major Faults in the Wellington Region. Adapted from: Begg. J.G and Van Dissen. R.J. (2000).

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 *recommended 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

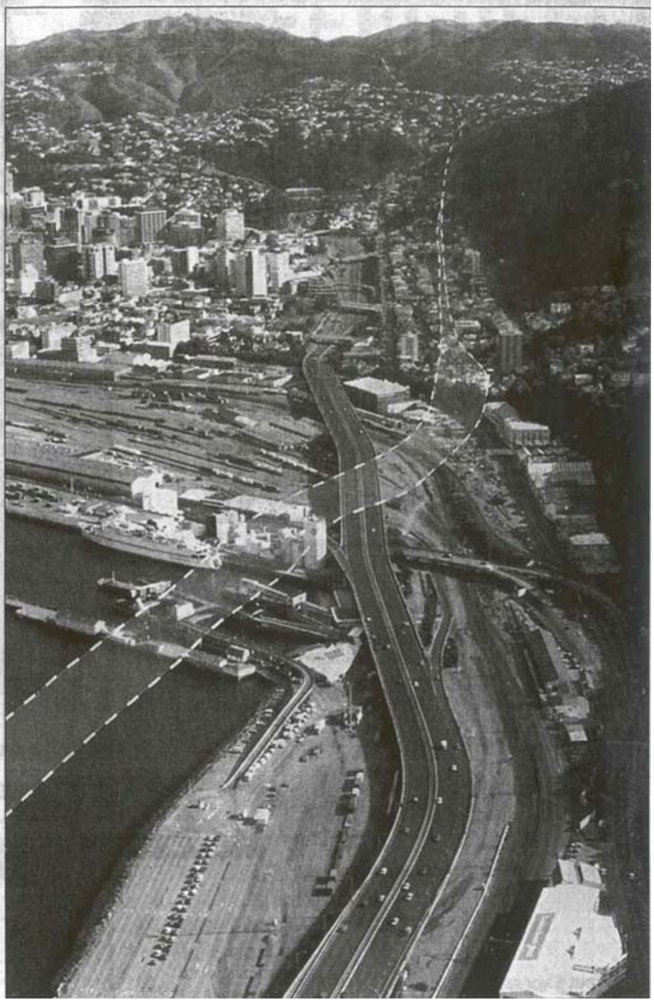


Figure 2 Newspaper article showing the line of the newly mapped Wellington Fault (looking south). The photo does not show the Fault Rupture Hazard Zone with the buffer. The article reflects effective communication between the WCC and the Dominion Post which has reported positively and discussed key issues 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):

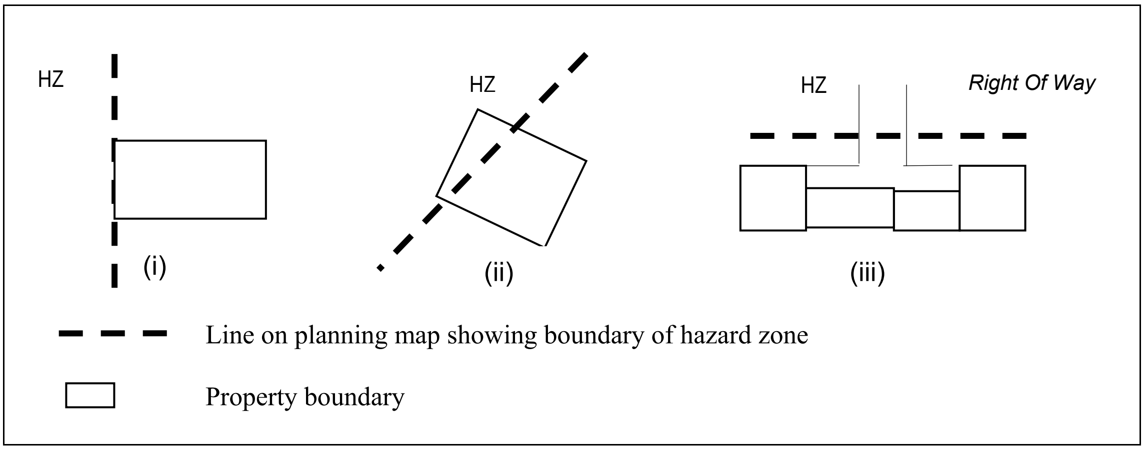


Figure 3 Interpreting fault rupture hazard zone lines

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. ≤ 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.

