Risk-based land use planning for natural hazard risk reduction

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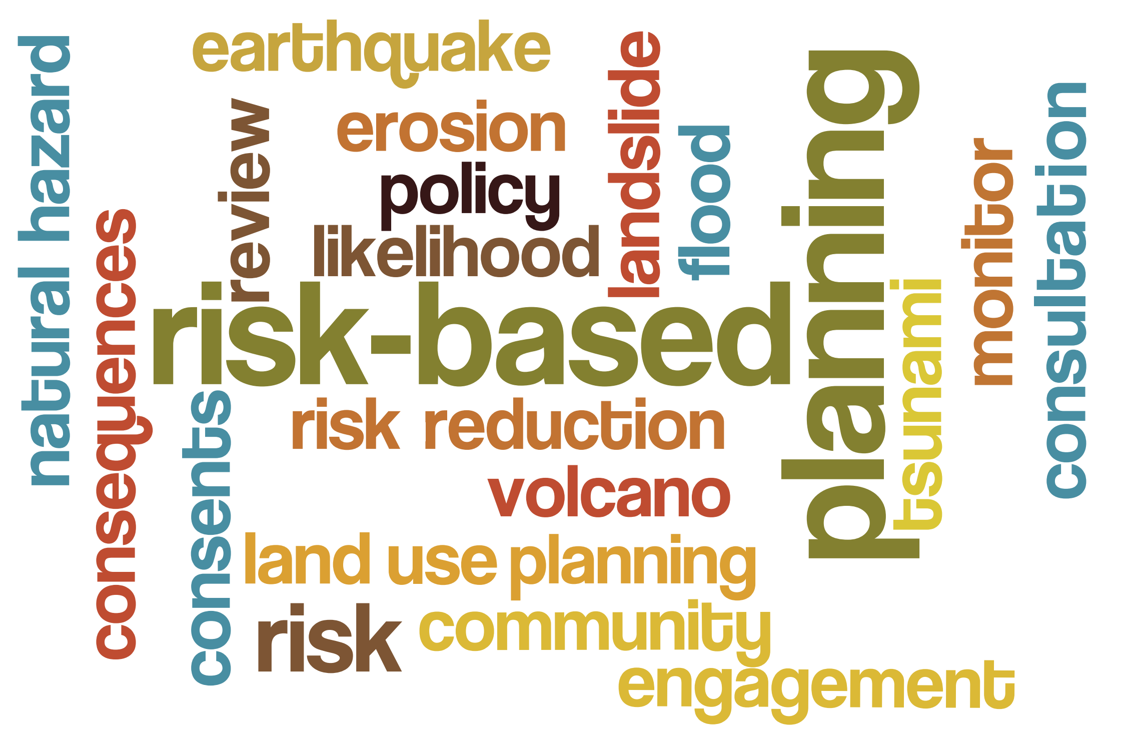

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We welcome any feedback that you have regarding this document. Please contact Wendy Saunders in first instance with any feedback that you may have via w.saunders@gns.cri.nz.

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EXECUTIVE SUMMARY

Planners have a responsibility to ensure that the safety and security of present and future communities are not compromised by urban growth and development. As such, land use planning is often described as an opportune tool for reducing or even eliminating risks related to natural hazards.

Many land use planning objectives, policies, rules, and decisions are based around a likelihood assessment of a natural hazard, such as the 1/100 year event. Alternatively, they may be based around what is termed the 'acceptable level of risk', which is not defined. As likelihood alone does not give the full picture of the impact or consequences of a natural hazard event, and acceptable risk has no standard definition, many developments are being approved which have substantially increased the risks (or potential risks) to people and property. To assist planners to define levels of risk, and to include natural hazard risk in land use planning, a five-step risk-based approach has been developed with an associated engagement strategy.

This report outlines the content of an online toolkit on risk-based planning (available at http://www.gns.cri.nz/Home/RBP/Risk-based-planning), as at September 2013. As such, the web page is the most up to date version of content. The toolkit will be relevant to decision makers, planners, and others with an interest in risk-based planning. This toolbox aims to support risk-based land use policy and plan development in local government. It offers a new approach where consequences of natural hazard events are the focus. It presents techniques, practice steps and options for enabling local government to review multiple natural hazard risks within councils, with external stakeholders, and with the wider community.

Similar to the toolbox, this report has three key sections:

- Setting the scene for why this approach is important;
- The five-step risk-based approach for natural hazards; and
- Examples of implementation.

A summary of the approach is provided in the following table (Table ES1). This toolbox is offered as a resource and guide, and is not intended as a prescription or an off-the-shelf solution to successful management of natural hazards.

Feedback is welcomed on the approach, report and website, and can be emailed to w.saunders@gns.cri.nz.

KEYWORDS

Risk-based planning, natural hazards, risk engagement, risk communication, consequences, land use planning

Table ES1 Summary of risk-based approach.

Step 1 - Know your hazard	Risk analysis tasks	Risk communication tasks
The purpose of this step is firstly to determine the scope of the issue to be addressed, to identify the team of professionals and experts whose input will be needed, and to cover the important base elements of a public engagement strategy. The second stage of this step is to assemble hazard information for analysis and review, and to prepare materials for engagement with affected parties and/or discussion by expert panels or representative groups.	Scoping – 1. **Establish problem/decision parameters** (e.g., what is the information (e.g., plan change, growth strategy?) How will the information inform policy? What scale is the information required at? What is the time frame for the decision? What are the risk outcomes sought (e.g., risk reduction, not increasing existing levels of risk)? 2. **Identify team and resource needs** (e.g., what expert information is required and who is available to provide it? Who is able to provide useful local context information, e.g., CDEM.	1. **Prepare an** engagement approach including stakeholder analysis, context analysis, assessment of existing perceptions. 2. **Begin** internal communication within local government agency including public representatives, and other departments. 3. **Begin** external communication (e.g., early notification of upcoming decisions).
	Preliminary assessment and information preparation 3. **Identify hazard information gaps and uncertainty**, gather further information where existing information is lacking or does not meet requirements. 4. **Gather background information** for consequences analysis (e.g., inundation maps, fragility curves, regional GDP figures, land use plans). 5. **Agree on an information management system** to store, retrieve, and access hazard information.	4. **Identify hazard information gaps and uncertainties** Identify useful information for sharing with stakeholders; clarify areas of uncertainty, note gaps and likely areas of contention. Also consider hazard complexity. 5. **Update engagement approach** – following a hazard information review (new stakeholders may become apparent)
Step 2 - Determine severity of consequences	**Risk analysis tasks**	**Risk communication tasks**
The purpose of this stage is to build a picture of the possible consequences of a natural hazard event. Natural hazard information, coupled with information about the proposed development and existing land use is used to undertake an assessment of consequences. Information about the natural hazard consequences and the development is confirmed through engagement with specialists, those with local knowledge, and stakeholders.	1. **Determine** consequences for a) individual and b) cascading hazards and assess against a consequence table. 2. **Determine** severity of consequences for the hazard event with the highest severity of impact to set the consequence level.	1. **Validate hazard information:** Use the engagement approach identified earlier to share, review and update information about natural hazards and potential consequences. 2. **Update stakeholder analysis** (following consequences analysis new stakeholders may become apparent). 3. **Assess engagement approach** – is it still right for the situation? 4. **Record decisions and assumptions** for transparency.
Step 3 - Evaluate likelihood of an event	**Risk analysis tasks**	**Risk communication tasks**
The purpose of this stage is to assess the likelihood of any event that will result in the consequences outlined in Step 2.	1. **Assess the likelihood** of individual and cumulative hazard events (cascading hazards are addressed against the trigger hazard). 2. Cumulative hazards may result in an increase in **likelihood**, e.g., three cumulative hazards which are 'possible' may increase overall likelihood to 'likely'. 3. In some instances the **likelihood** will be required for modelling and assessing the hazard (Step 1).	1. **Record decisions and assumptions** about likelihood and occurrence for transparency and use in communication at Step 4.
Step 4. Take a risk-based approach	**Risk analysis tasks**	**Risk communication tasks**
This is the stage where stakeholder acceptance of the calculated levels of risk and associated consent categories (and the implications of these) are assessed. It is also when ideas about risk mitigation may emerge – particularly in relation to areas of greatest contention. Discussions with stakeholders and affected parties will include whether the risk categories and/or consent levels are appropriate, and what trade-offs might be made between extra margins of safety, possible benefits, and costs of mitigation.	1. **Determine** levels of risk for policy. 2. **Determine** resource consent activity status based on levels of risk. 3. **Assess** against assessment criteria and anticipated environmental outcomes. 4. **Identify** and consider risk mitigation options.	1. **Validate levels of risk for policy and consent categories with stakeholders** - i.e., confirm and check for perverse outcomes. 2. **Engage stakeholders in identifying and reviewing risk mitigation options**. 3. **Update stakeholder analysis and engagement approach** (after mitigation options new stakeholders may appear). Hold forums/meetings/public events in accordance with engagement strategy, e.g., with representative groups, expert panels or communities. (See 'key points for public forums on local hazards and their impacts').
Step 5 Monitor and evaluate	**Risk analysis tasks**	**Risk communication tasks**
While evaluation and monitoring have taken place throughout at this final stage, the outcomes of the process and the process itself are assessed to determine any further necessary actions.	1. **Evaluate risk-reduction effectiveness**, i.e., risks are not increased. 2. **Plan to change or revisit strategy** if required to ensure risk outcomes are being achieved.	1. **Evaluate** acceptance of mitigation options. 2. **Evaluate** acceptance of residual risks. 3. **Evaluate** communication and engagement strategy. 4. **Communicate** risk outcomes with stakeholders and community and review policy if required.

1.0 INTRODUCTION

Planners have a responsibility to ensure that the safety and security of present and future communities are not compromised by urban growth and development. As such, land use planning is often described as an opportune tool for reducing, or even eliminating, risks related to natural hazards.

Many land use planning policies and decisions are based around ‘a number’, such as the 1/100 year event, and/or an undefined level of risk, such as an ‘acceptable level of risk’. This has led to many developments being approved which have unsustainably increased the risks (or potential risks) to people and property. To assist planners in defining levels of risk and in promoting a risk-based approach to land use planning for natural hazards, a five-step risk-based approach to natural hazards has been developed with an associated engagement strategy.

The purpose of this report is to provide an overview of the web-based toolkit available on the GNS Science website at http://www.gns.cri.nz/Home/RBP/Risk-based-planning, as at September 2013. The website will be updated as required, as is therefore the most up to date. The goal of the project was to take the risk-based approach to land use planning for natural hazards (outlined in Saunders, 2012a), and further develop it so it could be practically implemented by land use planners.

The project has been funded and supported by the following agencies:

- GNS Science, a Crown Research Institute (CRI) and New Zealand’s leading supplier of natural hazards research (www.gns.cri.nz/);
- The Natural Hazards Research Platform – a multi-party research platform funded by the Ministry of Business, Innovation and Employment (MBIE), which is dedicated to increasing New Zealand's resilience to Natural Hazards via high quality collaborative research (www.naturalhazards.org.nz/); and
- Envirolink (www.envirolink.govt.nz/), which funds (via MBIE) research organisations (including CRI’s) to provide regional councils with advice and support for research on identified environmental topics and projects. This project was championed by Hawke’s Bay Regional Council.

As part of the project a Steering Group was formed, made up of representatives from the following organisations:

- Ministry of Civil Defence Emergency Management;
- Ministry for the Environment;
- Local Government New Zealand;
- Earthquake Commission (EQC);
- Massey University;
- Bay of Plenty Regional Council;
- Hawke’s Bay Regional Council;
- Thames-Coromandel District Council;
- Auckland Council; and
- Brendan Morris Consulting Ltd.

This steering group provided feedback on the risk-based and risk communication tools. This feedback was used to shape the final design of the toolkit and to ensure that the approach could be used by councils throughout New Zealand.

This report is structured in the following way:

Section 2 provides the legislative context for managing natural hazards, with particular regard to the Resource Management Act 1991 (RMA), Civil Defence Emergency Management Act 2002 (CDEMA), Building Act 2004, and the Local Government Act 2002 (LGA). Section 2 also provides an overview of the principles of risk communication. This sets the scene for risk-based planning, and provides justification for why risk communication and engagement is important in achieving good outcomes.

Section 3 presents the five-step risk-based approach and associated communication and engagement tasks. This is followed by the limitations and uncertainties associated with the approach in Section 4. Examples of the approach and engagement strategies – both national and international –are provided in Section 5.

Appendix 1 provides the methodology followed for the project, followed by additional information (i.e. examples, checklist).

Additional information and discussion on timeframes, mapping natural hazards, risks and uncertainties are provided in Section 6. Mapping is an important aspect of land use planning, as many hazards are mapped within district and regional plans. The methodologies employed to develop the risk-based approach and associated risk communication guidance is provided in Appendix 1.

2.0 SETTING THE SCENE

This section sets the scene in relation to planning for natural hazards, identifying general principles for engaging with communities, and how the risk-based approach is consistent with the international risk management process.

2.1 LEGISLATIVE FRAMEWORK FOR NATURAL HAZARDS[1]

The following discussion is an updated version of that provided in Saunders and Beban (2012). It includes an overview of the current legislative framework; definitions of natural hazards within legislation; roles and responsibilities; the New Zealand Coastal Policy Statement; risk reduction and the CDEMA; and reconciling avoidance, mitigation, and risk reduction under the RMA.

2.1.1 Current legislative framework

In New Zealand, no one agency is responsible for natural hazard management. Rather, a number of organisations, including the Ministry of Civil Defence & Emergency Management (MCDEM), regional councils, territorial authorities, civil defence emergency management groups and engineering lifeline groups hold these responsibilities (Ministry for the Environment, 2008). Co-operation between these agencies is essential to ensure a streamlined and holistic national approach to planning for natural hazards and disasters.

There are four key pieces of legislation that have a primary influence on natural hazard management in New Zealand: the RMA, Building Act 2004, CDEMA, and LGA. The four key statutes are intended to be integrated in their purposes, and promote sustainability, as shown in Table 2.1. Other statutes also contribute to natural hazard management, to a lesser degree. These include the Local Government Official Information and Meetings Act 1987 (LGOIMA), which allows hazard information to be available for all parcels of land through a Land Information Memorandum (LIM); Environment Act 1986; Conservation Act 1987; Soil Conservation and Rivers Control Act 1941; Land Drainage Act 1908; and the Forest and Rural Fires Act 1977 (see Tonkin & Taylor, 2006, for further information).

Apart from the LGA, the purposes of the statutes in Table 2.1 are consistent in that they have a focus on sustainable management or development, and refer to social, environmental, economic and cultural wellbeing, as well as to health and safety. However, while sustainable management is defined under the RMA, it is not defined in the CDEMA; sustainable development is also not defined in the Building Act or LGA. Also, balancing of the four well-beings is not required; rather, economic considerations can take priority over social, environmental and cultural well-beings. This priority reflects the political prerogative to encourage market solutions to the management of natural and physical resources (Ericksen, Berke, Crawford, & Dixon, 2003).

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1 The following discussion is provided based on the legislative environment at the time of publication (September 2013). The legislation is expected to change in regards to hazard management as part of reforms to the Resource Management Act. Therefore how natural hazards are addressed under this legislation will change with time.

Table 2.1 Purposes of key legislation for the management of natural hazards (emphasis added).

Statute	Purpose
Resource Management Act 1991 (Part 2, Section 5)	To promote the sustainable management of natural and physical resources. *Sustainable management* means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their *social*, *economic*, and *cultural wellbeing* and for their *health and safety*.
Building Act 2004 (Part 1, Section 3)	To provide for the regulation of building work, the establishment of a licensing regime for building practitioners, and the setting of performance standards for buildings, to ensure that: (a) *people who use buildings can do so safely and without endangering their health*; and (b) buildings have attributes that contribute appropriately to the *health*, physical independence, and *well-being* of the people who use them; and (c) people who use a building can escape from the building if it is on fire; and (d) buildings are designed, constructed, and able to be used in ways that promote *sustainable development*.
CDEM Act 2002 (Part 1, Section 3)	To improve and promote the *sustainable management* of hazards in a way that contributes to the *social*, *economic*, *cultural*, and *environmental well-being and safety* of the public and also to the protection of property
Local Government Act 2002 (Part 1, Section 3)	To provide for democratic and effective local government that recognises the diversity of New Zealand communities

Given this non-alignment between the various pieces of legislation with the definition of sustainable management, the following section outlines the definitions of natural hazards within these statutes.

2.1.2 Definitions of natural hazards

While the purposes of the four statutes are intended to be integrated and consistent, their definitions of natural hazards vary. While the LGA does not define natural hazards, they are defined under the RMA, Building Act and CDEMA, as shown in Table 2.2.

While the Building Act is limited to certain phenomena, the RMA and CDEMA have unlimited definitions, both of which are based on consequences (i.e., may adversely affect human life and property; may cause or contribute to an emergency). This allows for consequences (and associated vulnerabilities, susceptibilities etc.) to be assessed. The implication of this difference in approach to defining natural hazards is often not fully appreciated by land use planners, building officers, or emergency management officers, and can lead to inappropriate decisions being made. It is therefore important that the linkages between the statutes is understood and integrated between roles (planners, emergency management officers, building officers etc.). The following section outlines these linkages, roles and responsibilities.

Table 2.2 Legislative definitions of natural hazards.

Statute	Definition of natural hazard	Comment
Resource Management Act 1991	Any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire, or flooding), the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.	Under Section 106, a consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent with conditions, if it considers that the land, and any subsequent use of the land or any structure is or is likely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source. This section does not include consequences from active faults, tsunami, or geothermal activity, and is inconsistent with the definition of a natural hazard.
Building Act 2004	Erosion (including coastal erosion, bank erosion, and sheet erosion); falling debris (including soil, rock, snow, and ice); subsidence; inundation (including flooding, overland flow, storm surge, tidal effects, and ponding); and slippage.	Definition does not include active faults, liquefaction, lateral spreading, or tsunami.
CDEM Act 2002	Something that may cause, or contribute substantially to the cause of, an emergency.	Includes all natural and anthropogenic hazards.

2.1.3 Integrated roles and responsibilities

The practice of hazard management can be improved by understanding how the various roles and responsibilities of central government agencies, regional councils and territorial authorities, and non-statutory planning tools, can be integrated to provide a holistic approach. Figure 2.1 shows these relationships, and areas for improvement.

Figure 2.1 presents the five main statutes that govern natural hazards planning at different levels of government, namely the central (orange), regional (green) and district/city (blue) levels. The hierarchy of plans established under each statute provides various regulatory and non-regulatory tools for natural hazards planning. The solid arrows show established relationships in the hierarchy of provisions. The dashed arrows highlight relationships between existing provisions where there is an opportunity for strengthening linkages. The relationships may be one- or two-way. These legislative provisions and the array of tools they provide constitute a robust 'toolkit' for natural hazards planning. However, many of these tools are not well known amongst either planners or emergency management officers, nor used to their full potential to reduce hazard risk and build community resilience (Glavovic, et al., 2010; Saunders, Forsyth, Johnston, & Becker, 2007).

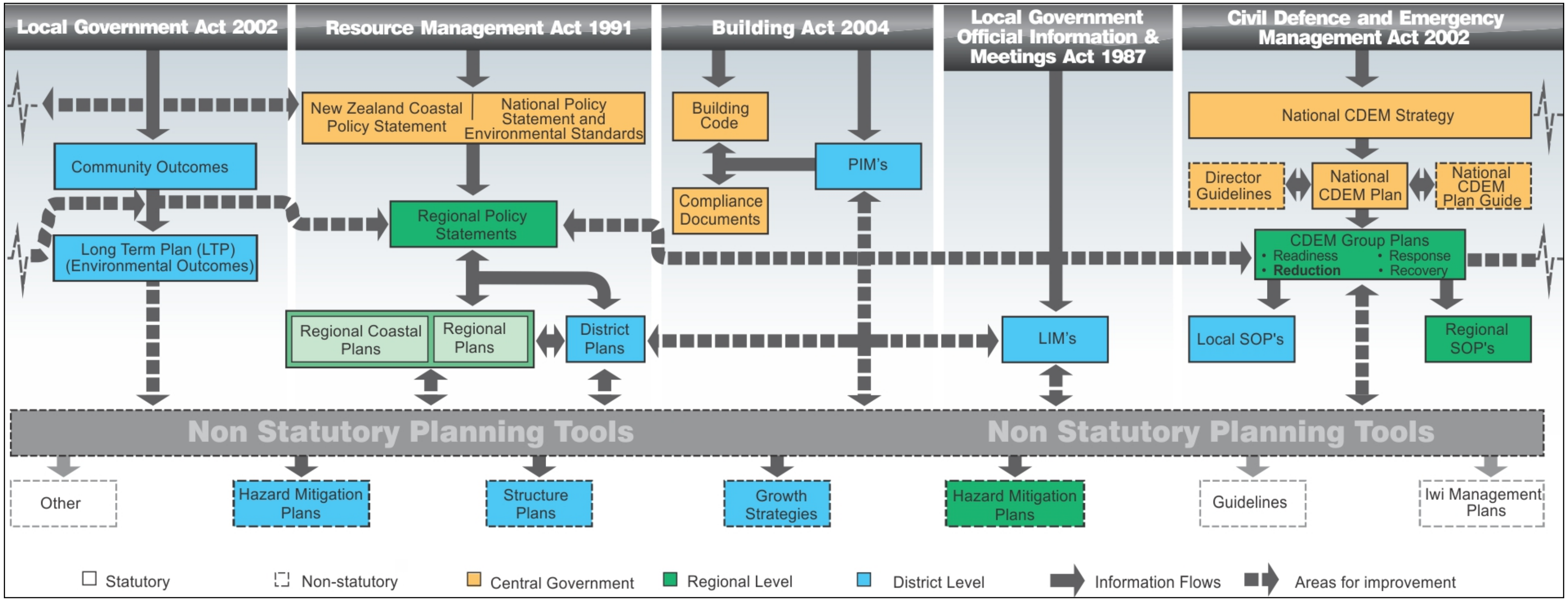

Figure 2.1 Legislative roles and responsibilities for hazard management in New Zealand (adapted from Glavovic, Saunders, & Becker, 2010)

Under LGOIMA, territorial authorities must issue a LIM on request. The LIM provides information that a council holds on a parcel of land, including natural hazards information. LIMs allow the applicant to become aware of any natural hazard on which a council holds information that may affect their property, and enables them to assess their willingness to accept or tolerate that risk. However, if hazard information is included in the district plan, it is not required to be included in the LIM. It is questionable whether applicants for LIMs are aware that the LIM may not include all information held by a council for a site, if that information is held in the district plan. Many LIM applicants assume that the LIM will contain *all* hazard information available.

Table 2.3 provides a summary of how these statutes contribute to the management of natural hazards in New Zealand. It can be seen from the table that primarily the reduction of risk lies with the RMA, whereas emergency management (readiness, response, recovery) lies with the CDEMA.

Table 2.3 Summary of ways in which statutes contribute to the management of natural hazards.

Statute	Implication for natural hazard management
Resource Management Act 1991	• Health and safety issue must be addressed • Local authorities are required to avoid or mitigate the effects of natural hazards, but not their occurrence (*Canterbury RC v Banks Peninsula DC, 1995).* • NZCPS includes specific coastal hazard policies. • S106 (consent authority may refuse to grant subdivision consent) does not allow for the consideration of all natural hazards as defined. • There is the ability to develop national policy statements and national environmental standards to address natural hazards. However, none currently exist.
Building Act 2004	• Requires all buildings to be ‘safe from all reasonably foreseeable actions during the life of the building’. • Reference is made to the joint Australian/New Zealand loading standard AS/NZS1170 (Standards Australia/New Zealand, 2002), where the acceptable annual probability of exceedence for wind and earthquake loads are identified. These relate to the return period for an event (being 1/500, 1/1000 and 1/2500) and the building importance categories of II (Ordinary), III (Important), and IV (Critical). The more important the building, the longer the return period of an event the structure is required to be designed for. • These annual probabilities of exceedence correspond to a 10%, 5% and 2% probability within the nominal 50 year life of the building. • The ability to resist actions from other hazards is specified in the Building Code (a regulation that accompanies the Building Act) but no acceptable intensity of action or recurrence interval is prescribed in either the Code or in the Loading Standard (except for snow, which has a nominal annual probability of exceedence of 1/150 years). • Sections 72 – 74 of the Building Act identify the process that councils must follow when considering a building consent on a site subject to one or more natural hazards. The Building Act allows for council to decline a building consent if, by granting the consent, the development would worsen or accelerate the effects from a natural hazard. Alternatively, building consent can be granted if: i. adequate provision has been or will be made to protect the land, building work, or other property from the natural hazard or hazards; or ii. restoration is made of any damage to that land or other property as a result of the building work. • The definition of natural hazards under the Building Act is limited and does not include tsunami or fault rupture.

Statute	Implication for natural hazard management
CDEM Act 2002	• 4R philosophy (reduction, readiness, response and recovery) – risk reduction is assumed to be managed under the RMA (MCDEM, 2008a; Saunders, et al., 2007). • Encourage and enable communities to achieve acceptable levels of risk (which are not defined). • Readiness and response driven, e.g., guidance for tsunami evacuation planning, mapping, and signage (MCDEM, 2008b, 2008c).
Local Government Act 2002	• Financial planning for risk reduction activities. • Take into account the foreseeable needs of future generations. • Section 11A – *"a local authority must have particular regard to the contribution that the following core services make to its communities:* • *the avoidance or mitigation of natural hazards."*
Local Government Official Information and Meetings Act 1987	• Provides for natural hazard information to be included in LIMs. • If the natural hazard is identified within the District Plan, this information is not required to be provided within a LIM (S44A(2)(a)(ii).

