Natural Hazards Commission Toka Tū Ake

Risk Tolerance Methodology

2025

Natural Hazards Commission Toka Tū Ake

Te Kāwanatanga o Aotearoa New Zealand Government

Risk tolerance is our willingness to bear a risk.

Understanding risk tolerance helps us decide how to manage the potential impacts of a hazard on the things we value (such as our health, environment, economy, and buildings and infrastructure).

This methodology seeks to fill a critical gap in New Zealand's well-established hazard risk management approaches. This will enable more robust and transparent risk-based decision-making.

Contents

Preface

Since the release of the Risk Tolerance Methodology in 2023, it has been tested and used across government and with researchers. We have received feedback and suggestions, and as a result have enhanced several aspects of the methodology. Notable updates include the integration of scenario-based approaches for both pre- and post-event planning, expanded guidance on risk criteria and thresholds, and improved direction on managing uncertainty.

In addition, our organisation has undergone significant transformation. Key changes include the introduction of new governing legislation — the Natural Hazards Insurance Act 2023 — the establishment of our new identity as the Natural Hazards Commission Toka Tū Ake, and the revision or development of several strategic and guidance documents. This update also reflects these developments.

As the methodology continues to be applied, and anticipated legislative changes are implemented, we expect ongoing learning to further shape and refine our approach. Future updates will reflect this evolving understanding and collaboration with stakeholders and partners.

Introduction

Risk tolerance is our willingness to bear a risk. Understanding risk tolerance helps us decide how to manage the potential impacts of a hazard on the things we value (such as our health, environment, economy, and buildings and infrastructure). To manage risks effectively and appropriately, we must assess our risk tolerance.

While New Zealand has well-established approaches for hazard risk management, we lack a nationally agreed approach for assessing and reviewing our risk tolerance. Furthermore, there is no framework (regulatory or otherwise) to understand what is tolerable, intolerable, or acceptable, and there is no consistent, agreed terminology to support this. This often leads to ambiguity in who manages risk and inconsistency in what risks are significant, as well as inconsistent approaches to risk across regions and organisations. This is a critical gap that this methodology seeks to address.

This methodology provides an approach to integrate a risk tolerance assessment into New Zealand's current hazard risk management frameworks (typically based on ISO 31000:2018). Figure 1 demonstrates a conceptual approach to hazard risk management in New Zealand with the addition of a risk tolerance assessment. This can be adapted for any hazard risk or policy framework. Appendix A provides an example of where a risk assessment approach, such as ISO 31000:2018, sits alongside/integrates into the framework.

It is not the intention of this methodology to address how to engage on risk tolerance, as comprehensive guidance for this is already available[1].

This methodology enables consistency while being adaptable to suit varying contexts and timeframes, including for decision-makers across local, regional, and central government levels, and within the private sector. This will contribute to more robust, transparent, and documented risk-based decision-making. The methodology also proposes nationally consistent risk terminology for risk tolerance, and criteria for risk thresholds that can be used to aid both recovery and pre-event land use planning.

This methodology is one of the activities that supports the Natural Hazards Commission's (NHC) Resilience Strategy for Natural Hazard Risk Reduction. The Strategy[2] sets out the NHC's ambition to play a key role in addressing New Zealand's current and future natural hazards resilience challenges, through a focus on risk reduction actions, driven by our research, education, and information sharing mandate.

Aimed at central, regional, and local government agencies who manage natural hazard risks, this methodology was developed following an extensive literature review of international and domestic case studies and resources[3].

1 For example Resilient Organisations 'Let's talk about risk', available at https://www.resorgs.org.nz/our-projects/risk-communication/lets-talk-about-risk/

2 https://www.naturalhazards.govt.nz/assets/Publications-Resources/Resilience-and-Research-Publications-/Resilience.strategy.risk.reduction-2024-2029-1-1.pdf

3 https://www.naturalhazards.govt.nz/resilience-and-research/research/search-all-research-reports/natural-hazard-risk-tolerance-literature-review/

New Zealand's current natural hazard risk management approach

How we understand and manage natural hazard risk in New Zealand can be conceptualised by:

1. **Understanding the hazard** in all its dimensions using data, models, and historic data to learn about possible scenarios that could impact us (including multi-hazard or cascading hazards). Our understanding of hazards is always improving as science and technology develops, and as we learn from natural hazard events.
2. **Understanding the risk** the hazard presents (via a risk assessment) including the exposure and vulnerability of the things it might impact. This also includes considering the magnitude, intensity, duration, and evolution of the hazard scenario and likely consequences/impacts. If appropriate, the probability and likelihood of the hazard can also be assessed. Risk is not static and should be assessed regularly over time and as new science, data and knowledge are built, or as risk management measures are implemented (which will change exposure and vulnerability).
3. **Managing the risk** via policy, planning, and practice. When risk is understood in all its dimensions (including uncertainty), an assessment of priorities for managing it can take place. This includes comparing all risks and identifying linkages and dependencies between them to ensure informed decision-making for effective risk management.

Assessing risk tolerance – which involves reconciling different stakeholders' tolerances of risk – is generally missing from this process, given there is no standardised, agreed approach. To effectively treat and manage hazard risks, a standardised approach to risk terminology and thresholds is required, as shown on the next page in Figure 1.

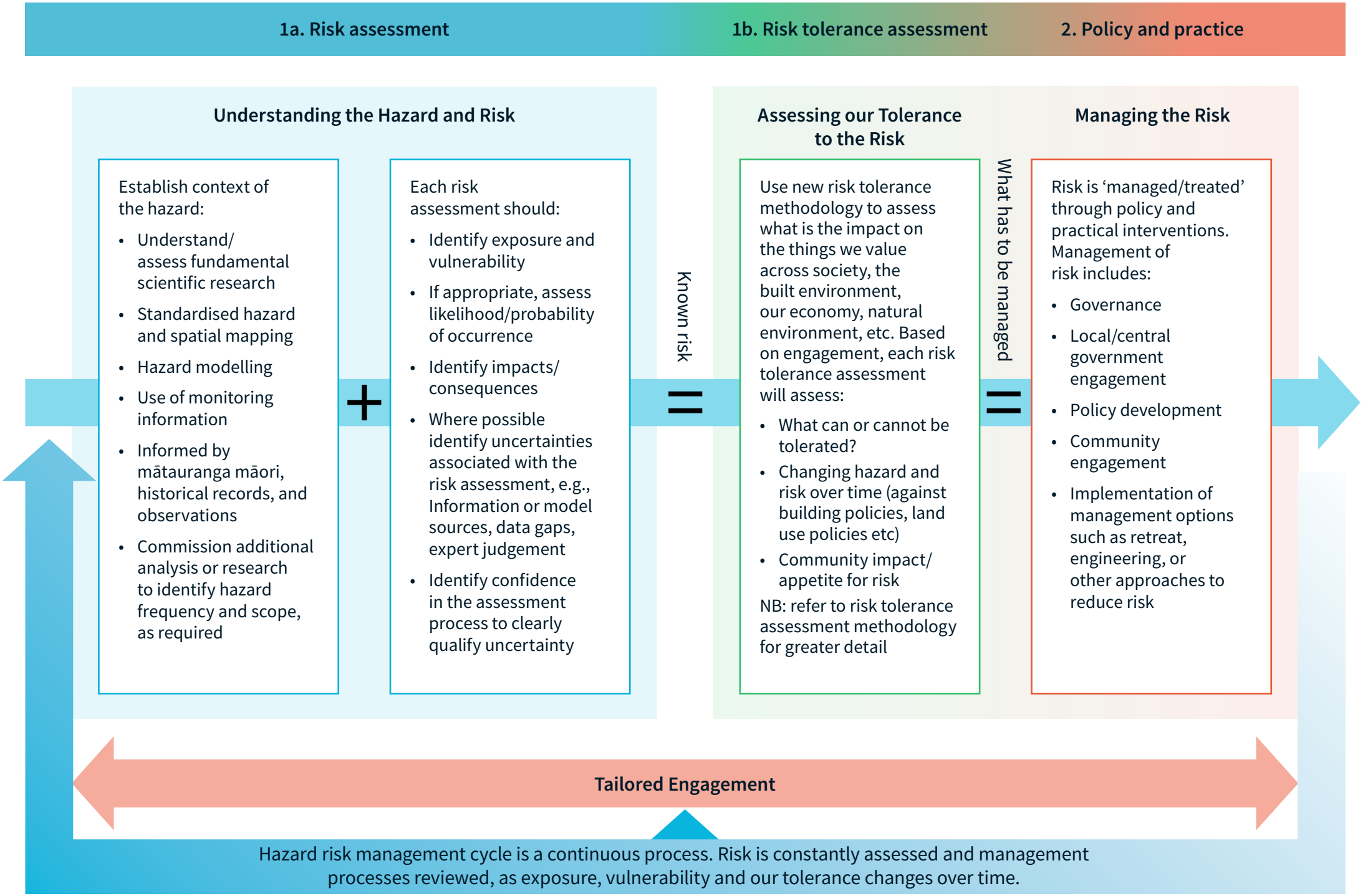


Figure 1 Conceptual approach to hazard risk management in New Zealand, including the assessment of risk tolerance.

Nationally agreed and consistent terminology

There is currently no consistent terminology for risk tolerance, or definitions of related, specific terms, nor for how they should be used in New Zealand. This contributes to confusion on intent and can result in inconsistent risk management outcomes. An example of this is the lack of direction on what 'significant risk' means under the Resource Management Act 1991, or how it is to be assessed, mapped, and planned for. Without national direction on what constitutes 'significant,' councils struggle to adequately plan for and manage natural hazard risk.

A nationally agreed approach with adopted terminology – for example, 'intolerable,' 'tolerable,' and 'acceptable' – is a vital part of improving natural hazard risk management. Additional clarifiers such as 'significant' or 'severe' could also be used to further describe risks beyond the overarching tolerability classifications.

Using agreed terminology will allow legislation and associated policies to describe risks in a consistent manner. For example, 'intolerable,' 'tolerable,' and 'acceptable' risks could correspond directly with 'removal,' 'reduction,' or 'monitoring' actions, respectively. This would allow for a consistent approach to how we treat risks, while still allowing flexibility for specific hazards. It would also provide national direction to the response appropriate to that level of risk.