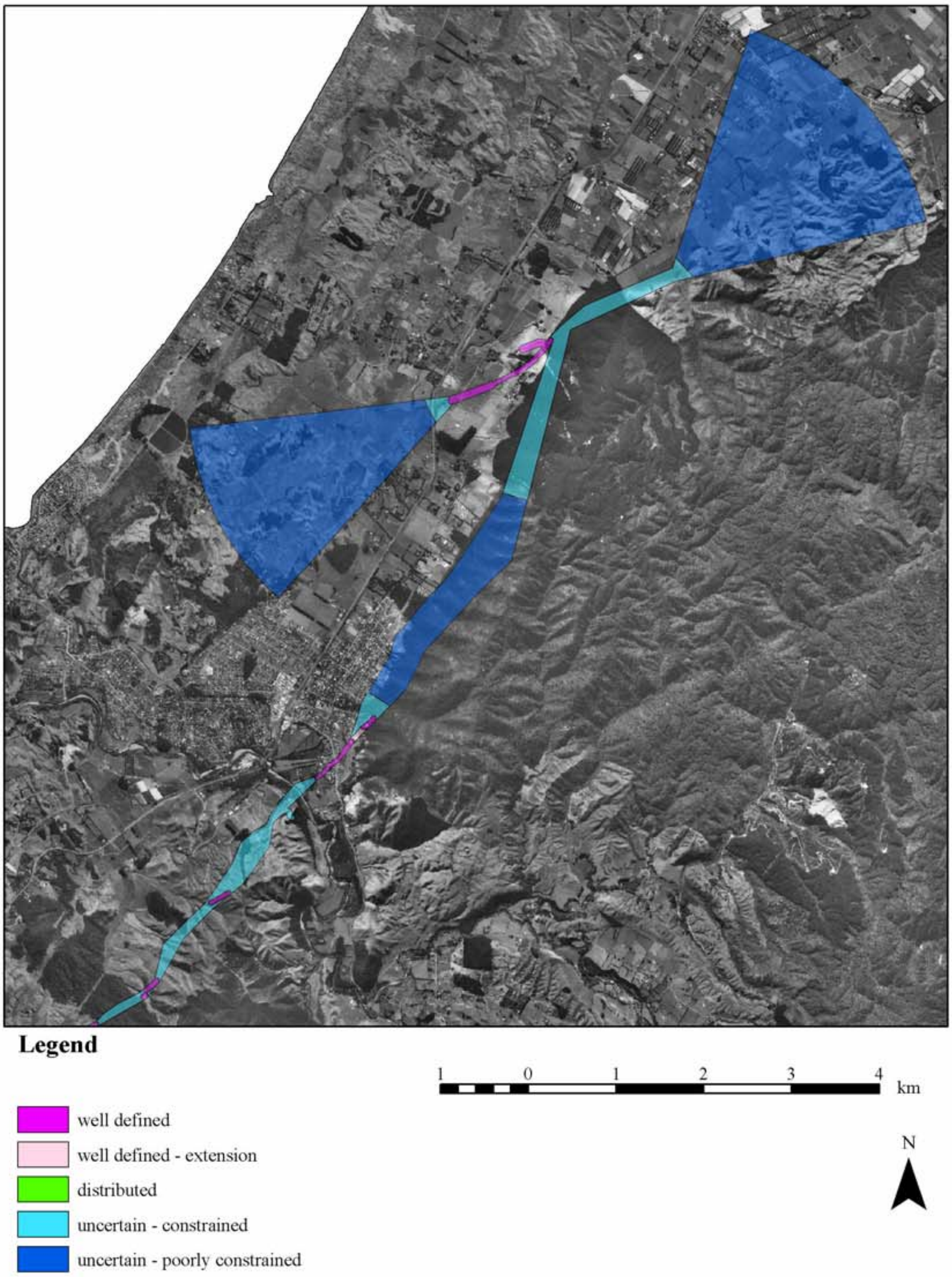


Figure 4. The Ohariu fault (northern end) showing Fault Avoidance Zones.