As this section has shown, although there is good integration of purposes across statutes, there are still inconsistencies in how natural hazards are managed. While there is limited non-regulatory guidance available to planners on hazards, with the exception of the New Zealand Coastal Policy Statement (NZCPS; refer Section 2.4), there is no statutory guidance available (i.e., a specific national policy statement or national environment standard available). The RMA allows for the development of these tools, but these are yet to be realised. While these statutes provide a framework for managing natural hazards, when an event does occur, new legislation may be enacted to assist the response and recovery (as seen with the recent Christchurch earthquakes). This has implications for the existing processes within the legislation, as outlined below.

2.1.4 Canterbury Earthquake Response and Recovery Act

On Saturday, 4 September 2010 at 4.35am, a magnitude 7.1 earthquake occurred, centred 9.7 km south east of Darfield, 37 km west of Christchurch and located at a depth of 10.9 km. Despite a maximum intensity of MM9, there were no deaths directly related to the earthquake, and only two people were seriously injured. The earthquake caused extensive ground liquefaction in some areas of Canterbury, and ground shaking resulted in irreparable damage to many commercial and residential buildings.

The implication of the event from a legislative perspective was the enactment of the Canterbury Earthquake Response and Recovery Act 2010, which was passed under urgency on 14 September 2010. The legislation enabled the relaxation or suspension of statutory requirements, until 1 April 2012, that have the potential to divert resources away from the recovery efforts; may be unable to be complied with as a result of the earthquake; or could delay a prompt response to the emergency recovery. This exemption applied to all legislation that may be affected during the response and recovery, including the Building Act, CDEMA, RMA, LGA and LGOIMA. Many orders refer to removing liability for certain actions, extension of legislative timeframes, and the amount of information provided in LIMs (refer to Wynn Williams & Co, 2011 for further details of orders). The legislation also created the Earthquake

Recovery Commission to provide advice and guidance, but the commission holds no liability for decisions being made.

On 22 February 2011 a shallow, magnitude 6.3 aftershock occurred under the Port Hills of Christchurch. This caused devastating damage to the CBD and to the greater Christchurch area, with 185 confirmed deaths and hundreds of injuries. The event resulted in the first national declaration of a civil defence emergency in New Zealand (Hansard, 2011). This earthquake resulted in further changes via Orders in Council under the Canterbury Earthquake Response and Recovery Act 2010, and the legislative establishment of the Canterbury Earthquake Response Agency (CERA) in April 2011. Changes under Orders in Council included the streamlining and fast-tracking of resource consents for land remediation works. It was considered that the normal process of public notification, hearings and appeals would delay the rebuilding of suburbs, potentially for years. Under this Order, affected parties have two weeks to provide written submissions prior to councils making a decision (NZPI, 2011). These new statutes show how the management of natural hazards is often reactive, in that the legislative environment can change in response to an event. Consideration of improving risk reduction via land use planning provides a proactive, rather than reactive, response to natural hazards, and helps to ensure that the sustainability of communities is not compromised.

2.1.5 New Zealand Coastal Policy Statement

The 2010 NZCPS (Department of Conservation, 2010) is the only national regulatory policy document that provides guidance on the management of coastal hazards. Regional policy statements, regional plans, and district plans must give effect to the NZCPS. The NZCPS specifically includes natural hazards in Policies 24 (Identification of coastal hazards) and 25 (Subdivision, use and development in areas of coastal hazard risk). In particular, Policy 25 states:

> … in areas potentially affected by coastal hazard over at least the next 100 years: (a) avoid increasing the risk of social, environmental and economic harm from coastal hazards; (b) avoid redevelopment, or change in land use, that would increase the risk of adverse effects from coastal hazards; … (f) consider the potential effects of tsunami and how to avoid or mitigate them.

Policy 24 refers to “areas at high risk”, but this risk level is not defined, i.e., factors that determine high or low risk are not provided.

2.1.6 Risk reduction and the CDEMA

Saunders et al. (2007) provide details on how risk reduction requirements under the CDEMA are assumed to be managed under the RMA, via regional policy statements and district plans. In summary, it is essential that consistent policies between CDEM group plans and RMA plans are provided, to ensure that risk reduction is effective in achieving common risk reduction objectives and outcomes, particularly around land use recovery (Becker, Saunders, Hopkins, Wright, & Kerr, 2008).

The term ‘risk reduction’ is not included in the RMA, only the requirement to avoid or mitigate natural hazards (see next section). This requires emergency management officers and land use planners to work together with their communities to ascertain levels of risk (as required under the National CDEM Strategy (MCDEM, 2008a)), which are otherwise not defined. RMA decision makers and planners are therefore primarily responsible for risk reduction

(Saunders, et al., 2007) and land use decisions – although there is often resistance to managing natural hazards due to the cost of undertaking risk assessments and the potential for litigation. In order to achieve sustainable risk reduction, it is imperative that these two professions work together (for further information refer to webpage http://www.em.gov.au/Documents/AJEM_Feb07_StrengtheningLinkages.pdf). Under the RMA, the primary focus is on avoiding, remedying or mitigating the effects of natural hazards. This is the focus of the following section.

2.1.7 Reconciling avoidance, mitigation, and risk reduction under the RMA

Within the RMA, the definition of sustainable management includes avoiding, remedying, or mitigating any adverse effects of activities on the environment, with no preference given for any option, or any reference to risk. Contrary to international definitions of mitigation that include avoidance (Burby, 1998; Godschalk, 2002; Mileti, 1999), in New Zealand the term mitigation is typically used to include measures other than avoidance, as that is a separate option. In the CDEMA, neither risk reduction nor mitigation is defined. In the National CDEM Strategy, risk reduction is a combination of avoidance and mitigation (MCDEM, 2008a).

The terms 'avoid, remedy and mitigate' are not defined in the RMA, and there is limited case law to provide guidance on how these concepts can be applied to natural hazards. In practice, greater emphasis is given to avoiding and mitigating the risks associated with hazards than to remedying their effects. This is reinforced in Sections 30 and 31 (functions of regional councils and territorial authorities), where regional councils and territorial authorities are only required to avoid and mitigate natural hazards when controlling the use of the land and the effects of an activity. The common meaning of 'remedy' is "a means of counteracting or eliminating something undesirable" (http://oxforddictionaries.com/definition/english/remedy). In the case of most natural hazards (e.g., landslides, tsunami, flood, earthquake), the hazard cannot necessarily be eliminated and therefore remedying it becomes impractical. Rather, avoidance or mitigation measures can lessen the risk to people and property, and are therefore given greater emphasis (Burby, 1998; Ericksen, 1986; Mileti, 1999; Saunders & Glassey, 2007).

However, there are subtle differences in outcomes between avoidance and mitigation under the RMA, and risk reduction under the CDEMA. Mitigation can be defined as an element of risk reduction, involving an action taken to reduce or eliminate long-term risk to people and property from hazards and their effects (excluding avoidance)[2] (Godschalk, 2002). Under the National CDEM Strategy, risk reduction is defined as:

> *Identifying and analysing long-term risks to human life and property from hazards; taking steps to eliminate these risks if practicable, and, if not, reducing the magnitude of their impact and the likelihood of their occurring" (MCDEM, 2008a, p5).*

It is assumed that this definition includes avoidance via 'taking steps to eliminate these risks' – of which avoidance is an option. While avoidance is an option separate from mitigation in the RMA, risk reduction under the CDEMA includes both mitigation and avoidance. Levels of risk are often cited when mitigation and risk reduction are discussed (e.g., NZCPS Policy 25(a); CDEMA s3(b)). However, there is little guidance available on what an acceptable level

[2] Note that this definition of mitigation is based within the US context, which includes avoidance. However, for the purposes of this research, and as no definition of mitigation is provided under the RMA, it can be applied to New Zealand, acknowledging that avoidance is a separate option.

of risk is, to whom, and to what. This has implications for planning policy, when acceptable levels of risk are included in policy, but not defined.

In the New Zealand context, avoidance reduces risk by not putting people and property in harm's way. In contrast, mitigation provides measures that incorporate the risk, but may still leave people and property at risk (i.e., residual risks, which may require structural protective works), and therefore may not achieve risk reduction. Two Environment Court examples highlight the implications of this discrepancy: Kaihikatea Estate in the Coromandel, and the Holt case in Dunedin – both of which focus on acceptable levels of risk and mitigation measures. Kaihikatea Estate provides an example of the implications of mitigation, in that it does not require mitigation to be effective, only applied. This example is provided in Appendix 2.

2.1.8 Future changes to the Resource Management Act 1991

In 2012 a report prepared by a Technical Advisory Group (TAG) explored how the RMA could be amended to better recognise natural hazards (Technical Advisory Group, 2012). This report suggested a number of changes that could be made to the RMA including:

- Elevating the impacts of natural hazard to Section 6, including a reference to risk;
- Requiring Regional Policy Statements to specifically refer to CDEM group plans;
- Requiring the development of a combined hazards plan for a region;
- Amending s.106 so that it related to all natural hazards and to both subdivision and land use consents;
- Amending s.106 so that Councils can refuse consent if there will be a significant increase in natural hazard risk;
- Requiring local authorities to make information about natural hazards available to all other local authorities within their region.

These recommendations followed through into a discussion document released by the Ministry for the Environment for consultation with the sector (Ministry for the Environment, 2013a). Based on the consultation, reforms to the RMA were announced in August 2013, with two key changes relating to natural hazards. Firstly, the proposed reforms would identify the management of significant risks from natural hazards (Ministry for the Environment, 2013b) as a Section 6 matter (Matter of National Importance). This is an important change, as it introduces the concept of risk for the first time into the RMA. This will mandate land use planners to consider both the consequences and the likelihood of a natural hazard event when making a resource management decision. In turn, planners will be able to make an informed decision around the level of risk that they are willing to accept, and expand the consideration of natural hazards away from the current approach of just considering the likelihood of an event.

Secondly, the reforms proposed to expand the consideration of s.106 (consent authority may refuse subdivision consent in certain circumstances), so that *all* natural hazards are considered at time of subdivision, as opposed to the limited few that currently require consideration (i.e., erosion, falling debris, subsidence, slippage, or inundation).

At time of this report, these reforms had not been before a Select Committee. It is possible these reforms will be amended through the process, which could have implications for the management of natural hazards through land use planning.

2.2 RISK COMMUNICATION AND THE RISK-BASED APPROACH

When undertaking a risk-based approach, a robust process for public engagement and risk communication needs to be implemented at every step. The aim of this is to ensure that communities and stakeholders are informed of the process, can actively contribute to building an understanding of the hazard impacts and key vulnerabilities, and are involved in the decisions on risk acceptability and mitigation options. One of the elements of a good risk communication and engagement approach is that it will achieve multiple outcomes for council and community:

- Creative solutions to challenges can emerge;
- Communities are informed and interested in developing personal strategies to cope with natural disaster events;
- Communities support the greater consideration of natural hazards in land use decisions;
- Council strategies to mitigate or moderate proposals on the basis of natural hazard risk are better understood and supported; and
- Vulnerable communities and future generations are not burdened with higher risks than society as a whole is prepared to accept.

The risk-based planning approach incorporates engagement and communication tasks in each of the five steps). The risk engagement and communication approach:

- Is based on internationally recognised principles for risk communication;
- Builds capacity for engagement through progressive stages;
- Allows flexible options for different contexts;
- Is responsive to changes through continuous assessment and modification; and
- Provides a robust, defensible process for negotiating acceptable risk.

The following sections outline the international principles for good public engagement, the goals of a risk engagement strategy, factors that influence public views on acceptable risk, and the key stages of risk engagement.

2.2.1 Internationally recognised principles for good public engagement in risk management

International trends in risk management and risk communication place increasing emphasis on providing adequate opportunities for public engagement. This is a move away from the historic view of risk analysis as solely a matter for experts. It is in response to changed understanding about the importance of building knowledge about natural hazard impacts using input from those directly affected, and a recognition that decisions about risk management strategies and land use planning ultimately involve value judgements about the costs and benefits of different margins of safety.

The move toward participatory risk management has been driven in part by the prevalence of conflicts between land use policies and hazard mitigation agendas, and an increased focus on sustainability and community resilience as a best long term approach to hazard management.

Internationally recognised principles for good public engagement in risk management include:

- Enabling dialogue between actors with different forms of knowledge and interests – i.e., combines technical and on-the-ground knowledge;
- Involving stakeholders and people at risk in the pre-assessment of risk and in the planning and decision-making on structural and non-structural measures through two-way communication;
- Going beyond hazard prevention and integrating it with wider issues of sustainable community development;
- Informing the general public about decisions and measures;
- Targeting the affected area (e.g., catchment area, river basin) and the whole of affected municipalities; and
- Providing continuity in that it supports lasting communication.

These principles are explored in more detail on the web site http://www.caphaz-net.org/.

2.2.2 Acceptable risk

Many land use planning documents throughout the country refer to 'acceptable risk'. However, these documents do not define what acceptable risk is, or for whom the risk has to be acceptable (i.e., the developers, council, future occupants, or the community). This has resulted in developments being approved in areas susceptible to natural hazards, as the applicant or the developer has been willing to accept the risk associated with the development. When land use planning documents make reference to 'an acceptable level of risk', it is important that this term is defined, as it provides guidance to developers, council, and the community around what this level of risk is, and to whom the risk has to be acceptable.

There are a number of differing metrics and perspectives on what constitutes acceptable risk. In any decision-making process it is important to be clear what approach to defining acceptable risk is being used (and to be aware that councils, stakeholders and communities may be basing their responses on differing views of what is acceptable risk).

Possible perspectives on acceptable risk include (from Hunter & Fewtrell, 2001, in Wein, Journeay, & Bernknopf, 2007):

Currently tolerated	Risk that is no worse than the current risk is acceptable
Improvement of current risk	Any decrease in the risk is acceptable
Intolerable probabilistic threshold	The probability of a specified loss (below a threshold) is acceptable
Benefit-cost	Risk is deemed acceptable relative to the cost of reducing the risk
Public acceptance and political resolution	Deliberative approaches determine acceptable risk

Factors that influence the acceptability of risk include (Institute of Risk Research):

- Voluntariness (the extent to which a person can chose to accept the risk rather than have it imposed on them);
- Control (the extent to which a person can modify their risk by their own influence);
- Fairness (whether everyone is equally affected);
- Familiarity (those risks taken in everyday life are tolerated more than new unfamiliar risks);
- Memorability (risks associated with major tragedies can have a lower risk acceptability);
- Dread (we are simply more afraid of some things, e.g., shark attacks);
- Diffusion in space and time (particularly affects perception of natural hazard risk);
- Morality (whether we can judge a risk or risk taker as being more or less moral – such as intravenous drug use); and
- Process – the way in which a decision about the risk has been made and the trust in the agency responsible has an impact on the acceptability of the risk.

2.2.3 Goals and stages of risk communication in land use planning

The goals of risk communication in land use planning go beyond providing information for people about hazardous situations, and include raising awareness, educating, developing ideas, reaching agreement, addressing conflict, and motivating action. They may also include building trust in the local authority and in the decision-making process. People hearing news about a hazard, or a land use decision that affects their property and their community, need time to process, consider and respond. If placed under pressure, the first reaction can be one of rejection and hostility. A good engagement strategy allows for several opportunities for people to build their understanding before making a final input or decision.

Typical questions that people express when first hearing about a natural hazard and land use planning issue include:

- Am I at risk personally?
- Will my property values be affected?
- How big and how likely is this risk?
- What can I do about it? (e.g., personal risk management and/or insurance)
- Are there any options for mitigating this risk and what are the costs and benefits of these?
- Who is making a decision about this, what is the timeline for this and can I be involved?
- Is this risk being shared by all or felt more by some?

A risk engagement approach needs to consider different communication activities that firstly prepare people for the decision that is to be made, and secondly create opportunities for council and community to build understanding about impacts of the hazard, core vulnerabilities, and concerns (Table 2.4). These stages should build both council and community capacity for a third stage of decision making – reviewing policy and considering mitigation options. A final communication task of reviewing the decisions and decision-making process not only provides useful feedback, but it builds continuity for future interactions.

Table 2.4 Summary of ways in which statutes contribute to the management of natural hazards.

Risk Engagement Stages	
Stage	**Action/Key questions**
Preparing	Outline the issues and who these concern. What kind of decision is being made and can people be involved? What can they expect to see in the future?
Building knowledge and capacity	Involve people in hazard and consequence identification. For example, field-check hazard information, check for vulnerabilities and key concerns.
Making decisions	Involve people in reviewing the risk-based policy/consent options. Check for perverse outcomes. Involve people in identifying and considering risk mitigation options.
Reviewing outcomes	Evaluate whether people are OK with the mitigation options, residual risks, and long-term outcomes. Did the communication and engagement approach meet their needs?

2.3 RELATIONSHIP OF APPROACH TO THE RISK MANAGEMENT PROCESS

The risk-based approach is consistent with international risk management best practice (AS/NZS ISO 31000:2009; AS/NZS 4360:2004). Figure 2.2 shows the standard risk management process, with the risk-based planning approach alongside for comparison. It shows that each step of the risk-based approach matched that of the risk management standard.

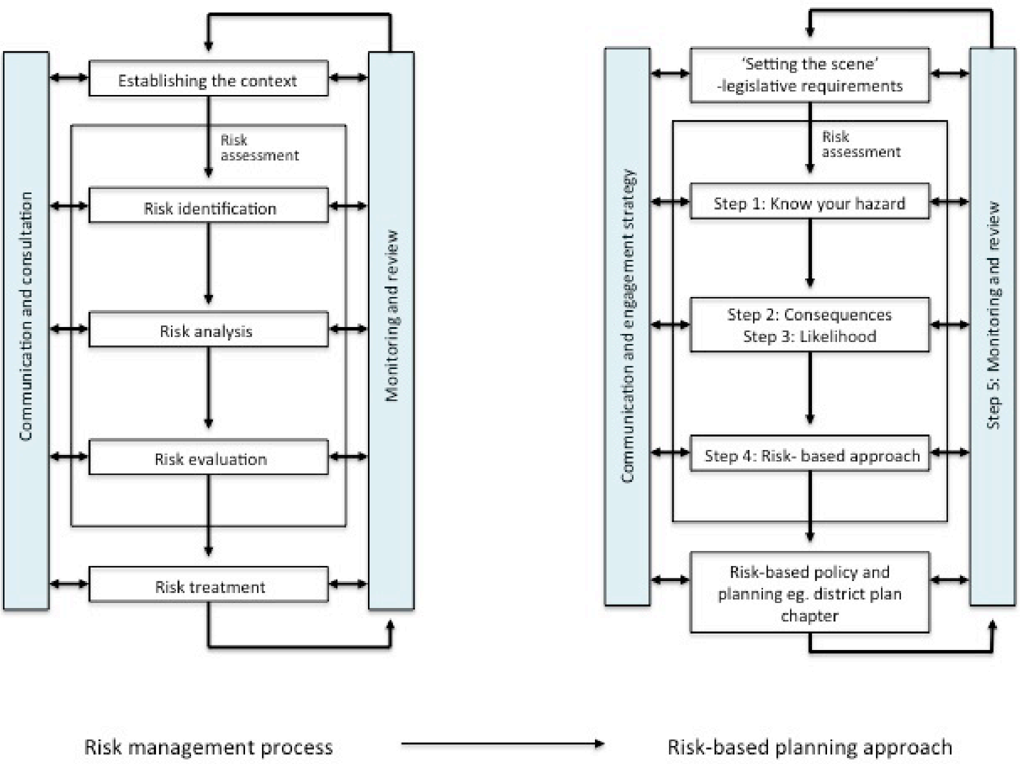

Figure 2.2 Relationship of risk-based planning approach to the risk management process.

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3.0 THE RISK-BASED APPROACH

Traditionally the planning approach for addressing natural hazards has been based on the likelihood of an event occurring. There has been little consideration of the consequences associated with a natural hazard event where it exceeds the design standards. For example, the recent earthquake sequence in Christchurch demonstrated the potential damage that can occur to buildings and communities when an earthquake that exceeds the Building Act (2004) design standards occurs.

A risk-based planning assessment can be used to address the effects of a particular natural hazard. A risk-based assessment ensures that the economic, environmental, social and cultural consequences of a specific development are explored and quantified as part of future planning decisions (Saunders, 2012a).

The advantage of a risk-based assessment is that once it has been incorporated into a district plan, it allows for the consideration of the risks associated with both the construction of buildings and a change in use to an existing building. This in turn allows for more robust planning decisions to be made for a particular development or activity when determining the risks arising from natural hazards (Saunders & Beban, 2011).

A risk-based approach to land use planning is based around five steps:

1. Know your hazard;
2. Determine the severity of the consequences;
3. Evaluate the likelihood of an event;
4. Take a risk-based approach; and
5. Monitor and evaluate.

These steps are interlinked, as shown in Figure 3.1.

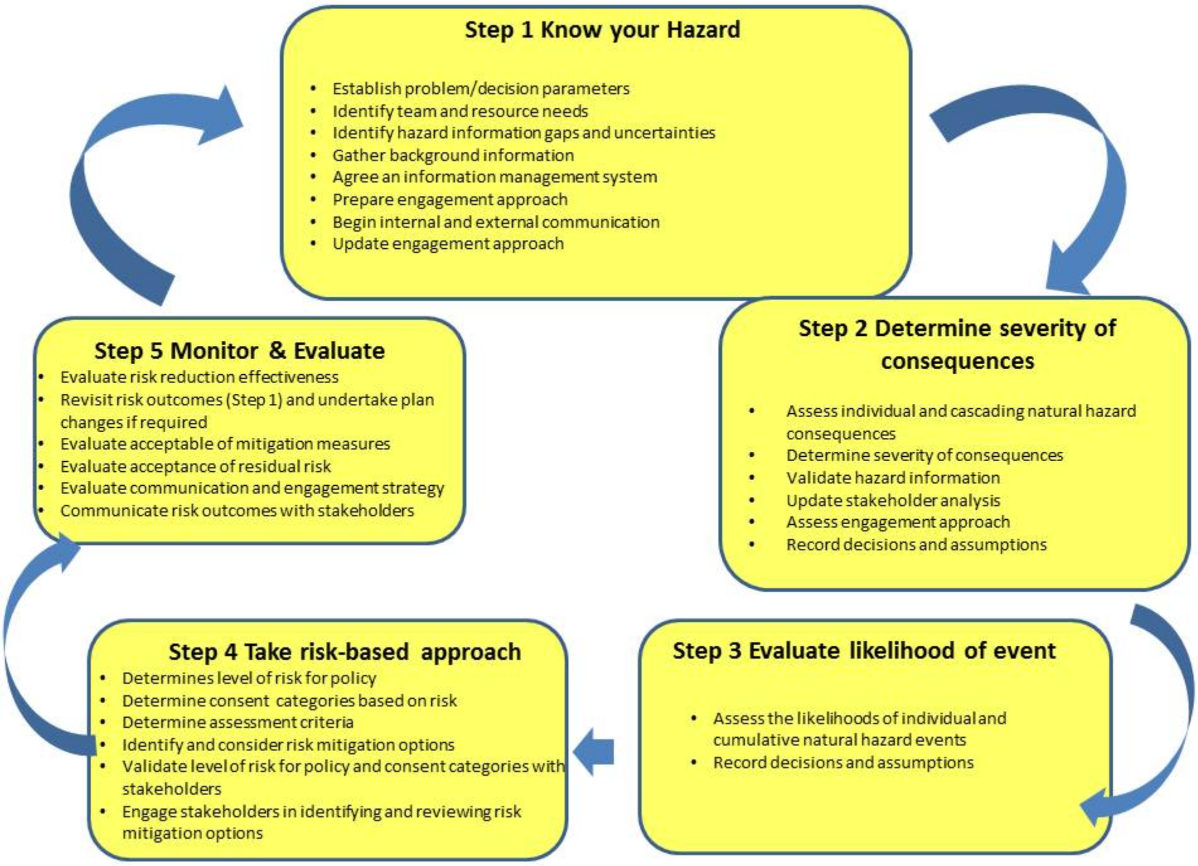

Figure 3.1 Five-step risk-based planning approach.

When undertaking a risk-based approach, a robust process for public engagement and risk communication is needed. This process is designed to ensure that the community and key stakeholders are informed of the process, can actively contribute to building an understanding of the hazard impacts, and are able to provide the council with constructive feedback leading to an agreement on the acceptability of the risk and mitigation options. This requires a two-way communication effort.

The five steps for the risk-based approach are explained in more detail below.

3.1 STEP 1 - KNOW YOUR HAZARD

A large amount of scoping work and information collection occurs under this step. Firstly, the nature of the planning decision needs to be identified, as this has a significant impact on the level of information required, on the stakeholders that need to be involved, and on the complexity of the risk assessments. If the planning decision is for a high-level strategic growth plan, the level of hazard and consequence information required may be less than that required for a change to a district plan. As part of this process, milestone dates for the completion of key components of the project should be identified, including the final date for delivering the product.

Once the planning decision has been made, the existing hazard information should be reviewed to determine whether it is ‘fit for purpose’. Any gaps or uncertainties in the existing information should be identified. Where these gaps and uncertainties exist, appropriate experts will need to be arranged to provide reports that address these issues. This may involve contracting specialist hazard experts who do not work at the council.

While the hazard information is being collected, the information required to undertake the consequence analysis under Step 2 should start to be collated. This information includes:

- The likely land use activities that would be undertaken in the zone, including whether any lifelines will be included in the future development;
- Likely type of construction (timber frame or reinforced concrete);
- Number of additional people likely to be living in the hazard area (and the number of existing people in the hazard zone);
- The regional Gross Domestic Product (GDP); and
- Whether any buildings or places with social, cultural or post-emergency function will be located in the hazard zone.

As Step 1 can involve the collection of a large amount of information, it is important to agree on an information management strategy. This strategy needs to ensure that the information is easily accessible and identifiable to the parties who need access to it. The information management strategy also needs to consider how the information will be accessed and used once the project has been completed.

Step 1 also involves first-stage communication with stakeholders, both internal and external. This includes building a team to undertake and contribute to the project. Team members may include internal council staff from the areas of:

- Communications;
- Emergency management;
- Planners – both policy and consent;
- Elected members; and
- Scientists with expertise in the area (if on staff).