To assist in reconciling the various terminology, NHC provided a recommendation for consistent terminology to the Environment Committee in their consideration of the 2023 Natural and Built Environments and Spatial Planning Bills. This is provided in Table 1 on the next page.

Table 1 Risk terminology usage in New Zealand regional policy settings.

Level of risk	Associated risk terms	Explanation	Descriptive examples
Intolerable	Catastrophic Severe Unacceptable Extreme High	Risk cannot be justified except in extraordinary circumstances. Activity must cease until risk is removed or reduced.	Resilience of the land use has or will soon be exceeded beyond sustainable risk reduction measures, with continued use of the land no longer sustainable; and/or The coping capacity of a community or property has been exceeded, or will soon be exceeded; and/or Life safety and/or functionality of the building is threatened beyond risk reduction measures; and/or The consequential effects of the development on the environment will be irreversible; and/or 'X' number of events leading to one or more of the points above have occurred in 'Y' years.
Tolerable	Significant Substantial Medium Tolerable	Risk is accepted only if the benefit gained is shown to outweigh the risk (using the 'As Low As Reasonably Practicable' principle[5]). Tolerable only if risk can be mitigated at a cost proportional to the benefit gained.	The sustainable use of the land can continue with cost-effective risk reduction measures; and Monitoring of the natural hazard and climate change risks is undertaken to allow changes in risks to be managed; and Communities can cope with the impacts from natural hazard events; and The life safety risk and/or functionality of the land use can be managed to safeguard the future of the land use.
Acceptable	Acceptable Low Insignificant Negligible	Broadly acceptable. Monitor and maintain assurance that risk remains at this level.	Activity can occur with limited controls or restrictions.

5 For a risk to be ALARP, it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained (Worksafe UK, 2024: What does ALARP mean? Retrieved from https://www.worksafe.uk.com/risk-assessment/what-does-alarp-mean/).

Assessment of risk tolerance

Natural hazard risk assessments are not required to follow a standard approach. Different methodologies exist and are used for different hazards and to serve different purposes. The companion risk tolerance literature review paper[6] found that this allows the most appropriate methodology to be used. Various councils, sectors, and agencies have established unique hazard and risk assessment methodologies that are fit for purpose. For example, the approach to assessing risk for earthquake-prone buildings is different from a climate change risk assessment.

However, to enable a consistent approach to assessing risk tolerance, the risk assessment should result in a clear level of known risk and include a transparent decision-making process to determine the tolerability of that risk and its management options.