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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14 Further Reading

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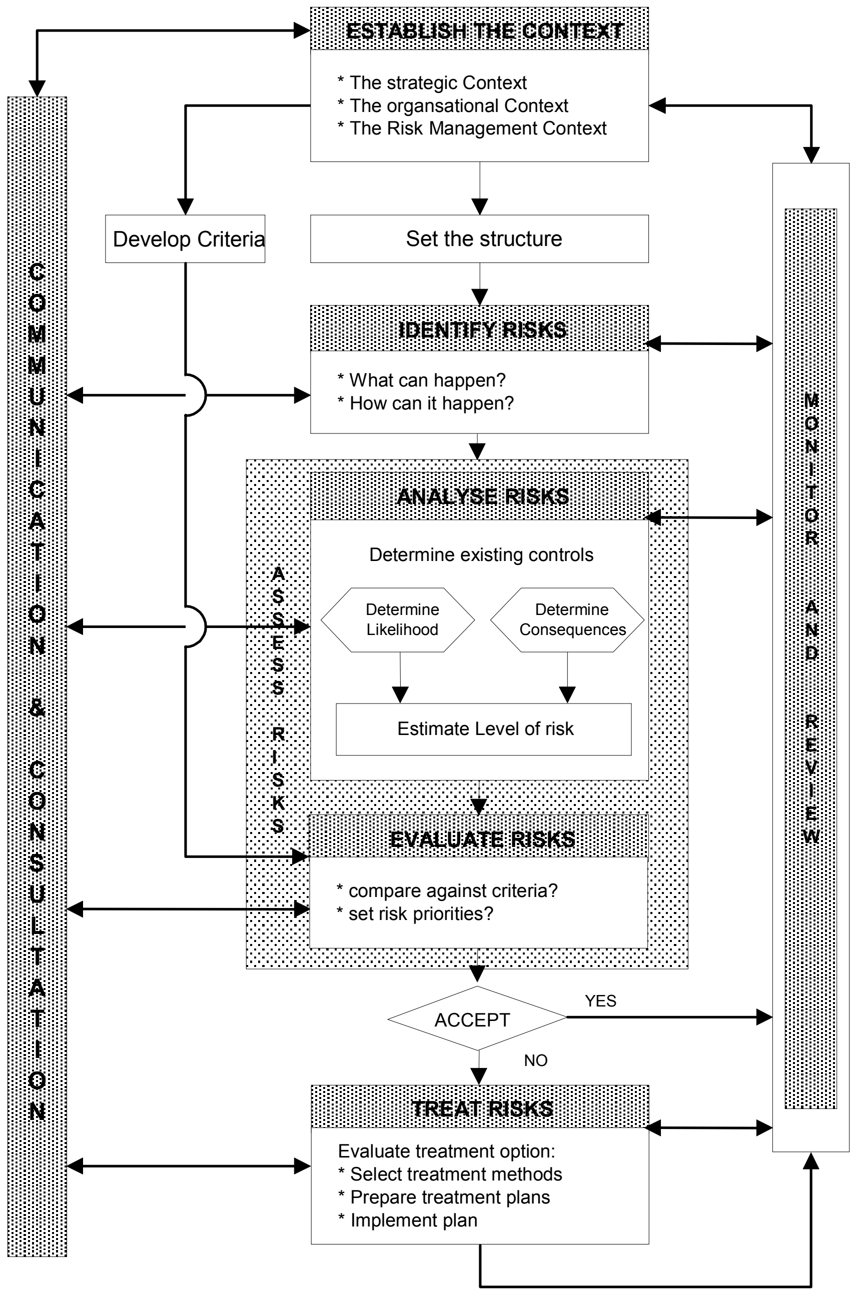
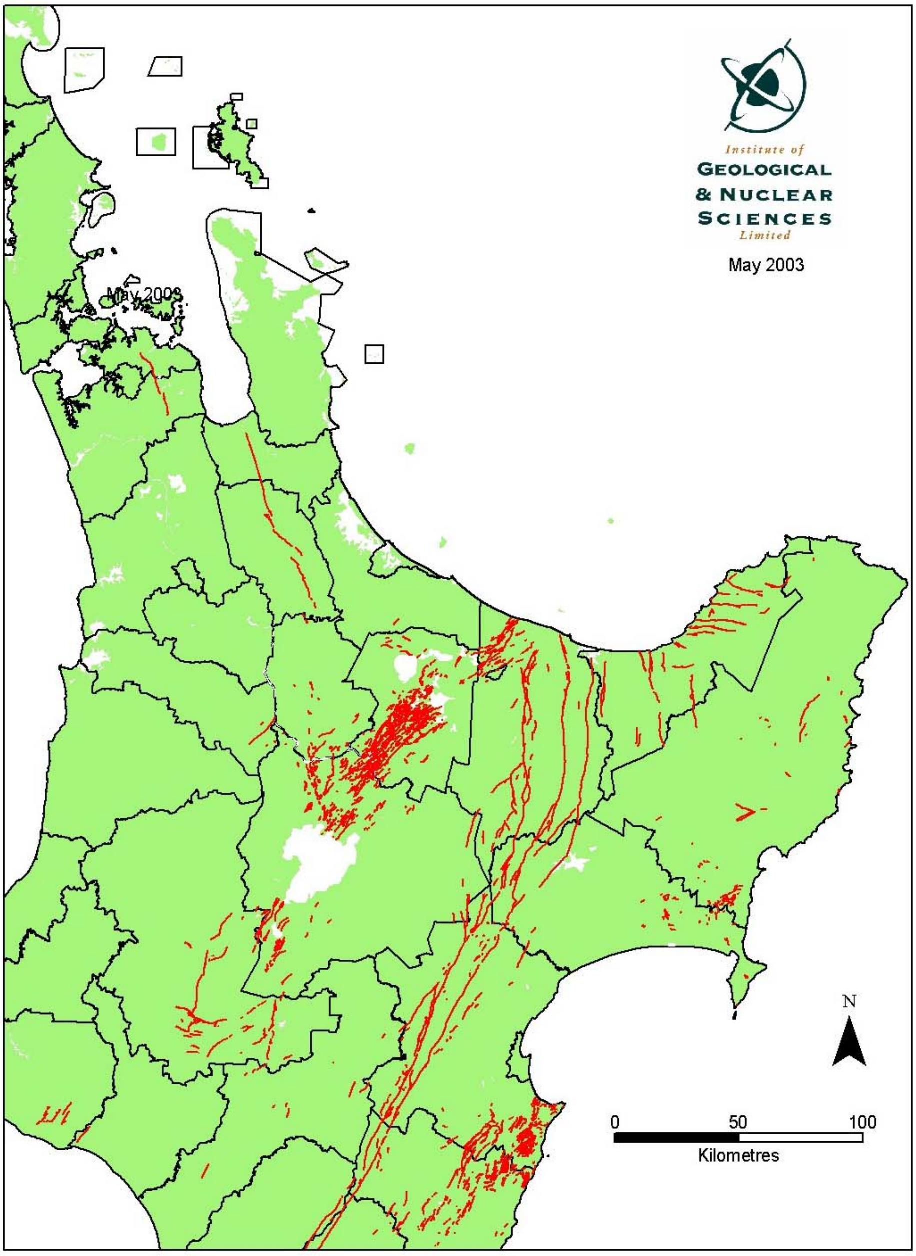
Appendix 1: AS/NZ 4360:1999