External stakeholders may also be beneficial to the team, such as:

- Scientists/researchers in the field;
- Community members;
- Business representation i.e. from business roundtables, chambers of commerce;
- Lifelines; and
- Other councils (i.e. regional council, or neighbouring territorial authority).

Early efforts at communication can shape the future of the whole engagement effort and are therefore very important. To ensure important areas are covered, an engagement strategy should be prepared. This is discussed in the following subsection.

3.1.1 Building an engagement strategy

Councils face numerous choices about how to communicate with stakeholders and facilitate public participation in risk-based planning. The type of policy and plan development they are undertaking may range from specific issues (e.g., coastal erosion) to broad strategic directions (e.g., urban growth). The scale of operations can also vary from discrete communities within a district to an entire region. While the core steps of engagement as part of the risk-based approach and the stages of engagement that need to be worked through remain the same, councils will want to develop a way of delivering engagement opportunities to suit their context and resources, and to respond to the unique demands of any given situation.

A useful approach to developing an engagement strategy is to work through a checklist (Appendix 3) or set of building blocks (Figure 3.2) in a workshop with a team of staff and elected representatives who are able to respond from their unique knowledge of the situation. A workshop approach, with participants with expertise from across council and other relevant agencies, ensures that the communication and engagement activities are an integral part of the entire risk-based planning initiative, and that the actions taken build council and stakeholder capacity to make robust and considered choices.

Figure 3.2 Building blocks for a risk-based planning engagement strategy.

Taking a workshop approach to building an engagement strategy for risk based planning has several advantages:

- It ensures that the risk communication activities are well integrated into the hazard identification, risk assessment, and policy/plan development activities;
- It enables you to check for competing and complimentary activities; and
- It enables you to use the experience and knowledge of a team of people for a full review of the important context and stakeholder issues.

Building an engagement strategy for communicating complex risk and land use planning issues is challenging. Consider using an independent facilitator to help participants work through the discussions thoroughly. A suggested approach to the workshop includes the features identified in Table 3.1.

Table 3.1 Suggested approach to the running of a workshop to develop an engagement strategy.

Feature	Explanation
Participants	• Can include those staff with roles in: strategic policy development, land use planning, civil defence and emergency management, community development, civil engineering, parks and reserves management, iwi liaison, natural hazard technical science, and communications. • At the first workshop or for subsequent meetings it may be appropriate to include participants from regional or district authorities with complimentary jurisdictions and interests. • Political representatives, and/or community board representatives.
Preparatory material	It is important to undertake a preparatory assessment of council responsibilities and legal obligations relating to the issue for a clear starting point. Where there is uncertainty regarding these, then it should be included as part of the risk identification stage of the workshop.
Goals, overall principles and risk identification	• Initial focus should be to identify a clear goal for the engagement strategy – phrased in an appropriate statement which allows for tracking achievement. • In defining the goal, the participants should consider the overall principles of how they wish to engage with communities (see IAP2). • Any potential risks for the local authority relating to public engagement in the natural hazard and land use planning issues should also be identified.
Further building blocks	The building blocks of hazard complexity assessment; context assessment; stakeholder assessment; and existing perceptions assessment can be reviewed through an open discussion amongst workshop participants. It is important to refer back to the overall goal of the strategy during the discussions. Refer to the checklist in the previous subsection for prompting questions. Each building block should conclude with a summary of: i. implications for the engagement approach; and ii. questions or unknowns that require further work.
First steps	The workshop can conclude with some first steps for beginning the process of risk and land use planning public engagement. This will include first steps that: i. build knowledge; and ii. prepare for decisions.

Appendix 3 also identifies the questions that should be considered for each of the building block actions.

Scope and goals assessment

This should be completed first to establish a clear task direction for the engagement strategy. The goals in particular are referred back to throughout and are used as a basis for tracking progress. At this stage, commitment to an overall engagement ethos (e.g., informing, consulting, empowering etc.) should be considered. Local authorities may try to build community capacity in the area for independent governance or may wish to adhere to resource management standards of consultation – the overall principles that currently direct council communications are important to consider in building an approach to engagement in natural hazard and land use planning. Further information can be found at http://www.iap2.org/associations/4748/files/spectrum.pdf.

It is also important to consider the risks of engagement for the local authority, and how these may influence the approach that might be taken. Opportunities can also be reviewed at this stage. For example, there may be coinciding activities being undertaken that may be useful to run conjointly.

The checklist in Appendix 3 identifies the questions that should be considered when undertaking this step.

Complexity of hazard issues

Natural hazard and land use planning involves varying degrees of complexity. An assessment of this considers:

- How much is known about the hazard?
- How straightforward is the issue?
- Will uncertainty and ambiguity significantly influence the risk-assessment and decision-making process?

A set of descriptors for different natural hazard risk situations, with comments about appropriate risk communication approaches derived from Renn 2010 (in Hoppner, Brundl, & Buchecker, 2010), are detailed in Table 3.2.

Table 3.2 Suggested approaches for running a workshop to develop an engagement strategy.

Natural hazard risk situation	Risk communication needs
Defined risk problems – This is where the potential negative consequences are obvious, the values that are applied are non-controversial and the remaining uncertainties are low. Examples are regularly recurring natural disasters such as flooding. Simple risks should not be equated with small or negligible risks.	Simple risk problems do not require a sophisticated approach to engagement involving all potentially affected parties. Rather. a discussion among agency staff, directly affected groups and/or individuals, as well as enforcement personnel, is advisable.
Complex risk problems – The characterisation of the risks under consideration is not immediately clear or widely agreed upon.	Addressing complex risk problems relies on setting up a discourse between experts who come from different discipline viewpoints, and those with key knowledge. Participants may come from academia, government, industry, or civil society. Their basis for inclusion is their ability to bring relevant knowledge to the negotiating table. This dialogue should occur during the risk appraisal phase, with a direct link to the phases of tolerability and acceptability judgement and to decisions regarding risk management. The goal is to resolve cognitive conflicts. Examples include: Group Delphi and consensus workshops.
Risks problems due to uncertainty. Characterising risks, evaluating risks, and designing options for risk reduction pose special challenges in situations where there is high uncertainty in the risk estimates.	Such situations call for ‘reflective discourse’ where the main stakeholders are included in the evaluation process and asked to find a consensus on the extra margin of safety in which they would be willing to invest in exchange for avoiding potentially catastrophic consequences. This relies on a collective reflection about balancing the possibilities for over- and under-protection. Policy makers, representatives of major stakeholder groups, and scientists take part. Examples include round tables, open space forums, negotiated rule-making exercises.

Natural hazard risk situation	Risk communication needs
Risk problems due to ambiguity – This is where there are different legitimate ways of evaluating the risk	If major ambiguities are associated with a risk problem, the process of risk evaluation needs to be open to public input and new forms of deliberation. High ambiguities require the most inclusive strategy for participation, since not only directly affected groups but also those indirectly affected have something to contribute to this debate. Resolving ambiguities in risk debates requires a 'participative discourse', a platform where competing arguments, beliefs and values are openly discussed. Examples include: citizen panels, citizen juries, consensus conferences, ombudspersons, citizen advisory commissions.

Context assessment

In a workshop, context analysis uses the team's knowledge of the background to the situation to explore such matters as:

- How has the issue has been dealt with historically?
- Will there be residual issues arising from this?
- What is the potential for conflict?
- What is the trust in the local government agency and the decision-making process?

This may highlight matters that will need to be dealt with up-front to prevent these becoming road-blocks to communication. It may also highlight the need for conflict management and/or trust-building to be built into the engagement strategy.

Stakeholder assessment

Although it is often tempting to begin an engagement strategy by identifying the key stakeholders, this becomes a much more thorough and easily achieved activity once the previous building blocks (goals, hazard complexity and context analysis) have been undertaken. The purpose of a stakeholder assessment is to:

- Identify and define the characteristics of key stakeholders;
- Draw out the interests of stakeholders in relation to the issue at the centre of the engagement strategy;
- Identify conflicts of interests between stakeholders, to help manage such relationships during the course of the project;
- Help identify relationships between stakeholders that may enable 'coalitions' of project sponsorship, ownership and cooperation; and
- Assess the capacity and preferences for participation of different stakeholders and stakeholder groups.

There are many resources available to aid stakeholder assessment. For example, see http://www.landcareresearch.co.nz/__data/assets/pdf_file/0007/28267/hatched_section4.pdf.

In hazard and land management situations, Table 3.3 is a useful prompt for considering the different possible interests.

Table 3.3 Prompts for assessing stakeholder interests.

Stakeholder analysis How will these interests or views be represented? What do we know about them?				
Life and Livelihood	**Legal**	**Financial**	**Have important knowledge**	**Those whose support is necessary**
Property owners Business owners Local iwi	Resource management authority Iwi management agency	Property developers Insurance companies	CDEM staff GNS, NIWA Regional Councils Local iwi Local groups	Local activist groups Resident advisory groups

Existing perceptions

It is important to understand what stakeholders and affected communities already know about a natural hazard situation, what beliefs they hold, and what issues they consider important. This ensures that any communications about the situation do not falter because they have not addressed the most important concerns, or because people do not yet realise that there is any issue to be addressed. Although national data on risk understanding and perception can be useful, it is also important to have some checks as to the local situation.

Ways of assessing existing views can be as simple or as sophisticated as the situation demands and the resources allow. They can include:

- Phone calls to key people (e.g., community boards, community leaders, iwi representatives, own in-house staff, e.g., CDEM);
- Surveys;
- Phone calls; and/or
- Mail drops.

An exercise that may be useful to include in an engagement strategy workshop is simple risk profiling based on two factors:

i. awareness of the hazard; and

ii. investment/interest in the activity (For example, interested in future development of their property)

In an engagement strategy workshop, participants can discuss their knowledge of the affected communities, and the different stakeholders regarding these factors, and consider the implications for an engagement approach (see Figure 3.3).

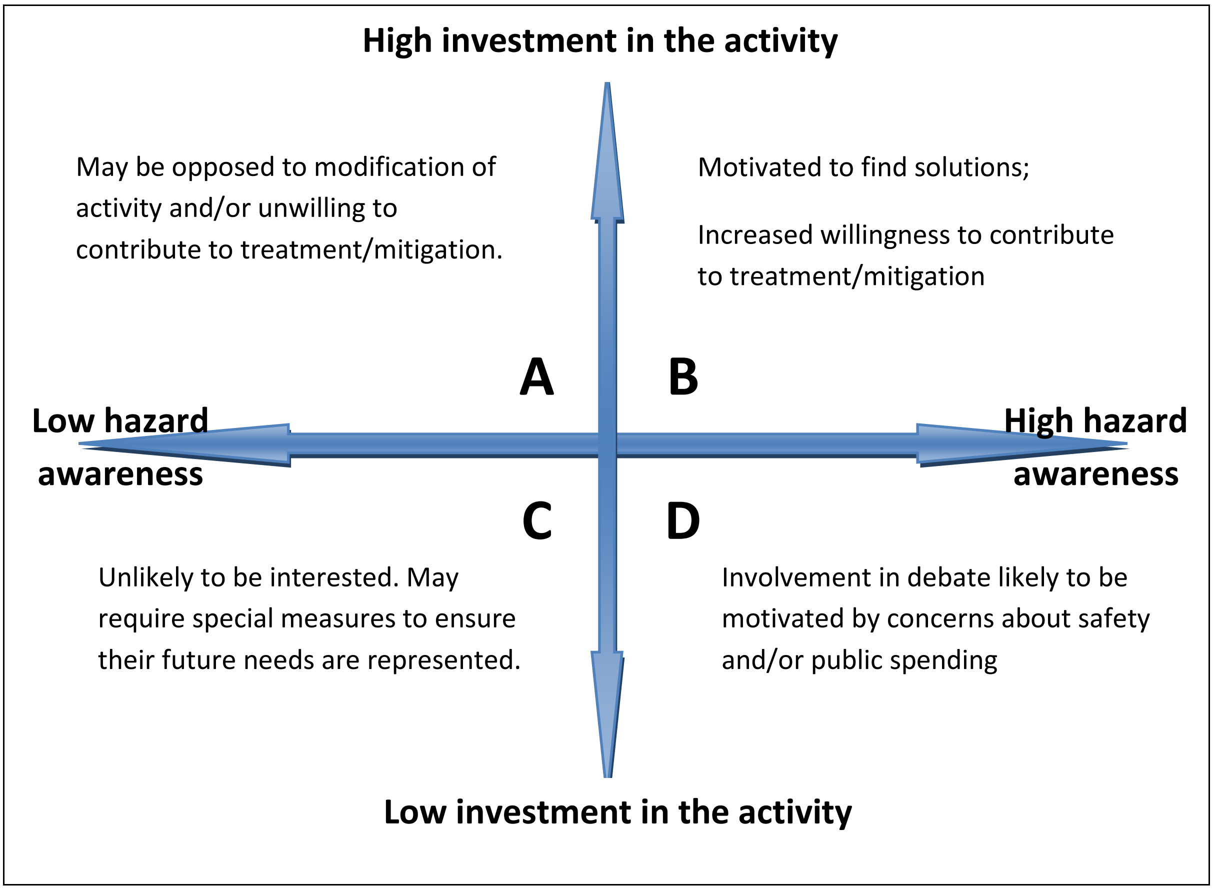

Figure 3.3 Risk engagement challenges for different types of audiences (from idea by Kaine, 2010).

Where awareness is low (A and C), effort will be needed upfront to raise awareness of the hazard before discussions can even begin. However, where this is coupled with high investment in the activity (A), such as an investor in a property development or an existing land owner where there is yet no concrete evidence of the natural hazard risk, there may be reluctance to receive messages about a natural hazard risk that will imply a cost, or a perceived loss of value in their current investment.

Where there is high awareness and acceptance of the natural hazard risk, and a high investment in the activity, the affected stakeholders are commonly keen to be involved in discussions about how to address the issue (e.g., directly affected coastal property owners who have already begun to see the effects of coastal erosion). However, where there is high awareness, but low investment – area D (e.g., district rate payers who don't own coastal property), their main concerns may be the use of public funds.

The group in area C is the hardest to motivate to participate in discussions about natural hazard risk since they have neither investment in the activity nor awareness of the natural hazard. Creative 'levers' may needed to include these stakeholders in discussions.

Where widely different views are held by different stakeholders in the same community (e.g., people in both group A and group D), a mediated/conflict resolution process may be needed as part of the engagement strategy.

First steps and options
The choice of what messages should be included in a first step in risk engagement depends on the context assessment (e.g., do you need to build trust first or to resolve an historic issue?).

Some tips for considering first steps of engagement:

- Is there a way to get someone else to drive this or to partner with?
- What are you expecting from this step and how will you make use of this (e.g., If your aim is to raise awareness – what will you do with this raised awareness?)
- When sending out messages, always prepare for the response/reaction
- Consider - how does this step prepare you for the next stage of the engagement? In particular, what steps will:
  - i. build knowledge; and
  - ii. prepare people for decisions?

Adapting the strategy
An engagement strategy should be referred back to, monitored, and adapted throughout the risk-based planning process. In particular, it is important to be aware how new knowledge might change the list of potentially affected stakeholders, and to keep track of progress towards the overall goals.

3.1.2 Internal communication

Internal communication is very important to ensure there is a consistent approach within the organisation. It also establishes the key internal relationships with other partner agencies. The two key actions are to:

1. Set up a team – (e.g., those who would contribute to an engagement strategy); and
2. Brief and inform political representatives.

When briefing political representatives, the following actions are recommended:

- Find a champion or two on the council (i.e. elected representatives, staff) who are interested and well respected;
- Give presentations to council about how similar situations have been dealt by other regions that have had success stories. These presentations should be from well-respected elected members and/or senior executives;
- Build the level of understanding first – never overestimate how much is already known.
- Use economic arguments to support your case. Many elected members are business people and will be concerned about this aspect of your proposal,
- The ability to make successful change depends upon the capability and capacity of councils (particularly financial), and the exposure to risk for the organisation. Councils and councillors may have the willingness but not the ability to effect change. Include a recognition of these factors in the options you present.
- Timing is important:
  - Avoid new initiatives that may have negative consequences (or the perception of these) in the lead-up to triennial elections. Alternatively, provide a way that they can be viewed positively.

- Piggy-back on recent emergency events that have caused problems – especially if communities are unhappy and council has incurred costs;

- Focus first on the highest risk hazards that are most likely to harm people;
- Concentrate efforts at the territorial authority level, as this is where risk and land use decisions have the most impact. Engage the communications team in helping to create and deliver key messages to councillors and to the public;
- Avoid 'tech-talk'(terms like AEP, probabilistic, regression analyses etc.), but have the technical information available if required; and
- Be realistic about what is achievable – start small.

3.1.3 External communication

The first goal of external communication is to let people know that there is an issue, what is going to be done about, it and what opportunities there will be to learn more and to contribute to the decision. Review the principal components of the overall engagement strategy before sending out first messages. The following actions are recommended:

- Present people with the information they need in a form that fits their intuitive ways of thinking;
- Keep first messages as simple as possible;
- What is the key message? Are you trying to:
    i. tell people about a new hazard?
    ii. change existing assumptions about the hazard?
    iii. change a view about a presumed risk that no longer applies?
    iv. invite people to discuss the implications of a hazard on their lives/property/future plans? or
    v. alert people to a long-term process of decision-making around an issue?
- 'Translate' pertinent data, such as hazard maps, susceptibility maps, flood extents, and GIS layers. What is of interest to people? Does this information affect how they can use their land, or what personal risk strategies they need to develop?
- Be clear about who is being affected, or what geographic boundaries this issue covers;
- Consider what topical issues or recent concerns might be good to link your message to, to help it gain purchase;
- Test out a first message and check that it conveys the message you expect it to; and
- Prepare for a response/reaction.

3.1.4 Know your hazard assumptions

The assumptions associated with knowing your hazard are as follows:

- Any hazard assessment will be based on the best available knowledge at the time; and
- A hazard assessment report will include assumptions, limitations and uncertainties.

3.2 STEP 2 CONSEQUENCES

The purpose of this stage is to gain an understanding of the possible consequences of a natural hazard event. Natural hazard information, coupled with information about the proposed development and existing land use, is used to undertake an assessment of consequences.

Information about the development and the natural hazard consequences is confirmed through engagement with specialists, those with local knowledge, and stakeholders.

3.2.1 Consequence table

Once Step 1 has been completed, the consequences from the natural hazard can be calculated (Figure 3.4). The consequences in Figure 3.4 are based on community well-beings, as well as what can be planned for (see Section 2.1 for more detail). When assessing consequences, the final level of impact is assessed on the 'first past the post' principle, in that the consequence with the highest severity of impact applies. For example – a natural hazard event resulted in moderate severity of impact across all of the categories, with the exception of critical buildings, which had a 'major' severity of impact. The major impact is what the proposal would be assessed on. If a natural hazard event resulted in all of the consequences being at the same level (for example, all of the consequences are rated moderate), then the level of consequence is considered to be moderate.

The consequence table does not include a column for the environment. The reasons for this are twofold:

- The risk-based approach has been designed for land use planning. This means it considers the interaction between human habitation and natural hazards. We do not, and are largely unable to, plan for the interaction between natural processes. For example, if a large earthquake uplifted an estuary, there is no land use planning options that could be implemented to prevent this from occurring, as it is a nature-versus-nature interaction.
- The risk-based approach concentrates on the primary (immediate) effects associated with natural hazards. Consideration was given to the effects a natural hazard can have on the environment through damaging or interrupting human processes. For example, an earthquake ruptures a pipeline and results in an oil spill. It is considered that the damage to the pipeline is a primary effect resulting from the earthquake. However, the effects on the ecosystem from the oil spill are a secondary and therefore are not considered as part of this risk-based approach.
- Other international best practice do not include environment (e.g. Integrated Research on Disaster Risk, 2011)

The consequence table has been developed as a multi-hazard table. That is, it can be used for different natural hazards – flooding, land instability, tsunami, fault rupture, liquefaction, etc. The scale of the table is such that while it provides a multi-hazard approach, not all hazards will result in catastrophic consequences. For example, a flood may never reach 'major', whereas an earthquake may.

The table has been developed based on the methodology provided in Appendix 1. However, if appropriate, the descriptors could be refined with further research, development, and testing. For example, if district GDP figures are available, these could be used within a district context instead of regional GDP.

Severity of Impact	Built				Economic	Health & Safety
	Social/Cultural	Buildings	Critical Buildings	Lifelines		
Catastrophic (V)	≥25% of buildings of social/cultural significance within hazard zone have functionality compromised	≥50% of affected buildings within hazard zone have functionality compromised	≥25% of critical facilities within hazard zone have functionality compromised	Out of service for > 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for > 6 months (affecting < 20% of the town/city population)	> 10% of regional GDP	> 101 dead and/or > 1001 inj.
Major (IV)	11-24% of buildings of social/cultural significance within hazard zone have functionality compromised	21-49% of buildings within hazard zone have functionality compromised	11-24% of buildings within hazard zone have functionality compromised	Out of service for 1 week – 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting < 20% of the town/city population people)	1-9.99% of regional GDP	11 – 100 dead and/or 101 – 1000 injured
Moderate (III)	6-10% of buildings of social/cultural significance within hazard zone have functionality compromised	11-20% of buildings within hazard zone have functionality compromised	6-10% of buildings within hazard zone have functionality compromised	Out of service for 1 day to 1 week (affecting ≥20% of the town/city population people) OR suburbs out of service for 1 week to 6 weeks (affecting < 20% of the town/city population)	0.1-0.99% of regional GDP	2 – 10 dead and/or 11 – 100 injured
Minor (II)	1-5% of buildings of social/cultural significance within hazard zone have functionality compromised	2-10% of buildings within hazard zone have functionality compromised	1-5% of buildings within hazard zone have functionality compromised	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting < 20% of the town/city population)	0.01-0.09 % of regional GDP	<= 1 dead and/or 1 – 10 injured
Insignificant (I)	No buildings of social/cultural significance within hazard zone have functionality compromised	< 1% of affected buildings within hazard zone have functionality compromised	No damage within hazard zone, fully functional	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for up to 1 day (affecting < 20% of the town/city population)	<0.01% of regional GDP	No dead No injured

Figure 3.4 Consequence table.

3.2.2 Consequence table assumptions

The assumptions associated with the use of the consequence table are as follows:

- A robust public engagement and risk communication process needs to be implemented. This is to ensure that the community and key stakeholders are informed of the process and that the council can receive constructive and useful feedback.
- The hazard information a council has available is sufficiently accurate to allow for the calculation of the consequences from the hazard event. To be able to use the consequence table, the hazard information needs to be relatively detailed and scientifically robust. Furthermore, in order to be able to fill in some of the categories in the consequence table, specialist information may be required (for example a risk modeller may be required to determine the number of deaths for a given natural hazard scenario).
- It is appropriate to consider mitigation measures where they can reduce the consequences from an event. For example, an activity may be considered 'moderate' (using 'first past the post'), but with effective mitigation the consequences could be reduced to 'minor'.
- For the majority of the consequences, the severity of impact is calculated based on the level of consequences in hazard zones (for example the extent of an area affected by flooding). The use of hazards zones prevents the effects of the natural hazard event from being diluted by including buildings from a wider geographical area that are not affected by the hazard. The exception to this is the calculation of consequences from damage to lifelines. Lifelines are a network and therefore if one area of the lifeline is damaged, then it is likely to have an effect on people and property outside of the identified hazard zone.
- Not all hazard events will result in catastrophic consequences. Many natural hazard events may result in only moderate or major consequences (e.g., flood versus earthquake).
- The consequence table focuses on the primary effects associated with the natural hazard event (i.e. the immediate damage). It does not take into account secondary effects (for example the loss of employment due to damage to buildings).
- For the consequence categories for the built environment, the severity of impact is based on whether the building is functionally compromised. Functionally compromised means whether the building can continue to be used for its intended use immediately after the event. For example, if an apartment building does not have a water supply, it is unable to be used for residential accommodation, due to requirements for fire fighting. As such, the functionality of this building has been compromised by the natural hazard event.
- Critical buildings are buildings which have a post-disaster function. These include:
  - Buildings and facilities designed as essential facilities;
  - Buildings and facilities with special post-disaster functions;
  - Medical emergency or surgical facilities;
  - Emergency service facilities such as fire and police stations;
  - Designated emergency shelters;
  - Designated emergency centres and ancillary facilities; and

- Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond the property boundaries.

- Social and cultural buildings are buildings that are of social and cultural importance. These include:
    - Places of worship;
    - Museums;
    - Art galleries;
    - Marae; and
    - Educational facilities.

  Sporting/recreational facilities are not included, as these are often specifically located in hazardous areas, e.g., flood paths. In some instances it is considered good practice to locate these types of activities in hazard zones, as the consequences associated with these activities can be low.

- The built environment covers all buildings not considered to fall under the definitions of critical buildings and social and cultural buildings.

- For the purposes of the consequence table, lifelines are considered to be the following:
    - Transportation;
    - Water and wastewater; and
    - Power distribution.

  These lifelines may include both networks and nodes.

- Economic consequences are measured as a percentage of Regional GDP as opposed to an absolute monetary amount (such as a dollar amount), as recommended in the Risk Management Standard (4360). This method is preferred, as the value of dollar amounts change over time, and do not allow for different scales, e.g., $1 million of loss in a small provincial town would have a greater consequence than $1 million of loss in a large city. If the data is available, the GDP of the territorial authority could be used instead of the Regional GDP. The economic category only considers the immediate economic impact and is derived using the following equation:
    - ((Value of buildings damaged + (number of deaths x $3.77 million) + (number of injuries x $207,000)) / Regional GDP) x 100.

  The monetary value of deaths and injuries will change with time. The value used in this formula is based on the values of deaths and injuries as a result of vehicle accidents in New Zealand (Ministry of Transport, 2012).