Once we understand the nature and level of a risk, we must consider whether we are willing to tolerate its consequences. Tolerance to the known level of risk should be assessed by considering the following:

- The policy timeframe the level of risk will be managed for. For example, policy cycles (~10 years), spatial planning (~30 years), built environment (~50 years), climate change adaptation (~100 years), etc.
- What could or has been impacted, and to what extent. For example, numbers of deaths (social), cost to repair damage (economic), irreparably altered ecosystem (environmental), who is affected, etc.
- Who bears the consequences of the risk and/or risk treatment option. For example, who are the stakeholders; do those who create the risk experience it or pay for its treatment, who decides, who lives with it, etc.
- Comparing the timeframes, consequences, and other factors against the pre-defined risk thresholds to determine the overall risk tolerability.

6 https://www.naturalhazards.govt.nz/resilience-and-research/research/search-all-research-reports/natural-hazard-risk-tolerance-literature-review/

Figure 2 shows there are two pathways for assessing risk tolerance – either using scenarios with pre-established risk thresholds, or assessed after a specific event. Both pathways require this methodology to aid their assessment and planned response. Pre-event and post-event risk threshold criteria tables to guide decision-making are provided in a following section. Further details on how to undertake pre-event land use planning is available on our website.

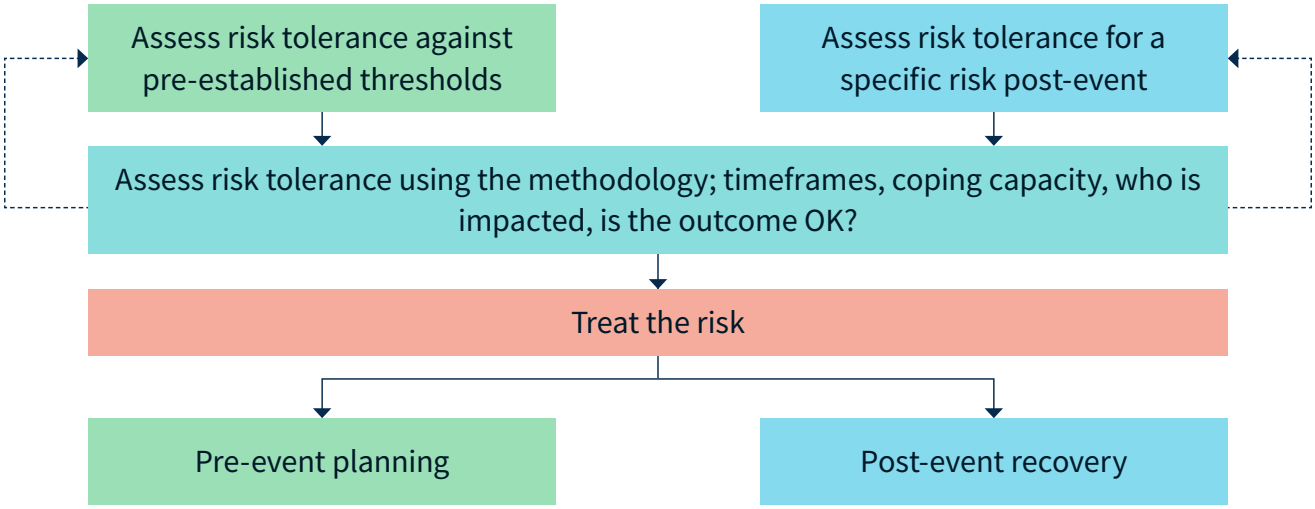


Figure 2 Use of the methodology pre- and post-event.

Each part of the process should be well documented for transparency. The components of the risk tolerance methodology are summarised in Figure 3.

Risk tolerance methodology

What is the decision for, over what timeframe?

What is the policy timeframe the risk tolerance decision will be managed over? What decision will the risk tolerance assessment inform?	~10 years	~30 years	~50 years	~100 years
	Government policy	Spatial planning	Built environment design	Climate change adaptation

What could, or did, happen?

Use **scenarios** to assess the consequences of an event **or** use impact data, hazard and risk assessments to assess the consequences of an event. Use the considerations below to test the coping capacity.