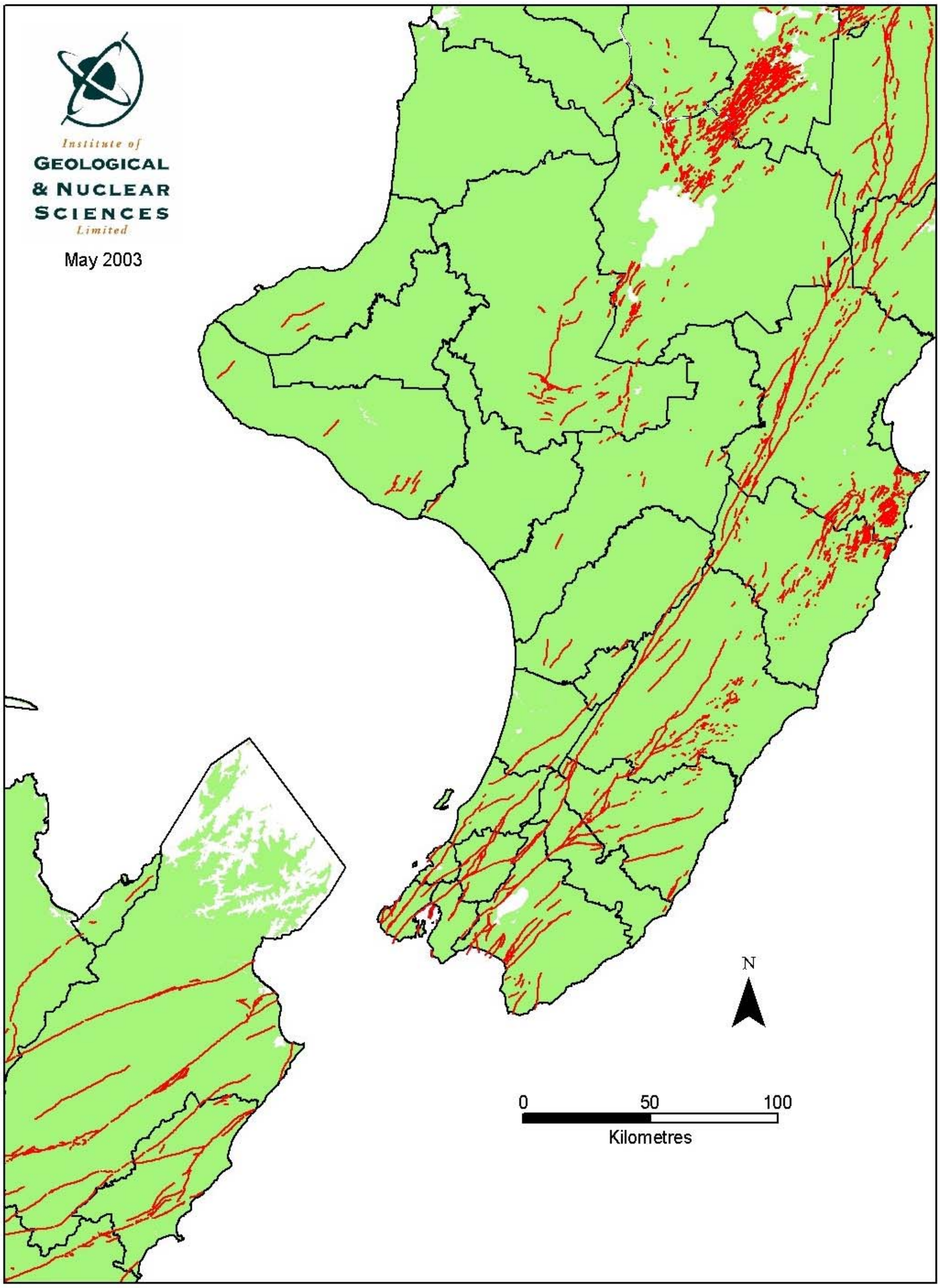
Figure A1.1: Stylised risk management process (after AS/NZS 4360:1999)