- Deaths are an absolute number and any calculations undertaken to estimate the deaths should be rounded up when a fractional number of deaths is calculated. For example, if the calculations result in 7.1 deaths, this should be rounded up to 8.

- The risk-based approach can be used for cumulative and cascading hazards. The district plan chapter example (see http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Risk-Society/Societal-Resilience/Policy-and-Planning) provides further information on how the consequence table can be completed for cumulative and cascading natural hazards (Beban & Saunders, 2013).

3.2.3 Validating local hazard impacts

The purpose of Step 2 of the risk-based approach is to build a picture of the possible consequences and impact of a natural hazard event. This stage combines technical and lay knowledge, as stakeholders may have important information about patterns of exposure that needs to be integrated into the overall assessment. This can include public expectations for the area such as future development interests, and important localities that require particular protection (e.g., key access routes and important buildings). The engagement strategy, and in particular the stakeholder assessment, should identify key stakeholders.

Risk communication at this step serves two purposes:

1. To confirm information about natural hazard consequence and key vulnerabilities by ensuring that generic knowledge and information held by the local authority is accurate at smaller scales, and takes adequate notice of community concerns.
2. To build awareness and capacity amongst stakeholders and communities to prepare for later contribution to decisions about natural hazard management and land use planning.

The engagement approach options available when undertaking this step include:

- Assessments undertaken in-house of the natural hazard consequences can be verified through surveys, field visits, interviews, and specialist working groups;
- Open days and road shows of natural hazard information depicting likely consequences at a local scale can build awareness amongst stakeholders and communities. Information regarding key concerns, locally important assets, and vulnerabilities can also be gathered this way.
- Workshops that include discussion opportunities and hands-on tasks build awareness and capacity for participants to make focused contributions to land use planning decisions. Possible elements to include are:
  - presentations of natural hazard consequences at a local scale;
  - tangible opportunities for participants to review and discuss the likely consequences across not only life and personal property, but also the local economy, infrastructure, and significant cultural and social assets; and
  - exercises that allow participants to come to grips with the task of ranking the severity of a risk and considering the possible management response.

The actions following on from undertaking the engagement process detailed in this step should include:

- Assess what (if any) were the main points of contention;
- Assess whether there are any major differences in perception about the hazards; which may require another communication effort;
- Revise engagement strategy and stakeholder analysis; and
- Input information into the risk-based planning approach.

Key actions for this step are as follows:

Share information:

- Hazard maps, inundation maps, overlays of current and proposed development;
- Consequence analysis – what do minor to severe events look like?
- Keep it simple.

Questions to ask and information to gather:

- If a major event happened to this locality, what would be the main issues of concern?
- What are the expectations about how this area is to be managed into the future? (e.g., housing, or commercial development)
- What are key matters affecting exposure, e.g., important buildings, access ways, vulnerable communities, important icons?
- What do people want to know more about?

Be prepared for:

- Conflicts that may arise due to stakeholders' unfamiliarity with risk estimation and the uncertainties and value assumptions associated with the method.
- This step will also reveal what are the 'sticking points' – areas of biggest concern or areas where beliefs about the hazard and associated risks are most at odds with those of hazard technical advisors.

3.3 STEP 3 - LIKELIHOOD

Once the land use and consequences have been determined, only then should the likelihood be evaluated (Figure 3.5). For example, if a natural hazard event has a return period of 1:100 years then, using the table below, this event would be considered to be "possible" (level 4). Similarly if a natural hazard even has a return period of 1:500 years, then it would be considered to be unlikely (level 3). The level calculated for the natural hazard is needed to complete the risk-based approach (Step 4).

Level	Descriptor	Description	Indicative frequency
5	Likely	The event has occurred several times in your lifetime	Up to once every 50 years
4	Possible	The event might occur once in your lifetime	Once every 51 – 100 years
3	Unlikely	The event does occur somewhere from time to time	Once every 101 - 1000 years
2	Rare	Possible but not expected to occur except in exceptional circumstances	Once every 1001 – 2,500 years
1	Very rare	Possible but not expected to occur except in exceptional circumstances	2,501 years plus

Figure 3.5 Likelihood scale.

As part of this step, while no formal communication with the stakeholders and general public is required, the decision around the likelihood, and the fundamental assumptions on which it was based should be recorded for the purposes of transparency and to allow for later use under Step 4.

Once the land use, consequences and likelihood have been determined (Steps 2 and 3), a risk-based approach can be applied.

3.3.1 Likelihood table assumptions

The assumptions relating to the use of the likelihood table are follows:

- The likelihoods provided are accepted by key stakeholders.
- The table is scaleable, in that it allows for the evaluation of multiple hazards, i.e., flooding, landslides, tsunami, fault rupture.

3.4 STEP 4: TAKE A RISK-BASED APPROACH

In order to take a risk-based approach, the consequences and likelihood need to be quantified to provide a level of risk.

To achieve this, a matrix can be used that incorporates the relevant risk level, expressed as a function of consequences multiplied by likelihood (Figure 3.6). The risk then ranges from 1 (extremely low) to 25 (extremely high).

	Consequences				
Likelihood	**1**	**2**	**3**	**4**	**5**
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Figure 3.6 Quantifying consequences and likelihood (adapted from Saunders, 2012b).

The risk levels then need to be determined. Figure 3.7 shows how the risk levels were determined from Figure 3.6. In practice, participation and associated debate would be required within council and with the community to determine the thresholds for the levels of risk (See Section 3.1.1– Building an Engagement Strategy).

Risk	**Level of risk**
1-9	Acceptable
10-19	Tolerable
20-25	Intolerable

Figure 3.7 Qualifying levels of risk from Figure 3.6 (adapted from Saunders, 2012b).

When decision makers are considering the risk levels and the planning options to address the levels of risk, they should consider the questions detailed in Table 3.4. A robust and thorough consideration of these questions will help ensure that the right risk and consent thresholds are established, and that the objectives, policies and rules developed in response to the risk levels achieve their intended outcomes.

Table 3.4 Questions to be considered when determining levels of risk (adapted from Standards New Zealand, 2004, p82).

Acceptability	Is the risk reduction option likely to be accepted by relevant stakeholders?
Administrative efficiency	Is this risk reduction option easy to implement or will it be neglected because of difficulty of administration or lack of expertise?
Compatibility	How compatible is the risk reduction option with others that may be adopted?
Continuity of effects	Will the effects be continuous or only short term? Will the effects of this risk reduction option be sustainable? At what cost?
Cost effectiveness	Is it cost effective, could the same results be achieved at a lower cost by other means?
Economic and social effects	What will be the economic and social impacts of this risk reduction option?
Effects on the environment	What will be the environmental impacts of this risk reduction option?
Equity	Are risks and benefits distributed fairly e.g. Do those responsible for creating the risk pay for its reduction?
Individual freedom	Does the risk reduction option deny any basic rights?
Jurisdictional authority	Does this level of organisation or government have the authority to apply this option? If not, can higher levels be encouraged to do so?
Leverage	Will the risk reduction option lead to additional benefits in other areas?
Objectives	Are organisational objectives advanced by this risk reduction option?
Regulatory	Does the risk reduction option (or lack of option) breach any regulatory requirements?
Political acceptability	Is it likely to be endorsed by the relevant government authority? Will it be acceptable to communities?
Risk creation	Will this risk reduction option introduce new risks?
Timing	Will the beneficial effects be realised quickly?

Once levels of risk have been determined, the matrix is then colour-coded (Figure 3.8), based on the levels of risk shown in Figure 3.7. The use of colours allows a faster assessment of the levels of risk involved. The colours of green and blue (acceptable i.e. permitted/controlled), yellow and orange (tolerable with consent i.e. restricted discretionary, discretionary) and red (intolerable i.e. non-complying, prohibited – see Figure 3.9), are considered standard colours for this approach (Standards New Zealand, 2004).

	Consequences				
Likelihood	**1**	**2**	**3**	**4**	**5**
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Figure 3.8 Colour-coding the matrix based on level of risk (adapted from Saunders, 2012b).

The stage uses the colours, based on the levels of risk, to determine the consent status (i.e., treatment) of the activity (Figure 3.9).

Level of risk	Consent
Acceptable	Permitted
Acceptable	Controlled
Tolerable	Restricted Discretionary
Tolerable	Discretionary
Intolerable	Non complying, prohibited

Figure 3.9 Level of risk and associated consent status (adapted from Saunders, 2012b).

Non-complying and prohibited are merged together, but it is acknowledged that the former allows for development, while the latter avoids development. For the purposes of this example, the two are merged to allow for high consequence activities to take place in high-risk areas that may not be able to be avoided, e.g., a port.

In the final stage of the process, consequence values 1–5 are relabelled into roman numerals to ensure no confusion between the likelihood scale and consequence scale. Figure 3.10 provides the final framework, where risk equates to consent status applied.

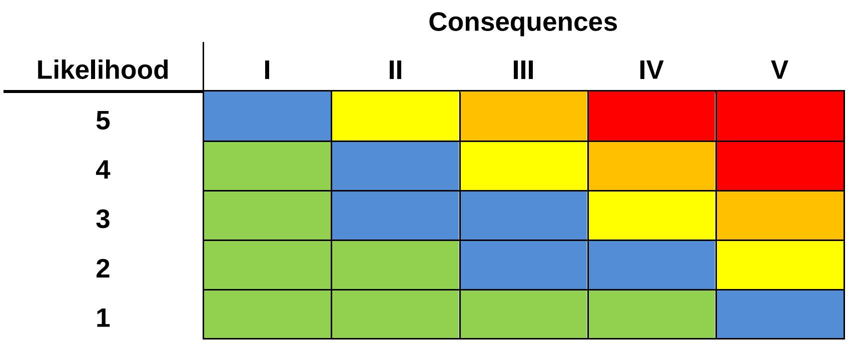

Figure 3.10 The risk-based planning framework (adapted from Saunders, 2012b).

Not all consent categories may be required. The consent categories that are used need to relate to the level of risk associated with the hazard, and the desires of the community to address this risk. As such, it may be that a council chooses to use only the following consent categories when implementing the risk-based approach: permitted, discretionary, and non-complying.

3.4.1 Public views on risk acceptability and mitigation

At this stage, stakeholder acceptance of the determined levels of risk and associated consent categories are assessed. It is also when ideas about risk mitigation may be reviewed – particularly in relation to areas of greatest contention.

Risk communication at this step serves two purposes:

1. To get feedback from stakeholders and affected parties on whether the risk categories and/or consent levels are appropriate, and to check for perverse outcomes; and
2. To discuss what trade-offs might be made between extra margins of safety, possible benefits, and costs of mitigation.

The actions that should be undertaken for completing this step include:

- A review of the proposed risk categories and the current and proposed land use activity, and identification of the areas of greatest contention;
- Getting stakeholder input to identify any control options for reducing risk. If necessary, review the risk control measures in terms of their impact on risk reduction, likely costs, and potential increased risk for other parties. Re-present these to stakeholders and affected parties for discussion about acceptable costs and benefits, and identification of any additional risks associated with the measures;
- Checking whether there are new stakeholders, affected parties, or issues associated with implementing control measures, and revise the stakeholder analysis and engagement strategy to address this.

Key actions for this step include:

1. Sharing information:
    - Clarify the purpose of this step – i.e., to agree on categorisations of risk as acceptable, tolerable or intolerable, so that appropriate decisions can be made about future land use;
    - Be transparent about the rationale (i.e., method and assumptions) behind the proposed levels of risk and the consent categories; and
    - Discuss what is known about the likely impact of the proposed consent categories on foreseeable land use.
2. Questions to ask and information to gather:
    - Are the risk thresholds levels for tolerable, intolerable, and acceptable appropriate?
    - Are there concerns about the impacts on land use?
    - Are risk trade-offs possible and/or desirable?
    - Are risk reduction measures desirable and acceptable?
    - Is further consultation/discussion required before recommendations are made?
3. Be prepared:
    - For changes from initial risk perceptions, as earlier steps (1 and 2) may have raised awareness the natural hazard, the decisions, and the planning options associated with this.
    - This stage may require several iterations.

Engagement approach options include holding working groups (e.g., community board members, CDEM representatives, iwi representatives, and local stakeholders) to hold initial discussions of the issues at this stage. This group may also serve as a conduit for wider public engagement.

3.4.2 Risk-based approach assumptions

The assumptions associated with the use of the risk-based approach are as follows:

- The decision around categorising the levels of risk (i.e., 1-4 permitted, 5-9 controlled, etc.) is undertaken with consultation and engagement with local communities and stakeholders;
- Not all consent categories (i.e., permitted, controlled, restricted discretionary, discretionary, non-complying, prohibited) may be required.

3.5 Step 5 –– Monitoring and evaluation

While this is listed as a final step, monitoring and evaluation are an integral component of the risk-based approach and occur throughout the entire process. Two key questions to be asked are:

- Do people agree with the mitigation options, residual risks and long-term outcomes?
- Did the communication and engagement strategy meet the original goals and/or public expectations around the opportunities to contribute to the decision?

There are four areas that require attention in this step: evaluating risk reduction effectiveness, acceptance of mitigation options, residual risks, and the communication and engagement strategy. These are each discussed below.

3.5.1 Evaluate the effectiveness of risk reduction measures

When evaluating the effectiveness of risk reduction measures, consideration should be given to the effects of the measures on the receiving environment. For example, a sea wall may have been installed to reduce coastal erosion, but the construction of this wall has resulted in the loss of a beach. The following questions can provide a framework for considering the effectiveness of risk reduction measures:

- Are the effects continuous or short term?
- Are the effects sustainable?
- Is it cost effective, or could the same results be achieved at lower cost by other means?
- What are the environmental impacts of the risk reduction measure?

3.5.2 Evaluate acceptance of mitigation options

The following questions can provide a framework for evaluating the acceptance of the mitigation options that may have been implemented to reduce the risks from natural hazards:

- Have mitigation measures been accepted by local stakeholders?
- What are the social, environmental, and economic impacts?
- Are the risks and benefits distributed fairly?

3.5.3 Evaluate acceptance of residual risks

The following questions can provide a framework for evaluating the acceptance of any residual risks following the installation of the mitigation options:

- Are residual risks accepted by local stakeholders?
- Have the mitigation options introduced new risks?
- Have the residual risks changed over time?

3.5.4 Evaluate communication and engagement strategy

It is important to consider, at all stages of the risk-based approach, whether new stakeholders and/or affected parties whose views should be included have emerged as a result of discussions, meetings, and information exchange steps. This may require revisiting the stakeholder analysis and new decisions on how to involve these new parties in further communications.

It is also important to assess whether the engagement approach is satisfactorily meeting the initial goals agreed to in Step 1. For instance, the initial goals for communication and engagement may include:

1. Building awareness of hazards and their impact on land use;
2. Ascertaining public appetite for expenditure on risk mitigation; and
3. Gaining public support for council efforts in risk management.

On-going monitoring of the achievement of these goals (e.g., feedback at meetings, formal post-workshop evaluations, phone polling, or discussions with community leaders) enables suitable adjustments to be made to further communication and engagement efforts.

3.5.5 Monitoring and evaluating assumptions

The assumptions associated with monitoring and evaluating the risk-based approach are as follows:

- The process of monitoring and reviewing policy will be undertaken as part of the Resource Management Act process.
- The monitor and review process will be resourced, and any findings will be given due consideration.

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4.0 LIMITATIONS AND UNCERTAINTIES

There are a number of limitations and uncertainties relating to the risk-based approach. These are as follows:

4.1.1.1 Know your hazard limitations

The limitations associated with knowing your hazard are as follows:

- If focussing on a single hazard, you need to be aware of other hazards that can result, i.e., cascading hazards. For example, if assessing just the earthquake hazard, you need to be aware that an earthquake may trigger land instability, liquefaction, and tsunami. These need to be included in the assessment in order for their consequences to be assessed. The consequence assessment should include all hazards resulting from a single trigger event.

4.1.1.2 Know your hazard uncertainties

The uncertainties associated with knowing your hazard are as follows:

- Any hazard assessment will involve uncertainties around the nature of the hazard; and
- If modelling is involved, uncertainties within the model need to be acknowledged.

4.1.1.3 Limitations of the consequence table

The limitations associated with the use of the consequence table are as follows:

- Scalability – while the table works well at the level of spatial plans, regional policy statements or district plan policies, or for larger scale developments (brownfield and greenfield), it is more limited at the level of individual consent applications. In this case, a precautionary approach should be applied if required; and
- As with all frameworks that require specialist knowledge input, the content of the table has been developed with the best available knowledge at the time. This should not be a reason for not utilising the information – rather, where there are uncertainties around information (refer to Assumptions in previous sections), the precautionary principle should be applied.

4.1.1.4 Consequence table uncertainties

The uncertainties associated with the consequence table are as follows:

- The parameters within the table have been based upon best available expert knowledge and opinion at the time of development. These may change with time and use.

4.1.1.5 Likelihood uncertainties

The uncertainties associated with the use of the likelihood table are as follows:

- Likelihoods of certain hazard events are based on the best understanding of the hazard at the time the assessment was undertaken. With time, and as the science and understanding of the hazard improves, there could be changes in the likelihood of the event.

4.1.1.6 Risk-based approach uncertainties

The uncertainties associated with the use of the risk-based approach are as follows:

- Individuals' levels of risk acceptance are different, so final consent categories may reflect this; and
- Political influence and decision makers' understanding and motives.

4.1.1.7 Monitoring and evaluating limitations

The limitations associated with monitoring and evaluating the risk-based approach are as follows:

- Need to have base line data to provide something to measure progress against.

4.1.1.8 Monitoring and evaluating uncertainties

The uncertainties associated with monitoring and evaluating the risk-based approach are as follows:

- Process and quality of the monitoring process; and
- Quality of base line data to allow for monitoring.

5.0 EXAMPLES

In this section of the report, several examples will be presented on how the risk-based approach (section 5.1) and associated engagement strategy (section 5.2) can be implemented. Not all of the examples presented on the webpage are repeated in this section. If the full selection of examples is required, these can be found at http://www.gns.cri.nz/Home/RBP/Risk-based-planning/A-toolbox/Examples.

5.1 RISK-BASED APPROACH EXAMPLES

The following examples are a selection of:

1. Existing risk-based approaches that are similar to the approach presented in this report, and are currently available to planners to use;
2. Examples demonstrating how the risk-based approach presented in this report can be used in the context of the current planning legislation; and
3. Implementing community engagement methods.

The examples presented here are:

- Ministry for the Environment – existing risk based approach: a central government guide promoting a risk-based approach;
- Regional Policy Statement and District Plan Guidance: how the risk-based approach can be incorporated into a regional policy statement and district plan;
- Eastern Coromandel Tsunami Strategy: the first in a series of joint territorial and regional community based planning initiatives;
- Mapua /Ruby Bay plan change: community engagement on complex, multiple hazards and planning issues; and
- Community based strategic risk management: - Otago Coastal communities: trial of a full local risk assessment workshop for communities affected by coastal hazards.

5.1.1 Ministry for the Environment – Existing risk-based approach

In 2010, the Ministry for the Environment produced the report *“Preparing for future flooding: a guide for local government in New Zealand”* (Ministry for the Environment, 2010). This guidance is based on a risk-based approach to flooding, using principles similar to those outlined in this toolbox. In particular, the guide provides an overview of the risk assessment process, including:

1. Rating the level of consequences from a flood (from significant to catastrophic);
2. Rating the likelihood of a specific flood event occurring (rare to almost certain); and
3. Assigning a risk level, given both the consequences and likelihood (low to extreme).

The above approach reflects the risk-based approach presented in this toolbox, in that the consequences are determined before the likelihood (with the same quantitative descriptors). A risk level is then assigned. Levels of risk are categorised from low to extreme, which for this toolbox is classified on whether a level of risk is acceptable, tolerable or intolerable. In the examples provided in the MfE guidance, the levels of risk (low to extreme) could be converted to acceptable, tolerable and intolerable levels of risk.

An example of a *consequence table* is presented, which includes social (public safety and community disruption), cultural, economic (local economy and growth; lifelines), and environment (Appendix 4). This table has a similar format to the consequence table in this toolbox, with similar consequence categories and quantitative descriptions for public safety/health and safety. The consequence table in this toolbox goes further than the MfE example, by including quantitative descriptors that allow for a measure of consequence.

An example of a *likelihood table* is provided for a flood occurring within a given time horizon (Appendix 4). The results are shown as a percentage, which can then be converted into a likelihood rating. The advantage of the table is that by providing percentages for a number of flood recurrence intervals across a range of time frames, the final likelihood rating can be more accurately specified.

A risk level is then assigned using a matrix, using the qualitative descriptors low, moderate, high, and extreme (Appendix 4).

While this MfE example differs slightly from that presented in this toolbox, it does show a very similar framework and process.

5.1.2 Matata Debris Flow Hazard – a risk-based approach

In this section the Matata debris flow that occurred in March 2005 is tested using the risk-based approach presented in this report. The debris flow resulted from a high intensity rainfall event. To undertake this assessment, information derived from the following sources has been used:

- Statistics New Zealand – population and GDP figures;
- Journal articles (Bull et al., 2010) (return period and damage from the debris flow); and
- Cost of deaths and injuries (Ministry of Transport, 2012).

5.1.2.1 Step 1 – Know your hazard

The keys inputs that are relevant to the consideration of the debris flow for the Matata area using a risk-based approach are as follows:

- Number of properties in the hazard zone – 122 properties;
- Number of buildings the hazard zone – 114 dwellings;
- Likely number of occupants – 300 (based on an average occupancy of 2.64 per dwelling) (Statistics New Zealand, 2006a);
- Regional GDP – $4.318 billion (2003) (Statistics New Zealand, 2006b);
- Lifelines – road, rail, power, telecommunications, water;
- Critical buildings – none in the hazard zone;
- Social cultural buildings – none in the hazard zone that we are aware of;
- Building value – (based on average value of a dwelling in Matata – 114 x $250,000) $28.5 million;
- Debris flow return period - 1:500; and
- Cost of a death $3.77 million and cost of an injury $207,000 (Ministry of Transport, 2012).

5.1.2.2 Step 2 – Consequence analysis

Severity of Impact	Built				Economic	Health & Safety
	Social/Cultural	Buildings	Critical Buildings	Lifelines		
Catastrophic (V)	≥25% of buildings of social/cultural significance within hazard zone have functionality compromised	≥50% of affected buildings [illegible]thin hazard zo[illegible]ve fu[illegible]lity compromised	≥25% of critical facilities within hazard zone have functionality compromised	Out of service for > 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for > 6 months (affecting < 20% of the town/city population)	> 10% of regional GDP	> 101 dead and/or > 1001 inj.
Major (IV)	11-24% of buildings of social/cultural significance within hazard zone have functionality compromised	21-49% of buildings within hazard zone have functionality compromised	11-24% of buildings within hazard zone have functionality compromised	Out of service for 1 week – 1 month (affecting ≥20% of th[illegible] town/city population) OR suburbs out [illegible] for 6 weeks to 6 months (affecting [illegible]% of the town/city population people)	1-9.99% of regional GDP	11 – 100 dead and/or 101 – 1000 injured
Moderate (III)	6-10% of buildings of social/cultural significance within hazard zone have functionality compromised	11-20% of buildings within hazard zone have functionality compromised	6-10% of buildings within hazard zone have functionality compromised	Out of service for 1 day to 1 week (affecting ≥20% of the town/city population people) OR suburbs out of service for 1 week to 6 weeks (affecting < 20% of the town/city population)	0.1-0.99% of re[illegible]onal [illegible]	2 – 10 dead and/or 11 – 100 injured
Minor (II)	1-5% of buildings of social/cultural significance within hazard zone have functionality compromised	2-10% of buildings within hazard zone have functionality compromised	1-5% of buildings within hazard zone have functionality compromised	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting < 20% of the town/city population)	0.01-0.09 % of regional GDP	<= 1 dead and/or 1 – 10 injured
Insignificant (I)	No buildings of social/cultural significance [illegible]ithin hazard zone ha[illegible]ctionality com[illegible]sed	< 1% of affected buildings within hazard zone have functionality compromised	No damage within hazard z[illegible]e, fully fu[illegible]al	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for up to 1 day (affecting < 20% of the town/city population)	<0.01% of regional GDP	No dead No i[illegible]red

Figure 5.1 Consequence analysis for the 2005 Matata debris flow.

Using the consequence table above, the severity of the impact for the identified consequences is as follows:

Table 5.1 Consequence analysis for the 2005 Matata debris flow.

Consequence	Severity of Impact
Buildings of Social and Cultural Value	Insignificant – none affected
Buildings	Catastrophic - All buildings in hazard zone had their functionality compromised
Critical Buildings	Insignificant – none affected
Lifeline	Major - Significant damage to road and rail which was out of service for greater than a week. Due to the importance of these links, greater than 20% of the population was affected.
Economic	Moderate - $28,500,000 / $4,318,000,000) x 100 = 0.66% of regional GDP (no deaths or injuries were required to be factored into the equation)
Health and safety	Insignificant – no deaths or injuries

5.1.2.3 Step 3 – Likelihood analysis

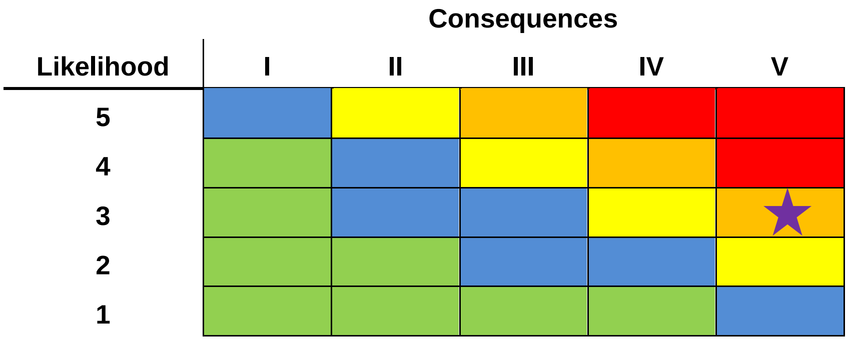
Using the likelihood table below (Figure 5.2), the debris flow is considered to be unlikely (level 3), as the return period is estimated to be once every 500 years.