Social	Economic	Governance/ Sovereignty	Natural environment	Cultural	Built
How many deaths, injuries, or illnesses will occur? Will mental health or public wellbeing suffer? Will the impacts be felt equitably?	How much will it cost to repair any damage? Will the risk disrupt the local or regional economy? How much disruption is ok?	Will the ability to govern be impeded? Does public perception demand or prevent a certain action? Does the risk affect NZ sovereignty?	How will the environment be affected? Will irreversible damage be done to an ecosystem? Does the risk affect how the environment affects society?	Does the risk affect places of cultural or archaeological significance? Will the risk preclude future generations from some experience or resource?	Will the risk prevent normal use or function of buildings? Will the risk disrupt normal infrastructure or utility service levels?

Who is affected?	What is the scale?	Who lives with it?
Homeowners – insured, non-insured, renters. Iwi/hapū – housing, marae, urupā. Infrastructure providers – roads, power, communications. Council – regional and/or district; other stakeholders.	Local – affects those both in and out of the hazard extent. Regional – districts are affected. National – significant social and economic impacts.	Does this require a short-, medium-, or long-term fix? Are people empowered to modify their own risk? Is there an equitable spread of consequences?

Is this ok?

Use the pre-event (table 2) or post-event (table 3) criteria to guide decision-making using risk tolerance thresholds.

If not ok, how can the risk be treated?

What are the options, and are they acceptable to the wider community, iwi/hapū, council, and infrastructure providers, both now and in the future?

Who decides?	Who pays?	Who lives with it?
Who participates in the decision-making – what are their values? Is the process robust, transparent and documented? Who has the authority to enact a change?	Do those who create the risk experience it or pay for its treatment? What is the opportunity cost of doing nothing? Is it cost-effective to treat the risk?	Does this require a short-, medium, or long-term fix? Are people empowered to modify their own risk? Is it sustainable to just accept the risk?

Is this ok?

Use the pre-event OR post-event criteria table to guide decision-making using risk tolerance thresholds.

Acceptable	Tolerable	Intolerable
Broadly acceptable. Monitor and maintain assurance that risk remains at this level.	Risk is accepted if benefit gained is shown to outweigh the risk. Tolerable if the risk can be mitigated at a cost proportional to the benefit gained.	Risk cannot be justified except in extraordinary circumstances. Activity must cease until risk is removed or reduced.

Figure 3 Risk tolerance methodology.

Why is a risk tolerance decision needed, and in what timeframe?

Before undertaking a risk tolerance assessment it's important to understand why the assessment is being done, what decision it will inform, and the timeframe over which that decision will apply.

Risk is a temporal phenomenon; it can vary over time due to changes in exposure, hazard, or vulnerability, or it may be acceptable in the present but become unacceptable at some point in the future. Additionally, the nature of some hazards (e.g. coastal flooding) causes their impacts to grow exponentially with increasing timeframes. Therefore, scaling timeframes does not, necessarily, directly correlate with scaling impacts or risk. A risk tolerance assessment should be able to reflect this by indicating a risk is "presently" one classification (e.g. currently 'tolerable') but will likely change over a different timeframe (e.g. become 'intolerable').

Government policies may be drafted for a 10-year period, while some climate change adaptation plans consider the next 100 years. Spatial planning considers matters for approximately 30 years, and the built environment typically assumes a 50-year design life for built assets. For example, a typical house in New Zealand is designed to be used for 50 years but may be in use well beyond this time. The risk associated with living in or using this house for those 50 years should be acceptable. However, living in the house for longer periods of time expose it to more – or more severe – hazards than intended. This means the risk may increase over time to a point that is no longer acceptable (e.g. the risk of living in a coastal location may be acceptable for 50 years, but after 75 years the coast has eroded metres, and the risk is no longer acceptable).

Using the risk tolerance methodology shown in Figure 3, assessing risk tolerance begins with understanding what timeframe the specific risk will be relevant or managed for, as well as how it may change over time.

What could, or did, happen?

Natural hazards can impact the things we value in different and multiple ways, affecting our society, economy, built environment, natural environment, or culture and heritage. When natural hazard events result in a range of consequences, it is important to evaluate them in relation to each other. For example, either using a scenario or post-event information:

- How many deaths, injuries, or illnesses can a community or society cope with?
- Will a hazard impede the ability of a government to function?
- Will the local or national economy be able to absorb the cost of any damage or disruption?
- Will built assets be damaged or unusable, and for how long?
- Will an ecosystem undergo irreversible damage?
- Will places of cultural or archaeological significance be affected?
- Who is affected?
- What is the scale of the event and consequences?
- Who lives with the risk?