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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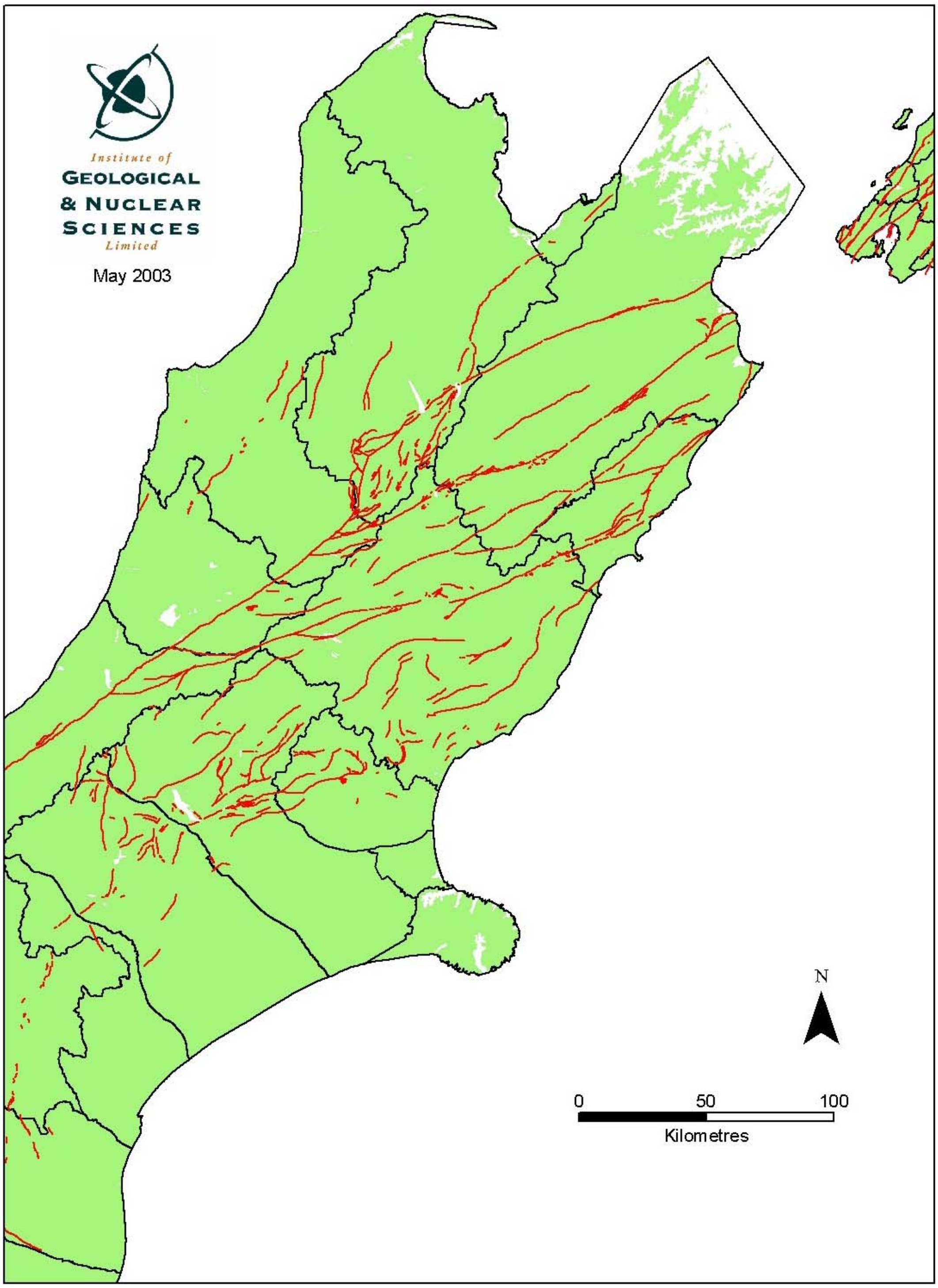
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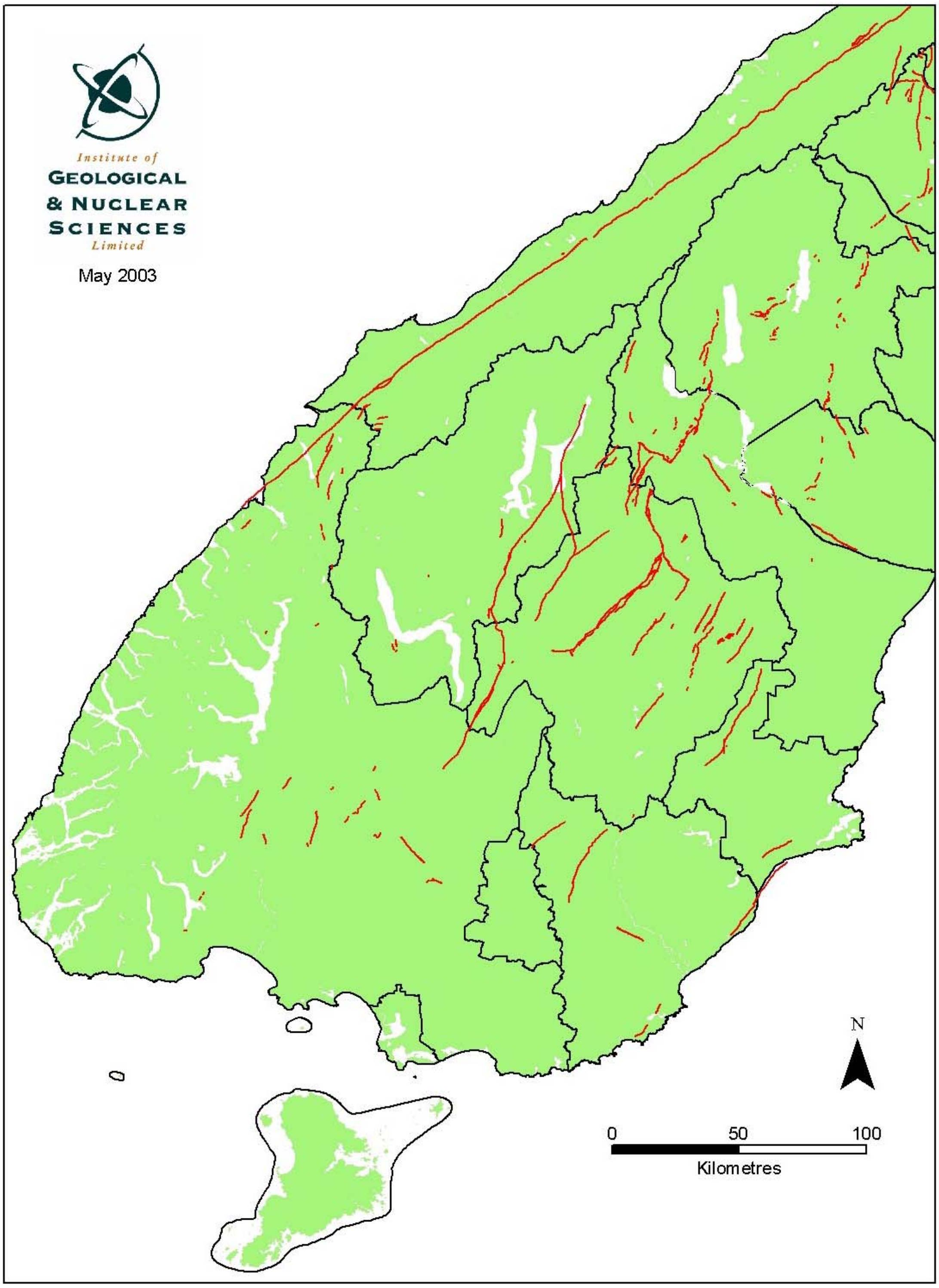

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Appendix 3: Classification of Faults

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	I, 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.