Level	Descriptor	Description	Indicative frequency
5	Likely	The event has occurred several times in your lifetime	Up to once every 50 years
4	Possible	The event might occur once in your lifetime	Once every 51 – 100 years
3	Unlikely	The event does occur somewhere from time to time	Once every 101 - 1000 years
2	Rare	Possible but not expected to occur except in exceptional circumstances	Once every 1001 – 2,500 years
1	Very rare	Possible but not expected to occur except in exceptional circumstances	2,501 years plus

Figure 5.2 Likelihood analysis for the 2005 Matata debris flow.

5.1.2.4 Step 4 – Take a risk-based approach

Using the severity of impact calculated in Step 2 and the likelihood number calculated in Step 3, the level of risk from the debris flow is considered to tolerable. This translates to a Discretionary Activity using the matrix in Figure 5.3.



Level of risk	Consent
Acceptable	Permitted
Acceptable	Controlled
Tolerable	Restricted Discretionary
Tolerable	Discretionary
Intolerable	Non complying, prohibited

Figure 5.3 Risk-based approach for the 2005 Matata debris flow.

5.1.3 Regional Policy Statement and District Plan Examples

The second generation Proposed Bay of Plenty Regional Policy Statement (Proposed RPS) (Bay of Plenty Regional Council) has taken a risk-based approach to natural hazards. Publicly notified in November 2010, some provisions are currently under appeal to the Environment Court (including the natural hazard provisions). Notwithstanding this, the Proposed RPS provides an example of how an RPS can incorporate a risk-based approach to natural hazards, particularly around acceptable, tolerable and intolerable risk levels.

Beban and Saunders (2013) present a district plan chapter that incorporates the risk-based approach. The chapter has been prepared for 'Urban Valley', a fictitious urbanised city in

New Zealand. The objectives and policies of the district plan chapter identify the risk outcomes sought for natural hazards in Urban Valley. The corresponding rules have been developed based on the risk to existing and future development, while ensuring that the risk outcomes sought under the objectives and policies are achieved. It is assumed these rules are associated with hazards zones, as shown on planning maps. These hazards zones show the extent of an area affected by a natural hazard, based on a likelihood determined by the council. The district plan chapter also sets risk-based anticipated environmental outcomes, methods of implementation and monitoring approaches and outcomes.

This district plan chapter is not intended to be a 'model chapter' that can be used in all district plans by all local authorities. Rather, it demonstrates how a comprehensive risk-based approach to planning for natural hazards can be undertaken under the existing legislative framework in New Zealand (Beban & Saunders, 2013). The district plan chapter is available at: http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Risk-Society/Societal-Resilience/Policy-and-Planning.

5.2 EXAMPLES OF NATURAL HAZARD RISK COMMUNICATION AND PUBLIC ENGAGEMENT

The following examples are a selection of real-life case studies in which councils and other agencies have implemented public engagement on a variety of natural hazard issues. The purpose of these examples is to show that councils around New Zealand are trying innovative ways to address natural hazard risk and land use planning issues – from these approaches they are learning what works and what does not.

5.2.1 Public engagement – Eastern Coromandel Tsunami Strategy

The aim of the Eastern Coromandel Tsunami Strategy project (started 2007/2008 - present) is to work with communities to minimise risks from tsunami hazards by developing and implementing risk mitigation actions in three categories:

i. land use planning;

ii. emergency management (warnings and evacuation); and

iii. public education and awareness.

The project is undertaken in stages, involving individual communities along the east coast of the Coromandel Peninsula. Whitianga was chosen as the starting point as it was identified as having the highest risk from tsunami (Table 5.2).

Table 5.2 Eastern Coromandel Tsunami Strategy: Whitianga public engagement example.

Eastern Coromandel Tsunami Strategy: Whitianga public engagement example	
Partners and key personnel	The project is a partnership between the Waikato Regional Council (WRC) and the Thames Coromandel District Council (TCDC). Each has multiple roles and responsibilities, (e.g., WRC provides technical and scientific input, TCDC provides local emergency management leadership). Project partners also include the Mercury Bay Community Board (MBCB) and the Whitianga Emergency Management Committee.
Overall approach	In discussion with the MBCB, a **community working group** (CWG) was formed, including members from the MBCB, Emergency Management Committee, and interested local stakeholders (e.g., local developer, rest home proprietor, hotel proprietor, and principal of the Mercury Bay Area School). The community working group acted as a

Eastern Coromandel Tsunami Strategy: Whitianga public engagement example	
	conduit for public input, managed, and contributed to public open days, and developed the draft tsunami risk management plan. Two well-attended public open days were held. Features of these were: • Technical information about the tsunami risk was presented as mapped inundation areas (including depth and flow) superimposed on aerial photos, clearly illustrating likely impact areas. • An open forum where the public could review material and have individual conversations with local council staff, technical and scientific advisors, CDEM personnel, community board members, elected representatives (including the Mayor) and local community response personnel (fire and police). • A prize draw was held for admissions with a written response to the question • '*What do you think should be done to help this community reduce the risks from tsunami?'* • The venue was the Town Hall, and the timing coincided with Queen's Birthday holiday to maximise attendance of non-permanent residents. • The timing closely followed the major tsunami that struck Japan in 2011. Further engagement activities: • Community summary document – simple outline of tsunami, risks to coastal communities, and future options. • The community working group got verbal feedback before, during and after the open days. • Written feedback (answers to general questions about tsunami risk management) was sought after the open days. • A Draft Whitianga Tsunami Risk Management Plan was compiled using public input from the open days, community working group public liaison, and written feedback. This was then made available for public review.
Did it turn out to be a good idea?	The goals of the public open days were to i. raise awareness about the project; ii. test levels of awareness; and iii. get feedback on what should be done to reduce risks locally. These goals were all achieved. There was good acceptance and buy in of the project overall from TCDC, WRC and from the public – which means people will think more about it. The MBCB approved the Whitianga Tsunami Risk Management Plan. Both TCDC and WRC are implementing the plan, but progress has not been as fast as anticipated. A second open day held between Christmas and New Year was unsuccessful (timing not attractive to people) and in hindsight it was unnecessary.
Key points about approach	• Working group driving the project – local people (don't call it a committee) • Project champion (Chair of the MBCB). • Format of the public days – allowed good, non-confrontational discussion and information exchange. • Up-to-date – robust scientific information used. • Multiple avenues for feedback. • Linked land use planning, emergency management and community awareness.

Eastern Coromandel Tsunami Strategy: Whitianga public engagement example	
When to use this approach	The project approach is best suited to a sub-regional level, 'community by community' initiative for tsunami or flood hazard management, but could also be used for other hazards. It is not a suitable process for a large urban area – unless broken into smaller communities.
Links and Contacts	Community summary document - The Eastern Coromandel Tsunami Strategy - Managing tsunami risks in Whitianga (Thames Coromandel District Council) Brendan Morris – project manager (http://www.naturalhazards.co.nz/member.jsp?id=25)

5.2.2 Land-use planning for multiple issues and natural hazards – Mapua and Ruby Bay example

The areas of Ruby Bay and Mapua in the Tasman region have an array of complex planning and natural hazard issues. They are subject to coastal inundation and erosion, as well as to increased risk from freshwater flooding associated with climate change. The area has projected growth and aspirations for development. Information about the hazards has changed since planning provisions were made (e.g., there are new MFE sea level rise guidelines) and the original provisions are no longer regarded as adequate.

Decisions are needed regarding the extent of the hazard area, future urban growth, management of risk for existing properties, maintenance of existing public protection works and provision of services (e.g., water, wastewater and storm water).

The project began in 2004 and a plan change is nearing completion. It is currently at the appeal stage, with three of four appeals resolved.

Table 5.3 Mapua and Ruby Bay example.

Mapua and Ruby Bay example	
Partners and key personnel	• Tasman District Council (TDC), and the Mapua and Districts Community Association. • Landowners (including some prospective developers). • Residents and wider community stakeholders concerned about issues such as coastal access and archaeological site protection. • A joint CRI (GNS, NIWA, AGResearch) project conducted a survey and provided good background information on Mapua/Ruby Bay communities (e.g., climate change attitudes, trusted sources of information, expectations of local government, acceptable costs for remedial activity). • Planning consultant – structure plan and Section 32 analysis.
Overall approach	1. A workshop was held with Councillors to present up-to-date projections of natural hazard risk; costs associated with maintaining public protection works; and options for Council's response in a worst-case scenario. LIDAR contour data was used to develop presentation materials. The CEO of TDC was involved and provided useful input. This was done early in the project, and before engagement with the public. 2. Public engagement began with discussion documents, assessing public response to the issues. 3. TDC staff attended monthly Community Association meetings. These meetings were productive, although at times heated. They could also be dominated by particular viewpoints.

Mapua and Ruby Bay example	
	4. Open days were held and were opportunities for those who preferred to discuss issues one-on-one with staff. 5. Feedback was extensive (this is an articulate community) and was incorporated in a draft structure plan, alongside TDC's own risk analysis and work on different options. The structure plan laid out possible future areas for land use, and options for growth – presenting a clear vision without the complexity of rules. It was released in an attractive easy-to-read booklet. 6. The ideas in the structure plan were later refined and incorporated in a draft plan change. 7. To date the project has raised awareness and created a vision for managing growth and natural hazard risk in the area. Some decisions have been made about protection works (not a prohibited activity). The work is on-going.
Did it turn out to be a good idea?	• Gaining support from political representatives: holding the coastal hazard workshop with Councillors (with the CEO support) and ensuring the issues were well understood and supported before starting public engagement was critical to the project. • Structure plan: this was a very useful way to informally present the concepts of a risk-management-based land use strategy; it was a non-threatening precursor to a formal plan change. The first publication was a pamphlet that was too simple and not so successful. • Providing options for public input: there were strong emotions at the Community Association meetings, and while it was useful to have a forum where these could be expressed, particular views can dominate and it was important that there were alternative options for public engagement. • The public survey conducted through the joint CRI project was helpful because it was one step removed from TDC and offered another line of enquiry into public perceptions and views. • Documenting the options that TDC developed and other people suggested for the proposed district plan change section 32 analysis. • LIDAR provided good clear mapping outputs that supported communications. • Maintaining internal communication – it was important that all departments of council were aware of the strategy around the plan change development to avoid contradictory or undermining activity.
Key points about approach	• Mapua/Ruby Bay plan change has been a slow process. New information about natural hazard risk can be distressing and people need time to absorb it, to develop an understanding of what it means to them and to consider their own personal strategies. • The process revealed people had different levels of understanding about the natural hazard risk, and at times unrealistic expectations about the ease of providing mitigation. The approach to managing conflict was to slow down and be patient with people. • This is a resource-intensive process and may not be possible or suitable for all coastal communities. • It is harder to quantify risk with multiple hazards – people dispute that they will happen at same time.

Mapua and Ruby Bay example	
When to use this approach	Good approach for a relatively discrete community with a range of issues which includes natural hazards.
Links and Contacts	Environment and Planning department – Tasman District Council Mapua/Ruby Bay structure plan http://www.tasman.govt.nz/policy/plans/tasman-resource-management-plan/planning-proposals-and-summaries/draft-planning-proposals/mapua-and-ruby-bay-draft-plan-change/ Stewart et al., (2010). Mapua/Ruby Bay Coastal Management Study.

5.2.3 Community-based strategic risk management: Climate change impacts on Otago coastal communities

In 2008/2009, MWH initiated a pilot project aimed at providing a way for local government to work with communities on risk assessment and planning for challenges associated with climate change and sea level rise. This project was undertaken in Otago (Table 5.4)

Table 5.4 Otago coastal communities example.

Otago coastal communities example	
Partners and key personnel	A one-day workshop, run with members of the Ocean Grove seaside community in Otago. People were invited using public notices and leaflet drops. The workshop had three components: 1. Presentations – on climate change and ocean processes by NIWA and University of Otago scientists; 2. Linking general predictions to the local context – an interactive discussion about the broad impacts of climate hazards on local property, environment and infrastructure; and 3. A risk management process – a workshop session progressing through risk identification, severity assessment, and management options.
Overall approach	• Provide a replicable format for councils to use across communities; • Raise community awareness of local impacts of climate change; • Create an enabling environment for long-term planning for natural hazards.
Did it turn out to be a good idea?	• Presentations worked well – particularly the more they shifted focus from the general issues to the local implications; • The link-to-the-local-context exercise helped people think beyond their own properties to community-wide, financial and social implications of natural hazard events; • The risk assessment was not the same as a professional would achieve but had great value for building people's capacity to understand the issues at stake; • Facilitation relied on those with expertise in risk assessment.
Key points about approach	• One day is intense – consider spreading the workshop over two evenings; • Simplify the risk assessment matrix – the aim is to stimulate good discussions; • Find an immediate concern to illustrate long-term issues. A horizon of 50 – 100 years is too far away for people to be concerned with. For example, climate change can link to increases in storms; earthquakes to rises in insurance premiums.
When to use this approach	• This approach builds capacity for communities to make contributions to planning decisions that are clear and focussed – so begin the long-term planning process with something like this and repeat over time. • Has wide application for either a specific issue (e.g., coastal erosion, or solid waste) or a broad range of issues (e.g., urban design, sustainability).
Links and Contacts	Sally Dicey, Dunedin City Council; John Cocks – MWH, Dunedin

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6.0 SUMMARY

This report has detailed the content of the online risk-based land use planning toolkit, available at http://www.gns.cri.nz/Home/RBP/Risk-based-planning. The aim of the risk-based land use planning approach is to provide a framework to enable councils – regional, territorial and unitary – and communities to determine levels of risk from natural hazards. It offers a new approach that focuses on consequences of natural hazard events. It presents techniques, practice steps, and options for enabling local government to review multiple natural hazard risks, both within councils and with external stakeholders.

The approach follows five key steps:

- Know your hazard;
- Determine the severity of the consequences;
- Evaluate the likelihood of an event;
- Take a risk-based approach; and
- Monitor and evaluate.

At each step a communication and engagement approach is required, for both internal (i.e., councils) and external stakeholders and communities. A summary of the approach is provided in the following table (Table 6.1).

Section 2 of this report provided the legislative context for managing natural hazards, with particular regard to the RMA, CDEMA, Building Act, and LGA. This section also provided an overview of the principles of risk communication. Each of these helped to set the scene for risk-based planning, and provide justification for why risk communication and engagement is important to achieving good outcomes.

Section 3 presented the five-step risk-based approach and associated communication and engagement tasks. This was followed in Section 4 by the limitations and uncertainties associated with the approach. Examples – both national and international – of the approach and engagement strategies are provided in Section 5.

The methodology used and additional information is provided in the Appendices.

The outcome of this report – and the online toolkit – is to provide guidance to decision makers, planners, emergency management officers, and others with an interest in this approach, on how risk-based planning can be implemented. As such, it provides a rational approach to determining levels of risk.

Table 6.1 Summary of risk-based approach.

Step 1 - Know your hazard	Risk analysis tasks	Risk communication tasks
The purpose of this step is firstly to determine the scope of the issue to be addressed, to identify the team of professionals and experts whose input will be needed, and to cover the important base elements of a public engagement strategy. The second stage of this step is to assemble hazard information for analysis and review, and to prepare materials for engagement with affected parties and/or discussion by expert panels or representative groups.	Scoping – 1. **Establish problem/decision parameters** (e.g., what is the information (e.g., plan change, growth strategy?) How will the information inform policy? What scale is the information required at? What is the time frame for the decision? What are the risk outcomes sought (e.g., risk reduction, not increasing existing levels of risk)? 2. **Identify team and resource needs** (e.g., what expert information is required and who is available to provide it? Who is able to provide useful local context information, e.g., CDEM.	1. **Prepare an** engagement approach including stakeholder analysis, context analysis, assessment of existing perceptions. 2. **Begin** internal communication within local government agency including public representatives, and other departments. 3. **Begin** external communication (e.g., early notification of upcoming decisions).
	Preliminary assessment and information preparation 3. **Identify hazard information gaps and uncertainty**, gather further information where existing information is lacking or does not meet requirements. 4. **Gather background information** for consequences analysis (e.g., inundation maps, fragility curves, regional GDP figures, land use plans). 5. **Agree on an information management system** to store, retrieve, and access hazard information.	4. **Identify hazard information gaps and uncertainties** Identify useful information for sharing with stakeholders; clarify areas of uncertainty, note gaps and likely areas of contention. Also consider hazard complexity. 5. **Update engagement approach** – following a hazard information review (new stakeholders may become apparent)
Step 2 - Determine severity of consequences	**Risk analysis tasks**	**Risk communication tasks**
The purpose of this stage is to build a picture of the possible consequences of a natural hazard event. Natural hazard information, coupled with information about the proposed development and existing land use is used to undertake an assessment of consequences. Information about the natural hazard consequences and the development is confirmed through engagement with specialists, those with local knowledge, and stakeholders.	1. **Determine** consequences for a) individual and b) cascading hazards and assess against a consequence table. 2. **Determine** severity of consequences for the hazard event with the highest severity of impact to set the consequence level.	1. **Validate hazard information:** Use the engagement approach identified earlier to share, review and update information about natural hazards and potential consequences. 2. **Update stakeholder analysis** (following consequences analysis new stakeholders may become apparent). 3. **Assess engagement approach** – is it still right for the situation? 4. **Record decisions and assumptions** for transparency.
Step 3 - Evaluate likelihood of an event	**Risk analysis tasks**	**Risk communication tasks**
The purpose of this stage is to assess the likelihood of any event that will result in the consequences outlined in Step 2.	1. **Assess the likelihood** of individual and cumulative hazard events (cascading hazards are addressed against the trigger hazard). 2. Cumulative hazards may result in an increase in **likelihood**, e.g., three cumulative hazards which are 'possible' may increase overall likelihood to 'likely'. 3. In some instances the **likelihood** will be required for modelling and assessing the hazard (Step 1).	1. **Record decisions and assumptions** about likelihood and occurrence for transparency and use in communication at Step 4.
Step 4. Take a risk-based approach	**Risk analysis tasks**	**Risk communication tasks**
This is the stage where stakeholder acceptance of the calculated levels of risk and associated consent categories (and the implications of these) are assessed. It is also when ideas about risk mitigation may emerge – particularly in relation to areas of greatest contention. Discussions with stakeholders and affected parties will include whether the risk categories and/or consent levels are appropriate, and what trade-offs might be made between extra margins of safety, possible benefits, and costs of mitigation.	1. **Determine** levels of risk for policy. 2. **Determine** resource consent activity status based on levels of risk. 3. **Assess** against assessment criteria and anticipated environmental outcomes. 4. **Identify** and consider risk mitigation options.	1. **Validate levels of risk for policy and consent categories with stakeholders** - i.e., confirm and check for perverse outcomes. 2. **Engage stakeholders in identifying and reviewing risk mitigation options**. 3. **Update stakeholder analysis and engagement approach** (after mitigation options new stakeholders may appear). 4. Hold forums/meetings/public events in accordance with engagement strategy, e.g., with representative groups, expert panels or communities. (See 'key points for public forums on local hazards and their impacts').
Step 5 Monitor and evaluate	**Risk analysis tasks**	**Risk communication tasks**
While evaluation and monitoring have taken place throughout at this final stage, the outcomes of the process and the process itself are assessed to determine any further necessary actions.	1. **Evaluate risk-reduction effectiveness**, i.e., risks are not increased. 2. **Plan to change or revisit strategy** if required to ensure risk outcomes are being achieved.	1. **Evaluate** acceptance of mitigation options. 2. **Evaluate** acceptance of residual risks. 3. **Evaluate** communication and engagement strategy. 4. **Communicate** risk outcomes with stakeholders and community and review policy if required.

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APPENDICES

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APPENDIX 1: METHODOLOGY

This appendix provides an overview of the methodologies used to develop the content for the toolkit.

A1.1 PARTICIPATORY ACTION RESEARCH

Participatory Action Research (PAR) was the primary method for undertaking the project. Rather than undertaking research independent of the practical end user (i.e., council staff), which could lead to results that have no support or are not able to be implemented, the PAR approach allowed the involvement of council staff within the research (Cameron, 2007), promotes engagement and subsequent implementation and use of concepts provided, and benefits future risk reduction initiatives. The councils acknowledged how well this approach worked for them, as it provided staff members the opportunity to learn along the way.

While there is no fixed formula for designing, practicing, and implementing PAR projects, nor one overriding theoretical framework that underpins PAR processes (McIntyre, 2008), there are 'spirals' of action which present a basic methodology which has three main steps which repeat: to plan, act and observe, and reflect (see Figure A 1.1). This is the approach adopted for this project.

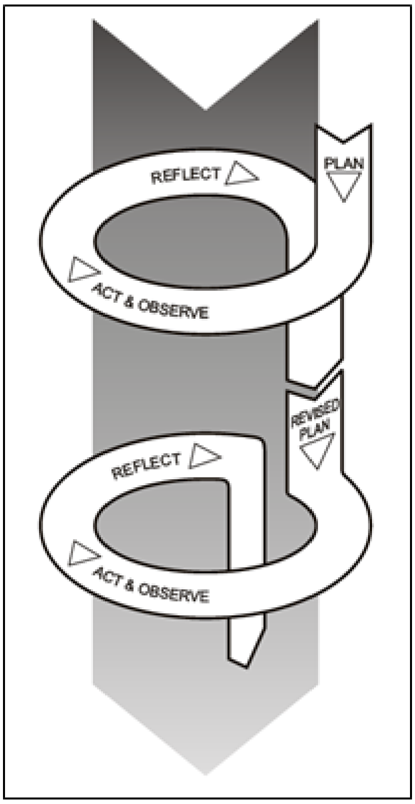

Figure A 1.1 Spiral of participatory action research (Kemmis & Wilkinson, 1998).

The steps taken for the project are summarised in Table A 1.1.

Table A 1.1 Summary of PAR steps employed for four key areas in this project.

STEP	ACTION	OUTCOME			
		Risk-based framework	**Engagement strategy**	**District plan chapter**	**Web-based toolkit**
Question	Question, reflect	How can the existing risk-based land use planning framework be improved to encourage better decision making for natural hazard risk reduction?	How can decision makers, communities and key stakeholders be actively involved in the risk-based approach?	How can the risk-based approach be incorporated into a district plan?	
Plan	Develop a research plan, investigate, reflect	Developed a research strategy – formation of a steering group, case study workshop locations, review of legislative framework, review engagement literature.	Review international literature, national and international examples.	Listed district plans to review; Developed a structure for the chapter.	
Act and observe	Implement plan, observe, analyse	Met with steering group, undertake workshop with preliminary framework.	Present overall issues associated with risk engagement and communication and land use planning to steering group for comment, and present to local government participants at the 6th Australasian Natural Hazards Management Conference (Saunders, Beban, & Kilvington, 2012).	Researched district plans; began drafting provisions and reviewed informally by GNS Science staff.	
Reflect	Reflect, review, investigations, more questions.	Reflected on results of above, review thinking, investigate more supporting literature, questions raised on consequence table	Reflected on divergence between New Zealand conditions and international conditions. Identify new research question.	Reflected on the feedback received from GNS Science staff. Undertook further research into how natural hazards are represented in planning documents.	
Plan	Investigate, reflect, plan future workshop.	Further research and expert opinion sought on consequence table, testing of the table on previous natural hazard events, plan workshop in Hawke's Bay.	How can good practice in public engagement and risk communication be integrated into the risk-based planning approach?	Redrafted the provisions and tested the new rules using existing hazard information.	Researched web format options, ask steering group for web layout ideas.
Act and observe	Implement plan, observe, analyse.	Undertook workshop, reviewed approach based on feedback received.	Undertook workshop at Hawke's Bay.	Sent a draft of the district plan chapter to Thames – Coromandel District Council and sought their feedback.	Ideas researched.
Reflect	Reflect, review, investigations, more questions	Reflected on workshop feedback, reviewed draft framework incorporating feedback, further investigations required into approach.	Reflected on workshop feedback, review draft framework incorporating feedback, further investigations required into approach.	Reflected on the feedback received from Thames – Coromandel District Council and made amendments based on their comments.	One recommended format supported, further assessment of website undertaken.
Plan	Investigate, reflect, amend research plan	Planned second workshop to review draft framework with Bay of Plenty. Started drafting best-practice district plan chapter.	What steps, tips and support material is most useful to include in a web-based toolkit?		Site plan of website drafted, development of website.
Act and observe	Implement plan, observe, analyse	Undertook workshop, reflected on results, reviewed framework. Continued to further develop framework. Sent district plan chapter for review.	Presented draft ideas to workshop at Bay of Plenty. Designed and undertook follow up workshop with Western Bay of Plenty District Council. Further presentation of ideas at GNS Science Risk Short Course.	Sent a draft of the district plan chapter to the steering group and Gisborne and Whakatane District Councils for review.	Tested website with steering group members and other interested stakeholders.
Reflect	Reflect, review	Reflected on feedback, reviewed framework and district plan chapter in light of feedback.	Reflected on feedback and rework most valued ideas into new format. Followed up case examples identified by participants throughout the project.	Reflected on feedback and reviewed the chapter in light of the feedback and changed accordingly. Had the final draft of the report formally peer review internally within GNS Science.	Reviewed feedback received, incorporate into website design where appropriate.
Record	Record project	This report; web-based toolkit.	This report; web-based toolkit.	Finalised the district plan chapter and issued it in an "It's our Fault" report (Beban & Saunders, 2013).	Web-based toolkit.
Share	Share outcome	Full toolkit is available on the website: www.gns.cri.nz/Home/RBP/Risk-based-planning. A communication strategy was also developed to share the outcome as widely as possible.			

A1.2 STEERING GROUP

To assist with the development of the risk-based approach and the online toolkit, a steering group was established. The purpose of the steering group was to provide strategic input into the development of the methodology and associate tool for assessing a community's risk tolerance to future natural hazards. The steering group involved representatives from the following organisations:

- Ministry for the Environment;
- Ministry of Civil Defence Emergency Management;
- EQC;
- Local Government New Zealand;
- Hawkes Bay Regional Council;
- Bay of Plenty Regional Council;
- Massey University;
- Thames-Coromandel District Council;
- Auckland Council; and
- Brendan Morris Consultancy.

Rather typically for a group like this, one of the challenges was managing the turnover of staff at organisations. In one particular case, three different staff members were involved from the development of the initial proposal to the final outcome. To counter this, additional one-on-one meetings were held with the new steering group member, to get them 'up to speed' with the project, and to answer any questions that they may have had.

Terms of reference were developed, revised and updated, with input from the steering group. In summary, the terms of reference included the following:

- Background and overview of the project;
- Purpose of the steering group;
- Goals;
- Scope of the group; and
- Level of commitment.

Meetings were held with the steering group when required, i.e., when advice or guidance was required. These meetings were typically held in Wellington, apart from one which was held in Hamilton. Review items were pre-circulated to allow for informed discussion at the meetings. At one of the first steering group meetings, Dr Allan Lavell (an international expert on the social implications of disasters) attended and provided valuable input and direction into the project.

The steering group process worked well, and an outcome of involving Council staff was that Bay of Plenty Regional Council incorporated the risk-based approach into their proposed Regional Policy Statement.

A1.3 DEVELOPMENT OF A RISK-BASED APPROACH

The methodology used to further develop the approach was the same as that used in Saunders (2012a). The primary areas of further development were Step 2 – determining the severity of consequences, and the likelihood scale in Step 3. The methodology used to refine these two steps is outlined below.

A1.3.1 Step 2 – Determine severity of consequences

Step 2 of the framework, i.e., the consequence table, was further refined from Saunders (2012), based on international best practice for risk management (ISO., 2009; Standards Australia/New Zealand, 2004, 2009). To refine the table, two recognised methodologies (International Electrotechnical Commission, 2009) were adopted:

1. Expert opinion, from GNS Science staff and external experts; and
2. Use of relevant historical data for testing of the consequence table.

When reviewing the descriptors in the consequence table, testing against previous natural hazard events and assessing various consent application and policy scenarios was undertaken to ensure perverse outcomes were not reached in this step, and related Steps 3 and 4.

The framework and consequence table were workshopped with Auckland, Bay of Plenty, and Hawke's Bay councils (refer A1.2), and planners from around the country have had input in developing the process.

A1.3.2 Step 3 – Evaluate likelihood of event

Similar to the consequence table (Step 2), the likelihood table was modified from Saunders (2012). The number of scales was reduced to make the table more useable, and again these refined scales were tested with the consequence table to ensure no perverse outcomes were achieved. Guidance on terminology was provided from best practice (Standards New Zealand, 2004)

A1.4 WORKSHOPS

Two facilitated workshops were undertaken to test the framework and receive feedback on the approach, e.g., its usability, ease of understanding, etc. The first, in the Hawke's Bay, included staff from the regional council and territorial authorities. Staff were a mix of planners and emergency managers. At the workshop, the risk-based approach was presented, along with the complimentary communication and engagement strategy. Once the approach was outlined, participants were then given a case study area and associated information to go through the process themselves. This case study was based on the coastal community of Tangoio, with the scenario of a tsunami with a 1:1000 year return period detailed by the authors. The participants were then requested to complete the scenario for the 1:2500 year event in groups. The following feedback was sought from the groups:

- The ease of use of the risk-based approach;
- Whether the thresholds and the descriptions in the consequence table were appropriate;
- Whether the final risk outcome was appropriate and why or why not this might be the case; and

- How the engagement and communication could be integrated within the risk-based approach.

Based on the feedback received, the risk-based approach was further refined and the scenarios were retested by the project team to ensure that the outputs from the risk-based approach were appropriate.

Once the feedback from the Hawke's Bay workshop had been incorporated, the workshop was undertaken in the Bay of Plenty, with staff from the regional council and territorial authorities in attendance. A similar format was followed to that of the earlier Hawke's Bay workshop, with the 5-step process being presented, then participants able to try the approach themselves with the same case study area used in Hawke's Bay. From the feedback received, the content was further reviewed, assessed, and tested.

Other informal workshops were also held with council staff from around the country for their thoughts and feedback on the approach.

A1.5 PUBLIC ENGAGEMENT AS PART OF THE RISK-BASED APPROACH

The project team recognised that ultimately the decisions on land use planning are always mediated by the views and values of the affected community. Providing a robust process by which public input can be utilised to contribute to the risk-based approach was therefore an important part of the project.

Local government agencies throughout New Zealand are already dealing with the challenges of interpreting and debating complex issues of natural hazard management within their communities. The aim of the public engagement component of the risk-based planning approach was therefore to support this burgeoning capacity. However, it was also important to make clear to planners that the risk-based approach could not be undertaken in isolation from community and stakeholder input, and that this was not an isolated phase but an integral component to the whole approach.

Using the cyclic reflection stages of the PAR approach, the development of the engagement component of the risk-based planning project went through three main stages, driven by three inquiry statements. Input from participants in the steering group, workshops and public presentations were invaluable. However, the active debate within the project team (who all came from different perspectives) was also critical.

Stage 1 - How can decision makers, communities and key stakeholders be actively involved in the risk-based approach?

This phase involved a review of international literature and preliminary conversations with those involved in CDEM and natural hazard planning in local government. Ideas were presented to the steering group for review. There was reflection on the divergence between New Zealand and international conditions. Drivers for local government were identified such as:

i. the challenge of getting to an acceptable risk;

ii. the need to comply with the RMA; and

iii. the dominance of the Environment Court as the arbitrator of good process.

Key literature at this phase included Eiser (2012), Fischhoff et al. (1992), Hoppner et al. (2010), Steelman & McCaffrey (2013), Wachinger & Renn (2010), and Wessilink et al. (2011).

Stage 2: - How can good practice in public engagement and risk communication be integrated into the risk-based planning approach?

This phase involved reflection on workshop feedback from the 6th Australasian Natural Hazards Management Conference (Saunders, et al., 2012), and Hawkes Bay, and active debate amongst the project team. The team were interested in what were the biggest skill and capacity needs amongst those in local government. There was a review of online sources provided for local government in similar areas, as well as international examples of community engagement in risk and land use planning, e.g., Black et al. (2010), Wein et al. (2007).

Stage 3 - What steps, tips and support material is most useful to include in a web-based toolkit?

This phase involved a second workshop (Bay of Plenty) and a follow-up workshop requested by Western Bay of Plenty District Council where ideas could be refined and further tested. An independent project, run parallel with the this risk-based toolkit project, had looked into best practice for preparing guidance material for land use planners (Kilvington & Saunders, 2013). This work highlighted the need for real examples – i.e., success and failure stories from those trying different approaches on-the-ground. Therefore this stage included a review of several examples from around New Zealand (Otago, Coromandel, and Tasman) and one international example (Squamish, Canada).

Stage 4 - The online-toolkit

This online toolkit is open to feedback from participants and is designed to build further through use by those involved in natural hazard and land use planning.

A1.6 DISTRICT PLAN CHAPTER

As part of this project an example district plan chapter was developed to show how a risk-based approach can be incorporated into land use planning. This district plan chapter was developed to ensure that it is consistent with the existing legislative requirements of the Resource Management Act 1991. However, recently, the Ministry for the Environment released a discussion document which identifies potential reforms to the Resource Management Act 1991 (Ministry for the Environment, 2013a). This district plan chapter has been developed to ensure that it is consistent with these potential reforms.

The district plan chapter was developed using the hazard and built environment of a city in New Zealand. This city was renamed 'Urban Valley' and the suburbs and the distinctive natural features were renamed. Based on this hazard environment, the levels of risk for the various natural hazards were determined and appropriate planning responses (objectives, policies, methods, rules, assessment criteria, and monitoring provisions) were developed. These planning responses have been designed to ensure that the risk from future development is managed, as opposed to ensuring that there is no risk from natural hazards. This is an important distinction to make, as it ensures that a balance is struck between the social, economic and cultural benefits that we derive from living in urban environments, whilst ensuring that the risks from natural hazards are managed and reduced over time. A no-risk approach is impracticable and would prevent development in many of New Zealand's cities.

This district plan chapter has been reviewed by the members of the steering group as well as by a number of people from the following organisations:

- Massey University;
- Tauranga City Council;
- Gisborne District Council;
- Thames-Coromandel District Council; and
- Whakatane District Council.

The comments and feedback from all parties has been considered, and in many cases has been incorporated into the final version of the district plan chapter. Following the feedback from these parties, the chapter was then reviewed internally within GNS Science.

The example district plan chapter is intended to provide a best practice example of how a risk-based approach could be incorporated into a district plan. While the objectives and policies take an all hazard approach, the rules that have been developed are very contextual to the hazard environment of 'Urban Valley'. This example is not intended to be a 'model chapter' that can be used in all district plans by all local authorities. Rather, it is seeking to show that a comprehensive risk-based approach to planning for natural hazards can be undertaken under the existing legislative framework in New Zealand.

It also needs to be recognised that the district plan chapter was developed without any public input. In reality, these chapters would be developed in consultation with the community, stakeholders, local politicians and relevant experts. This consultation process is an important component in the development of a district plan chapter and it is important that a communication strategy and engagement process is developed to manage and inform the process.

A1.7 TESTING OF RISK-BASED APPROACH

As part of the development of the risk-based approach, the methodology was tested on a number of previous natural hazard events in addition to potential future hazard event scenarios. The purpose of this testing was to ensure that the risk-based approach was not resulting in perverse outcomes, which resulted in the risk either being understated or overstated. This process of testing against natural hazard events also helped with ensuring that the various levels of the severity of impact for the different categories were measurable and comparable relative to one another. The natural hazard events / scenarios that were tested included:

- Liquefaction from the February 2011 Christchurch earthquake;
- The 2005 Matata debris flow;
- A tsunami resulting from a 30m slip on the southern portion of the Kermadec Trench on the potential future development of Te Tumu;
- A tsunami resulting from a 30m slip on the southern portion of the Kermadec Trench on the existing development form of Papamoa;
- A 1:100 year flood on the Waiwhetu Stream in Lower Hutt;

- A tsunami with a return period of either 1000 or 2500 years affecting Tangoio, Hawkes Bay;
- A tsunami with a return period of either 1000 or 2500 years affecting the future greenfield area of Te Awa / The Loop, in Napier;
- Liquefaction from a Wellington Fault earthquake; and
- A 1:440 year flood event on the Hutt River, Lower Hutt.

When the testing revealed a problem or a perverse outcome, the issue was reviewed and a solution was identified (this solution may have required expert opinion on the details of the thresholds identified in the consequence table). Once a solution was identified, the scenario was retested and the results were considered to see whether the risk outcomes were appropriate. If the results were appropriate, then several further scenarios were tested to ensure that there were no perverse outcomes resulting from the approach.

The two Tangoio scenarios were also tested in the workshops in Bay of Plenty and Hawke's Bay.

The testing against previous natural hazard events was also used to see what scale of development the risk-based approach can be applied to. From the analysis undertaken, it was apparent that the risk-based approach worked well for large-scale development or for local council policies such as growth plans, district plans, and regional policy statements. Presently, the risk-based approach is not effective at setting the consent level based on the risk for individual properties undertaking small-scale development. This is due to the uncertainties associated with both the hazard assessment and the estimation of consequences as a result of a hazard event.

A1.8 WEB-BASED TOOLKIT

The authors searched through many websites to find examples of a 'good' website format. The steering group were also asked to provide examples of websites they liked to use. From the feedback received, the website was developed within the constraints required of the GNS Science website. Once developed, the website was tested with the steering group and other interested stakeholders prior to launching. Feedback received was incorporated into the website as appropriate.

APPENDIX 2: KAIHIKATEA ESTATE DEVELOPMENT

An example showing how mitigation can be interpreted and implemented is the Kahikatea Estate subdivision application in the Thames-Coromandel District. The application provides one example where mitigation measures have been put in place, but risk to property (and personal safety, depending on the effectiveness of emergency management plans) is increased. This example also highlights how risk governance is dependent on institutional arrangements – in this case, the legal framework of the RMA.

Located on the Tairua River floodplain, the site is tidally influenced and had been flooded from the river five times during the previous 12 years. As such, the site is expected to flood on average every two to five years (Tonkin & Taylor, 2005). The site is deemed a high hazard site by the regional council, as the depth of flow in the main floodway is greater than one metre and/or speed of flow is greater than one metre per second. Rather than avoiding the risk altogether, this hazard was addressed by the applicants with mitigation options, their philosophy being to "recognise the risk of flooding that exists and to take measures to overcome the hazard risks, without endeavouring to impede the natural flow patterns of floodwater through the site" (Bhana, 2005, p7).

The original mitigation options proposed by the applicants included (Bhana, 2005, p7-8):

- A pontoon jet-drive rescue craft being permanently maintained on site. Carrying up to nine people, the craft would be used to evacuate people from their homes from designated loading and unloading areas. Several people in the area would be trained to operate the rescue craft on a first-response basis.
- Automated early warning systems to monitor river and rainfall levels, to provide adequate warning to evacuate if required. This system is also linked to the first response emergency management network.
- Safe areas will be provided above the flood levels, where cars could be stationed in the event of rising water levels, with all-weather access to the main road. Alarms would give ample time for vehicles to be taken to the designated area. Community facilities would be above any flood levels, and would provide shelter for the residents if required, as well as a command post for a first-response team.

Also identified in the consultant report (Tonkin & Taylor, 2005, p18) was that:

> Potential damage to buildings and building platforms will be mitigated by setting minimum floor levels to EW [Environment Waikato[3]] standards and constructing platform batters and building foundations to withstand flood velocities. In a similar way, the potential for loss of life and/or injury may be mitigated by proper planning and procedures.

The upstream corners of the building platforms were also to be reinforced (Arcus, 2006). It was summarised in the consultant report (Tonkin & Taylor, 2005, p20) that: "The risk of developing within the floodplain is accepted by the developer …". This raises issues of who is accepting the risks – the developer in the short term, but future purchasers in the long term. The Regional Council stated in their planner's report that:

[3] EW changed its name in April 2011 to Waikato Regional Council (WRC).

> …the current location of the building platforms or sites for residential development proximity to the Tairua River based a [sic] precautionary approach to represent too great a risk to be suitable for residential development (cited in TCDC, 2006, p23).

The application was publicly notified, and subsequently an independent commissioner was appointed. In June 2006 the Commissioner approved the application, subject to conditions of consent being imposed (including the provision of a rescue boat). In his conclusion, the Commissioner stated that “Material damage to structures is unlikely because the structures are above a very conservative minimum floor level” and “Occupants are unlikely to be at risk because of the warning system. In the unlikely event that it fails there are other factors which would alert occupants to flood” (Arcus, 2006, p31).

In May 2008 the Environment Court issued a consent notice which included the following conditions (Judge Dwyer, 2008, p3-4):

- The consent holder shall provide a detailed Emergency / Hazard Management Plan ‘E/HMP’, detailing the provisions to be made to ensure the safety of occupants of the subdivided lots in the event of inundation of the site. This shall be submitted for the approval of the Thames-Coromandel District Council’s Monitoring Officer. The E/HMP shall include but not be limited to the following measures:
  - a. Ensuring the installation and ongoing maintenance of a new river level recorder.
  - b. Ensuring an existing river gauge (Broken Hill) is upgraded to provide secure and ongoing river level data.
  - c. The installation and ongoing maintenance of a 24 hour a day river level monitoring system shall be connected to all residential buildings and the Regional Council.
  - d. Ensuring the provision of an evacuation plan. This is to be developed and maintained by the Residents Association of Kahikatea Estate, and will be developed around different responses corresponding to onsite water levels.
  - e. Ensuring members of the residents association receive as minimum annual training in compliance with the provisions of the E/HMP.
  - f. Ensuring the culverts under the internal driveway are regularly maintained including at least annually the
    - i. Clearance of any accumulated debris, and
    - ii. Rectifying any visible signs of erosion.
  - g. Ensuring any maintenance to the internal private way results in the RL of the private way being retained at the Hauraki Catchment BD Datum level of 14.5 metres with variance of 0.02 metres.
  - h. Ensuring the ongoing maintenance of the building platforms for flood defence purposes for each of the residential lots.
    - i. Ensuring the area defined as ‘Restricted Planting Area’ is managed so its primary purpose as a floodway is not compromised.

- The consent holder shall provide to the Thames-Coromandel District Council a copy of the documentation establishing the Residents Association and setting out to the satisfaction of the Council's Monitoring Officer the responsibilities of the Association in terms of on-going site management. This includes arrangements to ensure compliance of the E/HMP; and providing Council with an annual report demonstrating on-going compliance. This is to be prepared by an independent certifier appointed by the Association and acceptable to the Council's Monitoring Officer.

The original jet boat response measure was not included in the final decision. This case provides an example of the wider implications for risk reduction, including the importance of qualifying and/or quantifying the levels of risk for natural hazards to ascertain and clarify what is acceptable, tolerable and intolerable; who accepts the short- and long-term risks, i.e., the developer versus a future purchaser; and the paradoxical relationship between mitigation and risk reduction (i.e., mitigation does not necessarily result in a reduction of risk). In this case, risks to property are still potentially problematic for those dwelling in these properties. While the developer was willing to accept the risk, future owners/generations will have a legacy of flood risk to live with if they choose to (see also Handmer (2008)). The mitigation measures proposed lead to an increase in risk from the original land use; otherwise the consent conditions would not be required. To date, the development has not yet begun due to the 2009-10 economic recession.

The decision highlighted the inadequacy of the existing district plan provisions for managing flood risks. As a result of this decision, the Thames-Coromandel District Council undertook a plan change to the flooding section of the district plan's natural hazard chapter, which is yet to become operative. Ironically, the website for the development states that:

> Sites will have a high standard of amenities including a gravelled driveway to improve water dispersal … The development exceeds local body resource consent standards, preventing any possible risk of flooding to platforms or homes: so your house is safe as … well, houses (Kahikatea Estate).

This statement provides an example of the developer bearing the risk while properties are sold. Local body resource consent standards are exceeded due to the risk of flooding; it is still possible that platforms and homes can be flooded (hence the requirement for a warning system and evacuation plan).

When assessing mitigation measures, timeframes (i.e., likelihood, recurrence intervals, return periods, probabilities etc.) should be considered to assess whether mitigation measures are adequate for the risks and consequences involved.

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APPENDIX 3: ENGAGEMENT STRATEGY CHECKLIST

Building blocks	Questions		Engagement options
Scope and goals	Goals and outcomes	• What are the goals for this public engagement? I.e., where do you want to get to? • What are the intermediate (sub outcomes) that are important? I.e., what decisions need to be made along the way? • How will you know you have got there?	• Public notices (leaflets, newspapers, radio) • Information days • Public meetings • Expert groups • Stakeholder groups • Scenario workshops • Kitchen workshops
	Process orientation	• Is this engagement approach designed to gather ideas, meet statutory consultation requirements, foster debate, raise awareness? • What are the implications of this purpose for how the process should be run?	
	Timeline	• What is the timeline for this process? • Are there key dates? • Working back from fixed dates – when does engagement need to start?	
	Risks	• What are the risks for the council associated with this process? • How will these be managed?	
	Opportunities	• What are the opportunities – e.g., are there other events that can be piggy backed?	
Complexity and uncertainty		• How complex is this situation? • (see table – defined, complex, uncertain, ambiguous) • Where is there uncertainty and how can this be addressed?	• Direct discussion between agency staff and affected parties • Workshop, with science, management, and stakeholder representatives • Public - Open space forum • Citizen panel, citizen jury
Context	History	• What has been the history of dealing with this issue? • Are there outstanding concerns that will resurface?	• Conflict resolution
	Conflict	• What is the potential for conflict? How will this be managed?	

Building blocks	Questions		Engagement options
	Trust	• What is the existing level of trust in the organisation? In the decision-making process?	
Stakeholders	Different interests	• What are the different interests in the issue (e.g., life/livelihood, financial, legal, important knowledge, interest groups) – see table.	• Surveys • Phone calls to key stakeholders • Kitchen workshops • Public meetings • Hui • Individual group meetings
	Stakeholder representation	• What do you know about the different interests? • Are there existing relationships between council and stakeholders that are important to consider? • How will these different views be represented in the decision-making process at different times?	
	Engagement preferences	• What are the preferred ways these stakeholders like to be involved in land use decisions?	
Existing views		• What do people already know about the natural hazard risk? • What kind of investment in the existing land use is there? • What kind of appetite is there for land use restrictions or public costs associated with mitigation?	• Open, information days • Public talks • Articles in local online newsletters • Kitchen workshops
First steps	Partners	• Are there other, agencies or non-governmental bodies it would be helpful to partner with? • What are others already doing in this area?	• Media releases • Community board agenda items
	First messages	• When should the first information regarding this issue be released? • How should this go out? • What information should this message contain?	
	Building knowledge	• What knowledge needs to be built – by the council? • Are there exiting views that need to change about the issue? • How does this affect first steps?	
	Making decisions	• What decisions are possible? • What needs to be done to prepare for these?	

APPENDIX 4: MFE RISK-BASED CONSEQUENCE AND LIKELIHOOD TABLES AND ASSOCIATED MATRIX

Table A 4.1 An example of consequence ratings.

Consequence Rating	**Social**		**Cultural**	**Economic**		**Environment**
	Public safety	Community disruption (e.g., displaced people, social disruption, cancelled events, school closures)	(e.g., heritage sites, historic structures, archaeological sites, sites of importance to Māori, such as wāhi tapu)	Local economy and growth	Lifelines*	
Catastrophic	Fatalities, or serious near misses, affecting more than 1000 people	Significant disruption; international significance or concern	International significance or concern	Regional decline leading to widespread business failure, loss of employment and hardship; significant long-term impact on the national economy	Systemic failure of lifeline assets, including lost transport connections, water supply and power failure, and failed wastewater systems	Long-term, widespread impacts, slow recovery
Major	Some injuries or serious near misses, affecting more than 100 people	High-level disruption; national significance or concern	National significance or concern	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Failure of some lifeline assets (e.g., power lines or road access) that require significant recovery investment and long-term temporary lifeline services	Medium- to long-term widespread impacts
Moderate	Minor injuries, or serious near misses, affecting more than 10 people	Moderate disruption; regional significance or concern	Regional significance or concern	Significant but temporary reduction in economic performance relative to current forecasts	Partial failure of some lifeline assets that requires temporary measures to provide lifeline services	Reversible medium-term local impacts

Consequence Rating	Social		Cultural	Economic		Environment
	Public safety	Community disruption (e.g., displaced people, social disruption, cancelled events, school closures)	(e.g., heritage sites, historic structures, archaeological sites, sites of importance to Māori, such as wāhi tapu)	Local economy and growth	Lifelines*	
Minor	Serious near misses, affecting fewer than 20 people	Minor disruption; local community significance or concern	Local community significance or concern	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Some short-term disruption of lifeline assets raising public health concerns	Reversible short-term impacts on local area
Insignificant	Appearance of a threat but no actual harm	Individual significance or concern	Individual or small significance or concern	Minor shortfall relative to current forecasts	Minor disruption to lifeline assets	Limited impacts on minimal area

Table A 4.2 Likelihood of the flood occurring within a given time horizon.

Average Recurrence Interval of Flood (Years)	Design Life – Time Horizon (Years)								
	2	5	10	20	50	100	200	500	1000
2	75%	97%	100%	100%	100%	100%	100%	100%	100%
5	36%	67%	89%	99%	100%	100%	100%	100%	100%
10	19%	41%	65%	88%	99%	100%	100%	100%	100%
50	4%	10%	18%	33%	64%	87%	98%	100%	100%
100	2%	5%	10%	18%	39%	63%	87%	99%	100%
200	1%	2%	5%	10%	22%	39%	63%	92%	100%
500	0%	1%	2%	4%	10%	18%	33%	63%	100%

Table A 4.3 Flood risk likelihood ratings.

Rating	Percentage chance that a flood with a given average return interval will occur within the design life
Almost certain	> 85%
Likely	60% - 84%
Possible	36% - 59%
Unlikely	16% - 35%
Rare	< 15%

Table A 4.4 A risk assignment matrix for setting the level of risk, based on likelihood and consequences.

		Consequence Ranking				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood Rating	Almost certain	Moderate	High	Extreme	Extreme	Extreme
	Likely	Moderate	High	High	Extreme	Extreme
	Possible	Low	Moderate	High	Extreme	Extreme
	Unlikely	Low	Low	Moderate	High	Extreme
	Rare	Low	Low	Moderate	High	High

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APPENDIX 5: TIMEFRAMES, MAPPING NATURAL HAZARDS, RISKS AND UNCERTAINTY

This section provides some general guidance that is relevant when considering natural hazard risk and mapping natural hazards.

A5.1 PLANNING TIMEFRAMES FOR NATURAL HAZARDS

In order to manage the risks from natural hazards and their consequences, the likelihood of a specific event needs to be addressed (i.e., risk = consequences x likelihood). But how likely is an event to occur for it to be considered in land use planning? For many natural hazards there is no standard return period for planners to plan for. For example, while case law points to a 100-year timeframe for coastal erosion, often the 50-year timeframe (based on the minimum intended life of a building under the Building Act 2004) is thought to be adequate for flooding in some districts. For events where no forecasting or warnings can be provided (i.e., active fault rupture, some tsunami events), a longer timeframe is used – from 500 to 20,000+ years.

This section outlines the current timeframes used in planning for natural hazards; the influence of the Building Act 2004; and a discussion on what timeframes should be used. While case law has created some certainty around what return period to use, with the advent of climate change these judgements may need to be revised in the future.

A5.1.1 Current timeframes used in planning

While the NZCPS provides some guidance on timeframes for assessing coastal hazards (i.e., at least 100 years under policies 24, 25 and 27) (Department of Conservation, 2010), there is no national regulatory standard approach for deciding what timeframes should be used for other natural hazards. This has led to an inconsistent approach being adopted throughout the country, and has the potential to lead to an *increase* in risks if appropriate planning timeframes for natural hazards are not included in planning processes.

Choosing the appropriate timeframe as the basis for land use planning is difficult for communities, planners, and politicians (who tend to focus on outcomes within political cycles, rather than long-term) alike (Deyle, French, Olshansky, & Paterson, 1998; Ericksen, 2005). The decision of what return period[4] should be used often represents a value judgement that may be difficult to deal with in the political arena. At one end of the scale are hazards that produce modest levels of damage on a relatively frequent basis, generally with a recurrence interval of less than 20 years; at the other end are catastrophic events that recur less frequently, only once every 2,500 years or more, but produce devastating levels of damage and consequences (Deyle, et al., 1998; Ericksen, 2005). These high consequence, low-likelihood events are the most difficult hazards to manage (Slovic, Fischhoff, & Lichtenstein, 2000) due to a lack of understanding and awareness of the consequences of these events; and the 'it won't happen in my lifetime' view. It is essential that any decisions on these types of events are made with community and scientific input, to ensure support and understanding of risks and consequences.

4 For a discussion on terminology and definitions on the terms return period, annual exceedance probability (AEP), probability of occurrence and likelihood, see Saunders (2010).

In the Environment Court case *Save the Bay v Canterbury Regional Council* (C6/2001), the Court considered that there needed to be a greater recognition of catastrophic natural events, stating that 90% of damage to the environment caused by natural hazards occurs in 10% or fewer of the events. The Court suggested that "authorities should recognise this inverse relationship in the preparation and wording of their plans". This case, and *Bay of Plenty Regional Council v Western Bay of Plenty District Council* [2002] A27/02 EnvC, and *Skinner v Tauranga District Council* [2002] A163/02, all provide discussion regarding the appropriate risk period to plan for when preparing regional and district planning documents. These cases point to a 100-year planning horizon for hazards such as coastal erosion and coastal flooding, but should not be a benchmark for other natural hazards.

Flooding, coastal erosion, landslide hazards and tsunami risk are likely to be influenced by transient end points (Health & Safety Executive, 2001; Johnston & Paton, 1998) and affected by climate change, which may change their risk profile. For example, it is imperative that coastal erosion time frames of 100 years be adjusted over time to incorporate climate change – what was a '100 year event' in 1990 may be less than that in 2020. To ensure that the 100-year return period remains at 100 years over time, the effects of climate change must be regularly monitored and incorporated into any planning timeframe. Tsunami risk is also influenced by climate change. While climate change is not the trigger of a tsunami, climate-induced changes in storm frequency and sea level have the potential to increase coastal erosion, which can erode previously stable beach dunes, allowing a tsunami to have a greater run-up and inundation (and thus impact) on land.

There is no consistent all-hazard return period/AEP for land use planners to use as a basis for planning for natural hazards events in New Zealand (see Saunders, 2010). While some perils 'share' return periods, not all are equal, in part due to forecasting and warning capabilities, as outlined in Table A 5.1 and discussed below. For example, high rainfall events can be forecast, flood warnings can be given, and evacuation of communities at-risk is possible.

For floods and coastal erosion, forecasts of impending weather are available via the MetService. Through tsunami modelling, a forecast of wave height can be provided for distant-source tsunami, although only natural warnings are available for tsunami from local-sources. For other hazards such as earthquakes and some landslides, warnings are not possible due to the sudden onset of such events. Floods, coastal erosion, and tsunami inundation have the potential to be affected by climate change, due to increased severity of rainfall events, sea level rise, and associated impacts (e.g., decreased dune health).

For effective risk reduction, hazardous areas should be avoided, as even with warning and evacuation, property is still affected (with subsequent social and economic consequences). A balance needs to be reached between allowing a land use to proceed in an at-risk area; constructing buildings to withstand hazards; and having emergency management procedures in place when required. Once a land use has been permitted, and buildings have been constructed, the land use will carry on indefinitely beyond the 50-year default timeframe of buildings under the Building Act. Planning within a sustainability context, which implies planning for future generations, needs to extend beyond 50, and even 100 years. The influence of the Building Act is outlined in the following section.

Table A 5.1 Comparative land use planning return periods for selected natural hazards in New Zealand (adapted from Saunders, 2012a).

	Planning timeframe (years)	Case law	Forecast possible	Warnings available	Map extents	Affected by climate change	Likelihood	Consequence
Flood	20-100	~	Yes	Yes	Yes	Yes	Likely	Minor/ Moderate
Coastal erosion	100	Yes	Yes	Yes	Yes	Yes	Likely	Minor/ Moderate
Active faults	</= 20,000	Yes	No	No	Yes	No	Very rare	Moderate/Major
Tsunami (local and distal)	</+ 2,500	Yes	Yes (distal only)	Yes (distal only, natural warning for local source)	Yes	Not a trigger, but affects dune health	Unlikely	Moderate/Major
Landslide	</+ 2,500	No?	Yes (in some circum-stances)	No	Yes	Yes	Unlikely	Moderate

A5.1.2 The influence of the Building Act 2004 on timeframes under the RMA

Often there is reliance on timeframes under the Building Act 2004 for land use planning, in particular the 50-year timeframe. Under the Building Act, buildings have a minimum intended lifetime of 50 years, and are constructed to withstand a 475 year return period earthquake (i.e., a 10% probability of occurrence in 50 years). Critical facilities are constructed to withstand a 2,500 year earthquake event (2% chance of occurring in 50 years). Based on this approach, the timeframe of 50 years has become, in some districts, the default planning timeframe for flooding. However, as shown in Table A 5.2, a return period of 50 years coupled with a design life of 50 years, results in a 64% chance of an event occurring.

Table A 5.2 Return periods and design working life of buildings, with the likelihood of an event occurring. A return period of 50 years coupled with a design life of 50 years, results in a 64% chance of an event occurring.

	Design working life						
Return period	**2**	**10**	**50**	**100**	**200**	**500**	**1000**
2	0.75	1.00	1.00	1.00	1.00	1.00	1.00
10	0.19	0.65	0.99	1.00	1.00	1.00	1.00
50	0.04	0.18	**0.64**	0.87	0.98	1.00	1.00
100	0.02	0.10	0.39	0.63	0.87	0.99	1.00
200	0.01	0.05	0.22	0.39	0.63	0.92	0.99
500	0.00	0.02	0.10	0.18	0.33	0.63	0.86
1000	0.00	0.01	0.05	0.10	0.18	0.39	0.63

There is also a reliance on the Building Act to protect people's health and safety, rather than land use provisions. Within RMA case law from the Environment Court (*Petone Planning Action Group Incorporated v Hutt City Council, W020/2008)*, it is stated that:

> … the performance of the structure and the safety of people in earthquake events, is to be left to compliance with the Building Code and Standard … risks to safety from earthquake shaking, liquefaction and tsunami would be appropriately addressed and mitigated in the Building Code process and assessment in accordance with NZS1170.5:2004" (New Zealand Standard *Structural Design Actions Part 5: Earthquake Actions*).

The decision was summarised as follows:

> … we conclude that the consenting to the proposal on condition of compliance with the Building Code and NZS1170.5:2004 would enable people to provide for their safety against risks from earthquakes and other natural hazards.

However, NZS1170.5:2004 only considers earthquakes, not other natural hazards such as tsunami, landslides, or floods, leading to the conclusion that the Environment Court was questionable in its judgement that other natural hazards are provided for in this standard, and consequently peoples' health and safety is *not* provided for. Under the Building Act, only the *consideration* of other hazards is required. The implication of this is that planners should adhere to the purpose of s5 of the RMA and provide for people's health and safety. It is recommended that this includes planning beyond the default 50-year planning horizon of the Building Act. In summary, reliance on the Building Act is too restrictive in its timeframes, and does not allow for consideration of consequences beyond a 50-year timeframe for buildings (excluding critical facilities).

A5.1.3 Deciding a timeframe for land use planning

How should planners manage time frames for natural hazards? As discussed, the default 50 years of the Building Act is not enough to adequately enable people and communities to provide for their health and safety, social, economic or environmental needs for future generations. With no standard central government guidance on timeframes for New Zealand, and differences in management across the country, there are some key questions that need to be considered:

- What is a tolerable level of risk?
- Who should decide?
- What duty of care do Councils have?
- Should planning for natural hazards be consequence-driven rather than probability-based?
- Should baseline natural hazard risk be standardised for the whole country, or based on a community's tolerable level of risk?

For effective risk reduction, hazardous areas should be avoided, as even with warning and evacuation, property is still affected. Once a land use has been permitted, and buildings constructed, the land use will carry on indefinitely beyond a 50-year default timeframe for buildings. If planning within a sustainability context, which implies planning for future generations, then planners need to plan beyond 50, and even beyond 100 years. Any decision on approaches to managing risks from natural hazards, via a combination of land use planning and emergency management, needs to be undertaken with full participation of the community, including representatives from the market, scientists, and interest groups.

Councils have a duty of care to know their hazards and risks, and to ensure that communities have access to that information via Land Information Memorandum (LIMs), district/city/ regional plans, and reports. One barrier to information sharing with the community can be the challenge of translating scientific knowledge into 'plain English'. To aid this translation, maps and a description and/or photos of consequences can assist with this transfer and understanding.

Currently, there is no standard guidance on what levels of likelihood for hazard events should be used. Planners, together with emergency management officers, need to discuss the options and consequences with scientific experts, to gain an understanding. Once this is achieved, the community (market, civil society and other key stakeholders) need to participate in the decision making process to come up with an acceptable – or tolerable – level of risk.

A5.2 TYPES OF MAPS AND SCALE

There are many different ways to map various hazards and risks, for example:

- Hazard map;
- Risk map;
- Susceptibility map;
- Inventory map; and
- Evacuation map.

Each of these map types are explained in more detail below.

The scale of any map is important for its intended use. For example, a 1:250,000 map will not be useful for land use planning for specific sites.

A5.2.1 Hazard map

Hazard maps include a time frame/likelihood reference. For example, the map (Figure A 5.1) shows the 2010 national seismic hazard model for New Zealand, showing expected peak ground accelerations for a 475-year return period earthquake for shallow soils (Stirling et al., 2012, p1531).

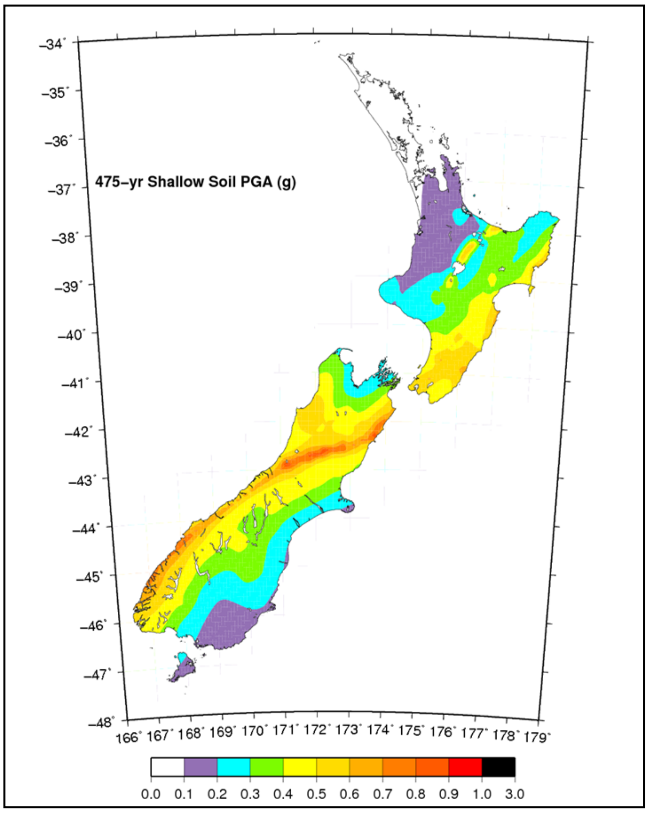

Figure A 5.1 A hazard map, showing the national seismic hazard model (Stirling, et al., 2012, p1531).

A5.2.2 Risk map

Risk maps show the consequences (e.g., building damage) of an event with a likelihood scale. Figure A 5.2 below shows Westport, with a 500-year flood hazard map on the left (i.e., a hazard map); and the figure on the right shows a risk map with the 500-year flood with the number of buildings per km^2 in a damage state of moderate or greater.

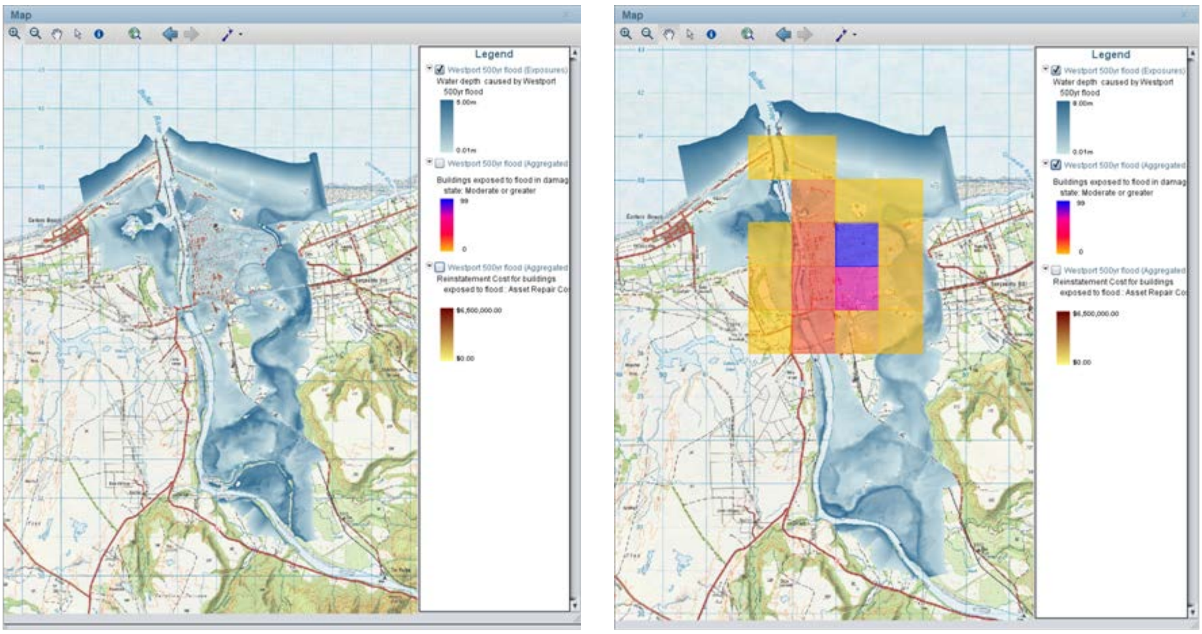

Figure A 5.2 An example of a hazard map (left) and risk map (right) (maps generated from Riskscape 2.82, May 2013, www.riskscape.org.nz).

A5.2.3 Susceptibility map

These maps combine different factors which contribute to a hazard, to give an indication of where hazard is more likely to occur. For example, Figure A 5.3 shows the susceptibility of slopes to landslides from an earthquake based on a combination of slope, geology, rainfall, vegetation, and aspect. No time factor is associated with a susceptibility map (unlike a hazard map).

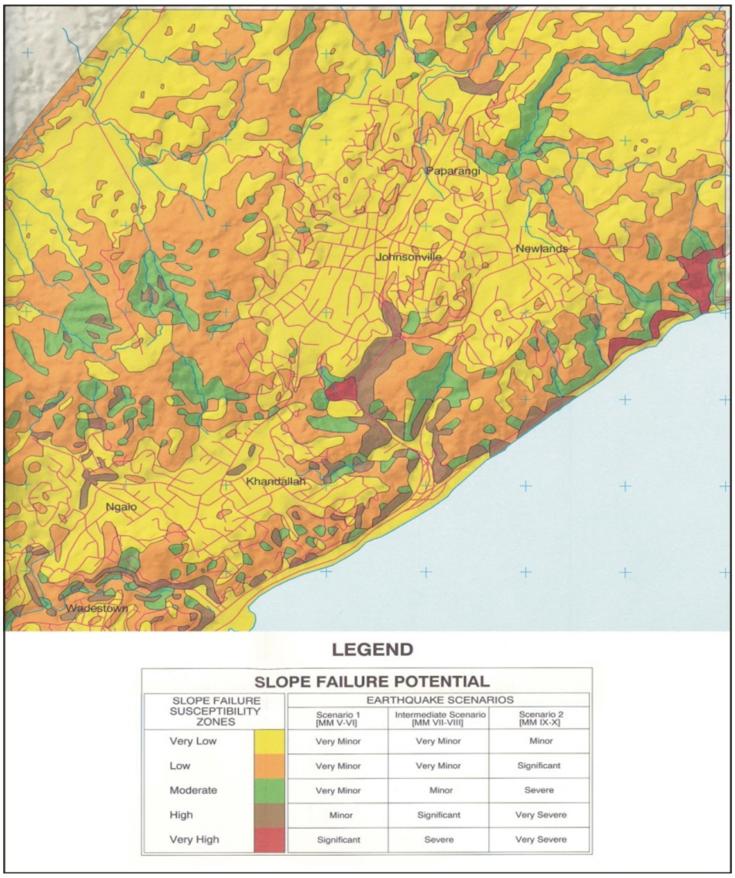

Figure A 5.3 Earthquake-induced slope failure susceptibility map, Wellington (Kingsbury, 1995)

A5.2.4 Inventory map

Inventory maps show a collection of events that have occurred at a location. The location of previous events is a good indicator of where future events may occur, and allows analyses and testing of susceptibility, hazard, and risk.

Figure A 5.4 shows areas inundated by lahars (or volcanic debris avalanches) and associated floods from Ruapehu, over the last 20,000 and 10,000 years, and since 1860. It is also a simplistic hazard map, as it has a timeframe associated with lahars.

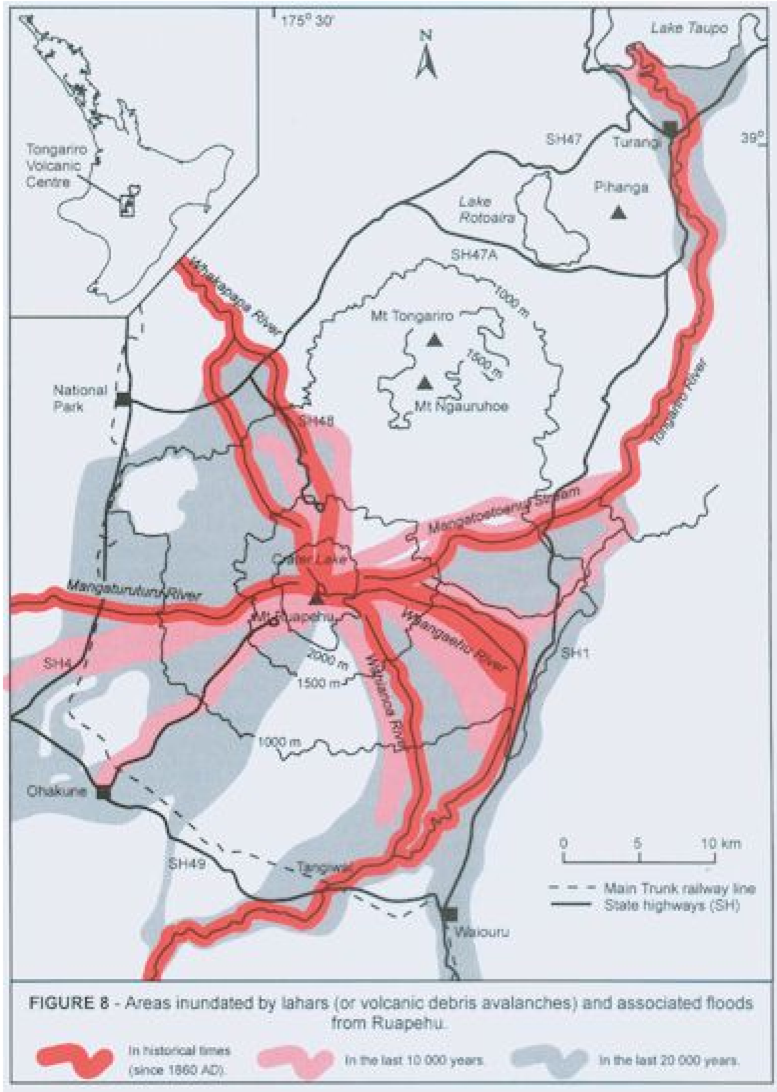

Figure A 5.4 Lahar susceptibility map for Ruapehu (http://gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/New-Zealand-Volcanoes/Volcano-Geology-and-Hazards/Ruapehu-Geology).

A5.2.5 Evacuation map

An evacuation map is used by emergency managers and communities to plan for evacuation in an event. For example, the Wellington tsunami evacuation map (Figure A 5.5) shows three different zones where evacuation may be required (http://www.gw.govt.nz/tsunami-evacuation-zone-maps/). A map like this is based on modelling of events, and for the purposes of Figure A 5.5 is colour coded in the following format:

- Red zone - Shore-exclusion zone that can be designated off limits in the event of any expected tsunami.
- Orange zone - Area evacuated in most if not all distant and regional-source official warnings (i.e., warnings that extend beyond the red zone, for tsunami from sources more than one hour of travel time away from the mapped location).
- Yellow zone - The yellow zone should cover all maximum credible tsunami, including the highest impact events. The intention is that the yellow zone provides for local-source maximum credible events, based on locally determined risk.

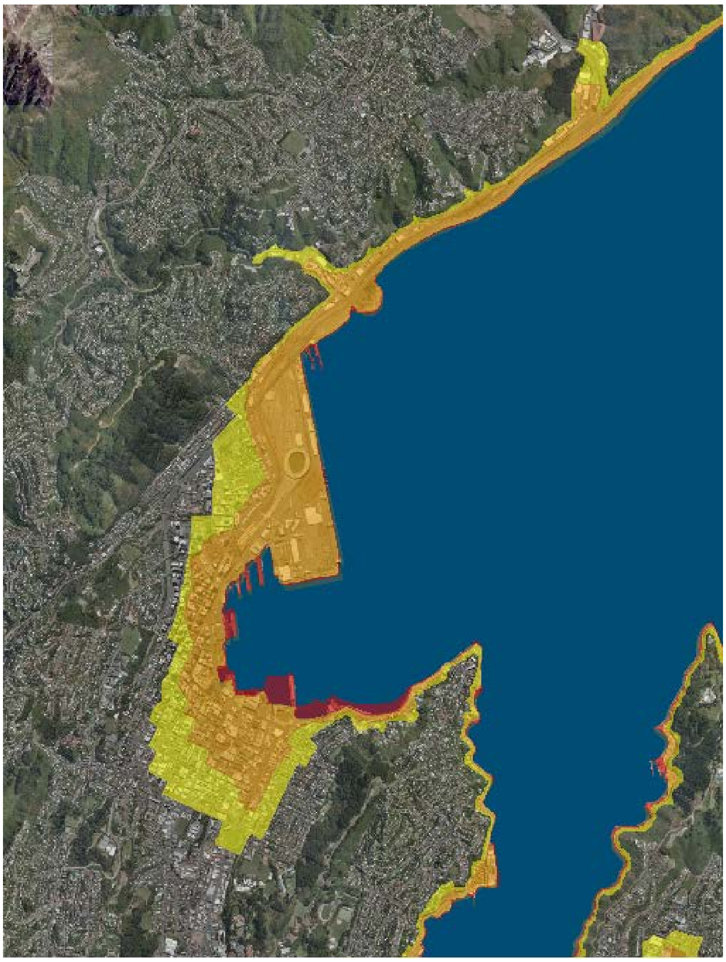

Figure A 5.5 Tsunami evacuation map, Wellington (http://www.gw.govt.nz/tsunami-evacuation-zone-maps/).

A5.3 SCALE OF MAPPING

Hazards, risk and associated information should be mapped at a scale appropriate for the end-use, in this case enabling planners to make decisions about land use on or close to hazardous areas. Local authorities should map hazard information to an appropriate planning-level scale of approximately 1:10,000, instead of relying on existing smaller-scale maps showing areas of unstable land (1:250,000 or 1:50,000 scale). While such maps are appropriate for regional studies, they are indicative only and do not provide adequate detail for many planning purposes which require detail to at least the level of property boundaries. An indication of the scales of mapping that should be used for natural hazards relative to the size of the land area of interest is detailed as follows (Saunders & Glassey, 2007):

- National (1:1,000,000);
- Regional (1:100,000 to 1:500,000) – QMAP Geological Map series;
- Medium (1:25,000 to 1:50,000) – typically municipal or small metropolitan areas; and
- Large (1:5,000 to 1:15,000) – typically site or property level.

Examples of the different scales are provided below for Moenui, Marlborough Sounds (Figure A 5.6 – Figure A 5.8). The examples show landslide information provided at different scales, and how these scales affect the information provided:

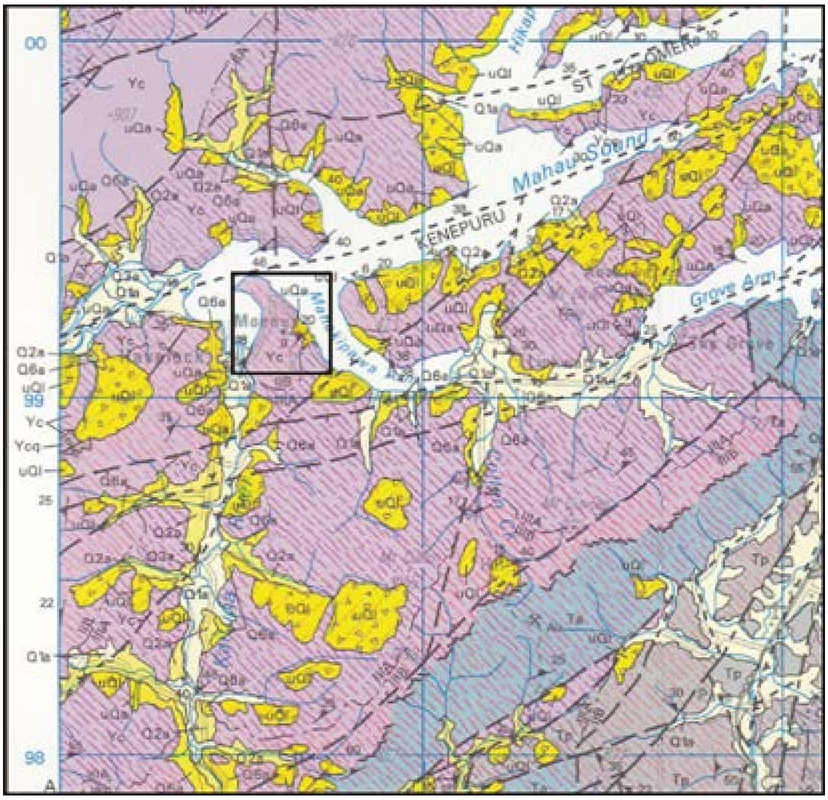

Figure A 5.6 Landslide inventory map. A snapshot of the QMAP 1:250,000 (Begg & Johnston, 2000) regional-level geological map showing main features of Mahau Sound (Marlborough Sounds). The speckled yellow areas show the location of large landslides. This is a most basic landslide inventory map. Moenui is located in the inset.

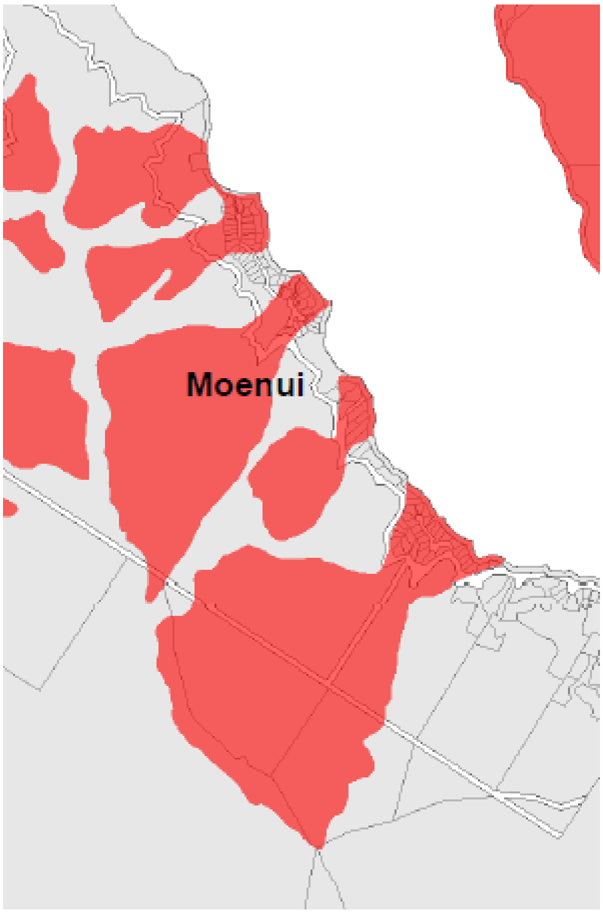

Figure A 5.7 A snapshot of the 1:30,000 Marlborough Sounds Resource Management Plan Area, Mahau Sound (map 90, Marlborough District Council, 2010). This simplistic landslide hazard zonation map highlights unstable areas (red).

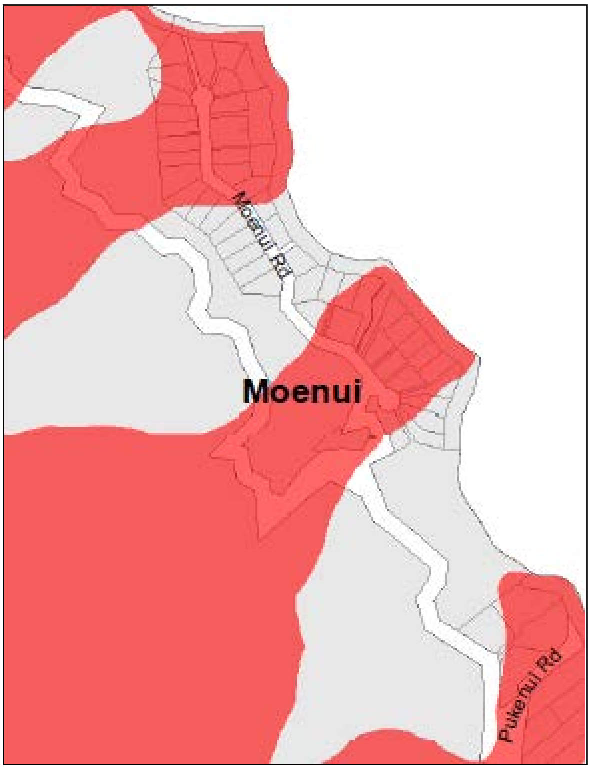

Figure A 5.8 A snapshot of the 1:10,000 Marlborough District Council Marlborough Sounds Resource Management Plan Area, Moenui (map 89, Marlborough District Council, 2010) and unstable areas (red).

When undertaking any hazard and/or risk modelling, planners should take the opportunity to discuss their scale needs with the modeller to ensure a practical map is produced that suits both the planners and modellers.

For example, tsunami modellers typically present their inundation maps with a scale based on grid spacing (e.g., 20 m), while planners require a ratio scale (e.g., 1:20,000). There are two primary issues that control the modelling outputs:

1. having a scale that is fine enough so that the inundation maps are not pixelated when viewing; and
2. computing restrictions, especially the amount of data in the modelling; the computational complexity; and the run time of the model (which can take from hours to weeks for an individual model). A probabilistic study may require running tens to hundreds of models. A process of 'line smoothing' is often required when raw map data is ambiguous, i.e., when no clear pattern of tsunami risk/inundation emerges from the modelling.

A5.4 UNCERTAINTY

There are two main types of uncertainty that can affect the inclusion of hazards in land use planning:

1. Uncertainties in the hazard modelling; and
2. Uncertainties in the decision making process, as shown in Figure A 5.9. When levels of uncertainty are deemed to be significant, a precautionary planning approach should be used.

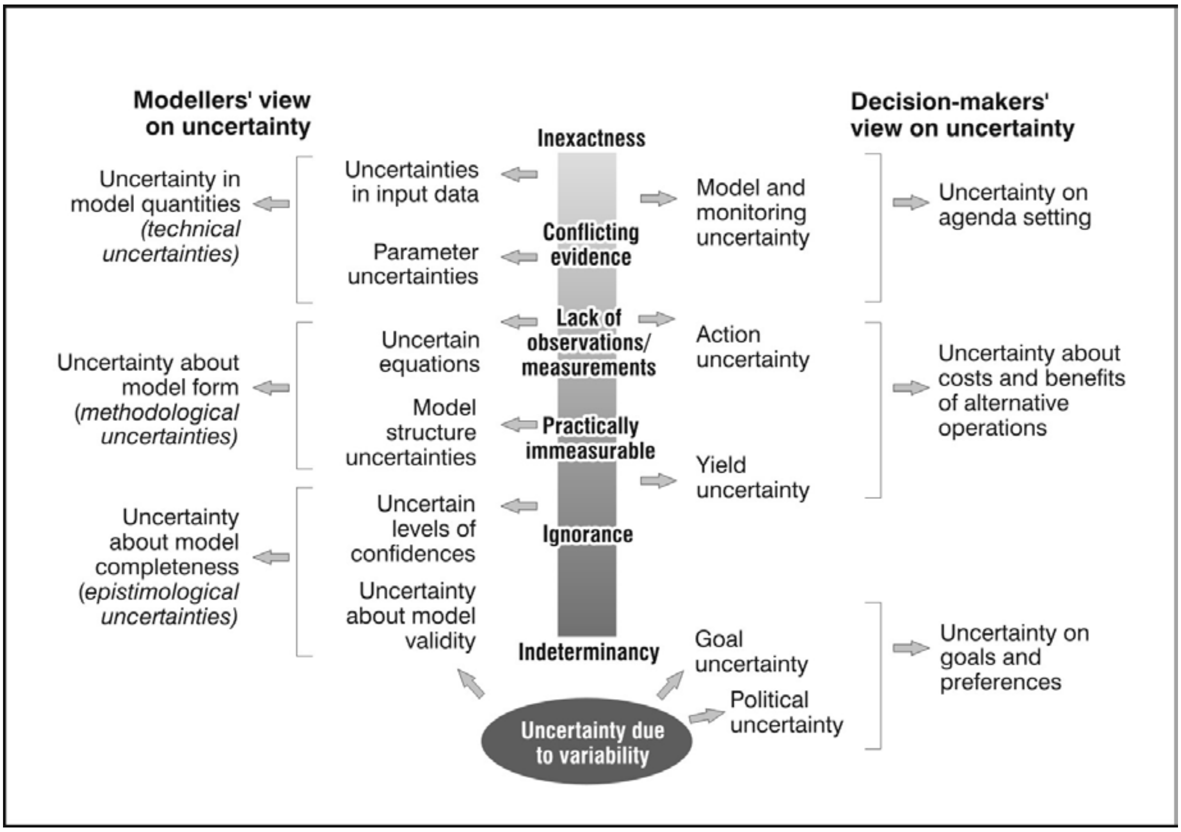

Figure A 5.9 Uncertainties in modelling and decision making (van Asselt, 2000, p91).

The following sections will discuss how to manage uncertainty in hazard modelling, decision making, and when mapping hazards.

A5.4.1 Uncertainty in hazard modelling

It is important to be aware of uncertainties in hazard modelling, to ensure that the limitations and assumptions of the modelling are well understood, taken into consideration (see following sub-section on mapping uncertainty), and the modelling data and quality are retained.

Uncertainty is encountered at various steps of the modelling process. There are four types of modelling uncertainties, as outlined below and in Figure A 5.9 (van Asselt, 2000):

1. Technical uncertainty: from the quality or appropriateness of the input data used to describe the system, from aggregation (temporal and spatial) and simplification, as well as from lack of parameters from data and approximations;
2. Methodological uncertainty: due to uncertainty in equations and model structures;
3. Epistemological uncertainty: uncertainty in levels of confidence and model validity; and
4. Model operation uncertainties: due to hidden flaws in technical equipment, and/or accumulation of uncertainties propagated throughout the model.

For example, uncertainties in tsunami inundation modelling include:

- uncertainties around earthquake parameters;
- the quality of the information about water interaction with ground roughness (including buildings and land use types);
- quality of the digital elevation model (map contours versus LIDAR); quality of bathymetry; real shape of ocean displacement (e.g., fault offset or bulge); and
- reflections and refractions of waves across the ocean.

Uncertainties from the modelling software can be reduced through validation of the modelling software using benchmark cases or common validation standards.

A5.4.2 Uncertainty in decision making

Various types of uncertainty in decision making may play a role in the process of deciding whether to incorporate tsunami modelling into land use planning. For example, political uncertainty may arise as the decision maker struggles with the political acceptability of options (van Asselt, 2000). To overcome this, decision makers need to be provided with an opportunity to learn and understand the importance of information and modelling, and the role it can play in reducing future risks to communities.

A5.4.3 Mapping uncertainty for land use planning

For other natural hazards, i.e., active faults and landslides, uncertainty is already included in planning maps.

A5.4.3.1 Active faults

Examples of mapping uncertainty include using ‘well defined’, ‘constrained’ and ‘distributed’ mapping of active faults (Kerr et al., 2003 - see Figure A 5.10 and landslide core and fringe areas (Saunders and Glassey, 2007 see Figure A 5.11).

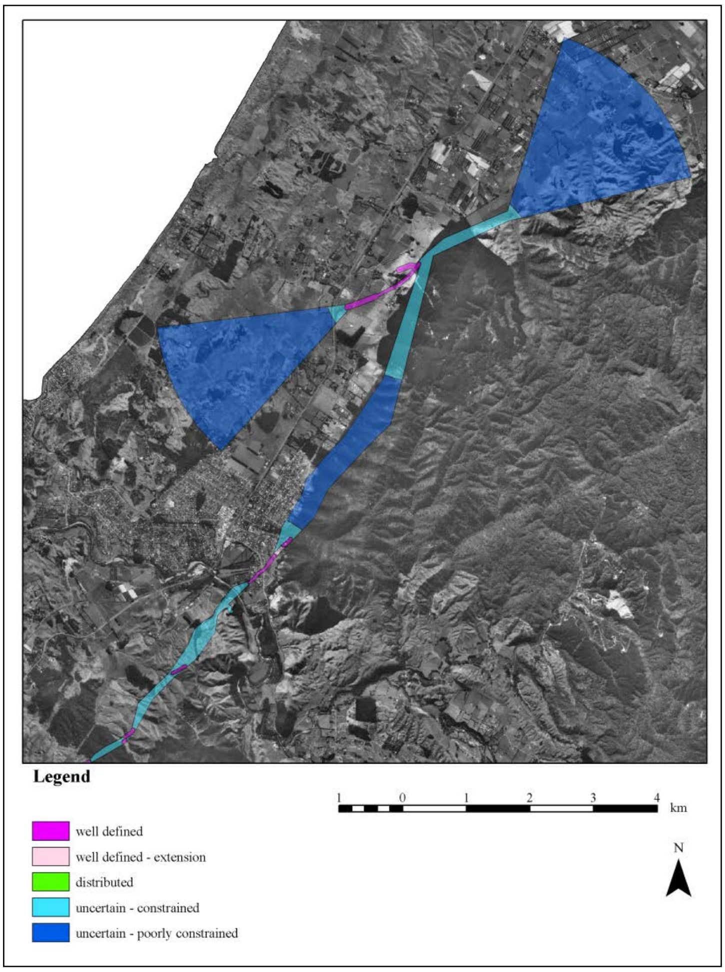

Figure A 5.10 Example of uncertainty in active fault mapping, with colours depicting type of fault and level of uncertainties (Kerr et al., 2003).

A5.4.3.2 Landslides

Many locations in New Zealand have been developed on areas of slope instability. While it is best to avoid these areas, in many cases the hazard was not known about before development occurred. Figure A 5.11 shows an example of one of these areas in Nelson, where the core area of a landslide has been mapped where the hazard is known (red), surrounded by a fringe area where the edge of the active slump has not been able to be accurately defined (green) (Nelson City Council). Rules stipulate that new residential units within the core are non-complying; within the fringe area they are a discretionary activity (Rule REr.77.3).

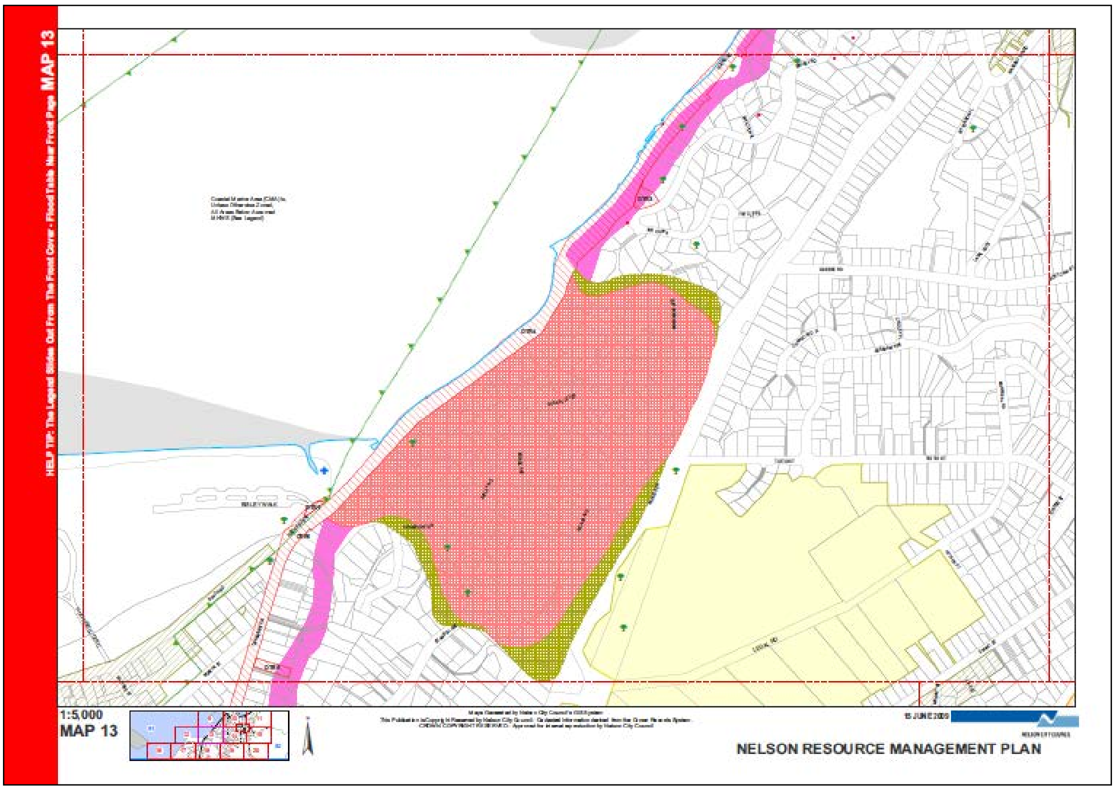

Figure A 5.11 The Tahunanui Slope Risk Area, commonly known as the Tahunanui Slump, is presented on the Planning Maps within the Nelson Resource Management Plan (Nelson City Council).

A5.4.3.3 Tsunami

For tsunami, an approach can be taken that is similar to landslides, as shown in Figure A 5.12 and Figure A 5.13. Figure A 5.12 presents a cross-section of modelled probabilistic tsunami wave heights at the coast, and associated levels of uncertainties. The middle hashed zone is bounded by the lower and upper levels of a chosen level of confidence. Figure A 5.13 presents a birds-eye view of the zones shown in Figure A 5.12.

Confidence levels are expressed as percentages. On a graph or a map they define a confidence interval on either side of an average value. In Figure A 5.12 and Figure A 5.13 this average value lies in the middle of the hashed 'uncertain tsunami inundation' zone. The confidence interval is the size of the hashed 'uncertain tsunami zone'. For 99% confidence, 1% of the time the true value will lie outside of the interval, while at 95% confidence, 5% of the time the true value will lie outside. Choosing a higher confidence (e.g., 99% instead of 95%) will make the hashed zone larger; the lower limit will become closer to the coast, and the upper limit will be further inland.

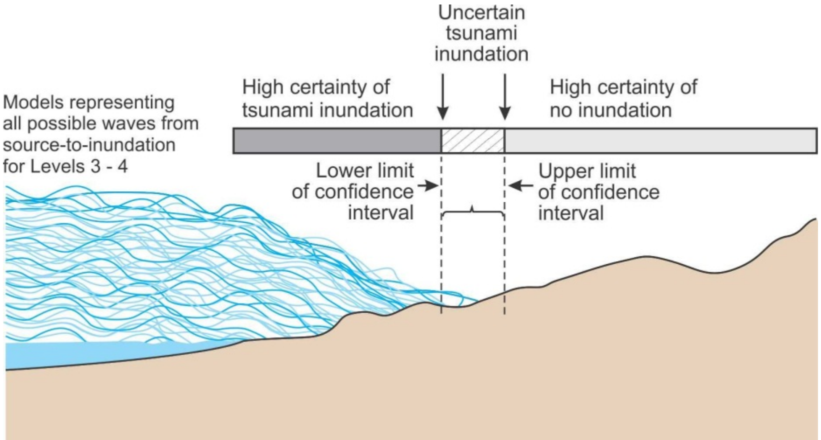

Figure A 5.12 Cross section of modelled probabilistic tsunami wave heights at the coast, and associated levels of (un)certainties (to a chosen level of confidence, i.e., a confidence interval) (Saunders, Prasetya, & Leonard, 2011).

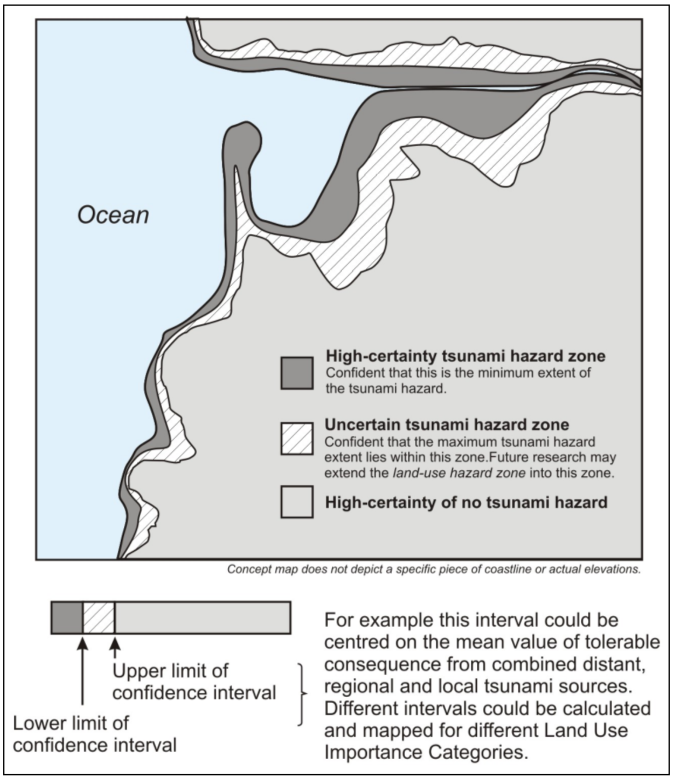

Figure A 5.13 Map view of the tsunami inundation shown in Figure A 5.12 (Saunders, et al., 2011).

The confidence interval used depends on how certain one needs to be that the following two situations will not occur:

a. a section of the 'high certainty of tsunami inundation' zone is actually not at risk from tsunami; or

b. a section of the 'high certainty of no inundation' zone is actually at risk from tsunami.

A5.4.3.4 Coastal erosion

Coastal erosion zones can be mapped using lines to represent risk zones. For example, Tauranga District Council has mapped three coastal erosion policy areas: the current erosion risk zone (red); the 50-year risk zone (yellow); and the 100-year risk zone (blue). An example of this is shown below in Figure A 5.14.

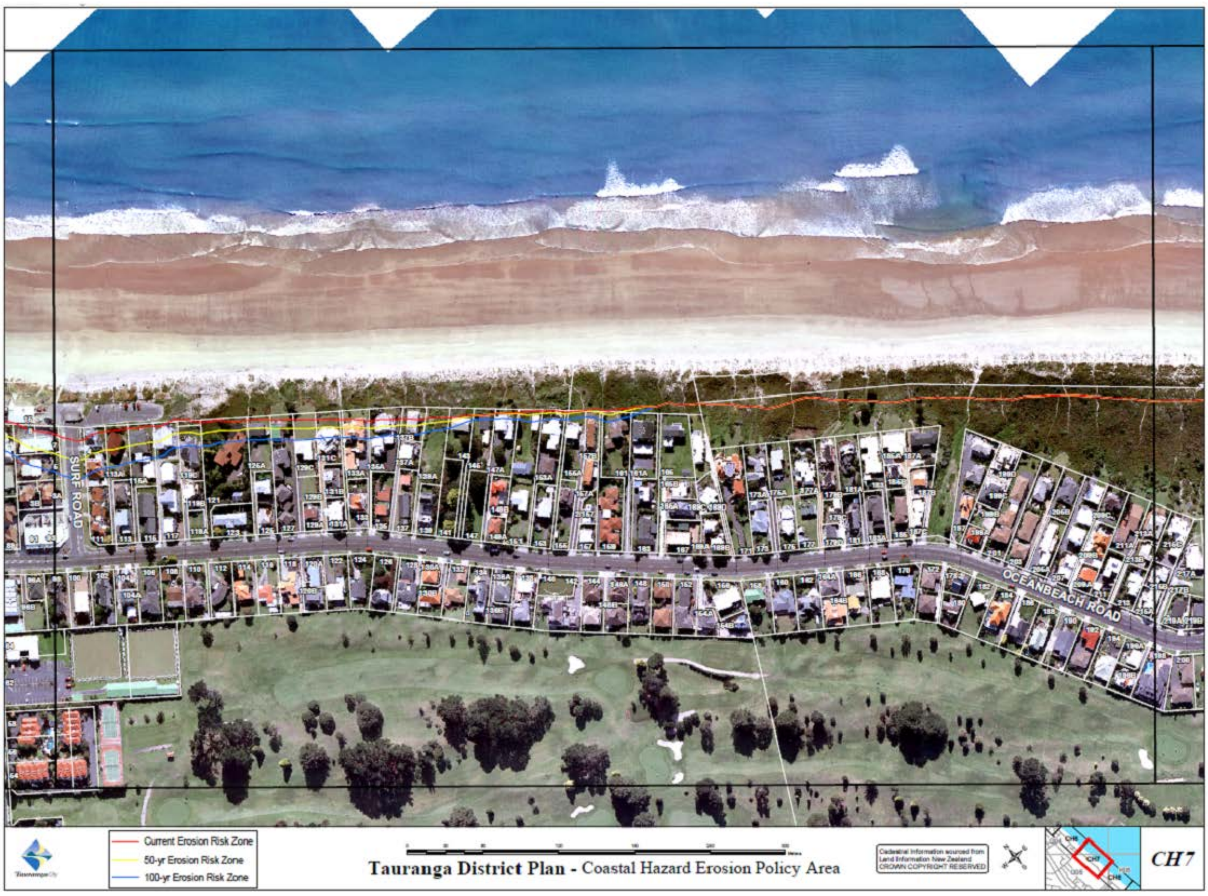

Figure A 5.14 Tauranga District Plan coastal erosion risk zones (Tauranga City Council, 2006).