Impacts should be considered within the possible range of outcomes for that specific type of consequence, and then against the risk threshold criteria (i.e. acceptable, tolerable, intolerable).

Using natural hazard scenarios

Scenarios are a practical tool to think ahead and prepare for the impacts of natural hazards before they happen. By looking at a range of possible events – from small disruptions to major disasters – scenarios help us picture what could happen to people, infrastructure, and the environment. This makes it easier to have informed conversations about what level of risk we're comfortable with. Additional benefits of using scenarios include:

- They make risk feel more real and relatable – instead of talking about hazards in abstract terms, scenarios help bring them to life. This makes it easier for communities and decision-makers to understand what's at stake and why certain actions might be needed.
- They support flexible, adaptive strategies that can evolve as we learn more about hazards. For example, strategies can be tested against scenarios to evaluate their effectiveness.
- They provide an evidence base for policies and land-use decisions that reflect what level of risk we're willing to accept or tolerate.
- They can show how one hazard might lead to another. For example, a flood might damage infrastructure in a way that increases the risk of landslides or other hazards. Understanding these knock-on effects helps us see the bigger picture – not just the immediate impacts, but also the longer-term consequences that can change how risk builds up over time.

By capturing both the direct and cascading effects of hazards, scenarios help ensure that our policies, plans, and mitigation efforts are based on a full understanding of the risks – and are proportionate to what we're willing to tolerate.

Can the risks be treated?

Risk treatment involves selecting and implementing strategies to manage the potential impacts from natural hazards. This process requires careful consideration of risk tolerance – for example, the level of risk the government, council or community is willing to accept. Decisions may include structural mitigation (e.g. strengthening buildings), land-use planning, early warning systems, or community preparedness initiatives. The outcomes of these treatments aim to reduce vulnerability, enhance resilience, and minimise potential losses. Whether a decision is acceptable depends on its alignment with community values, legislative requirements, cost-effectiveness, and its ability to reduce risk to a tolerable level. In cases where residual risk remains high and cannot be justified, the treatment may be deemed unacceptable, prompting the need for alternative or additional measures. Who decides, who pays, and who lives with the risk each need to be considered for the short and long term.

Engagement

Robust engagement must drive any risk tolerance assessment. Those who bear the consequences of the risk or risk management options are crucial in this process. Engagement should involve many diverse groups of stakeholders, therefore a rigorous process for reconciling different views or risk tolerances is also needed. Guidance on how to talk to communities about risk is available from the Resilient Organisations 'Let's talk about risk' project[7].

Engagement on risk tolerance must consider:

- who is affected, who is determined to be the 'community of interest,' and what is important to them
- who has been affected, and what their residual experience or attitudes are
- who contributes to the decision-making process. Do they have the authority to make a change?
- who will pay either directly or through risk financing for the risk management options
- who will live with the consequences, and are they empowered to make a change through this process.

A different engagement approach will be needed for Māori, whose relationship with the environment extends beyond the built environment. In addition to the points above, other cultural factors need to be considered in any risk tolerance conversations with Māori, for example the protection of whakapapa, knowledge of their history, what mātauranga Māori they hold, what local atua they may relate to, any sites of significance, connections to the whenua, and any Crown Te Tiriti o Waitangi obligations. Any engagement requires consideration of past, present and future experiences and events. Empathy, respect, and compassion needs to be shown, with an understanding of any equity challenges that communities may face.

Robust and transparent process

It is important to have a clear process for determining risk tolerance and thresholds, to ensure there is an agreed approach to putting risk-based policies into practice. For example, if a policy requires a risk to be 'acceptable', there should be an established way of assessing that risk, now and over time. In other words, this should not rely on one person deciding based solely on their own values, knowledge, and experience, or without using agreed metrics.

A robust and transparent process to assess risk tolerance (e.g. the decision-making process is well documented and publicly available) is important to ensure that those involved, and those who bear the impact of the decisions, understand why and how a decision was made. There are two key aspects to this: the risk assessment process, and the decision-making on levels of risk tolerance.

7 https://www.resorgs.org.nz/our-projects/risk-communication/lets-talk-about-risk/

Understanding how community perspectives on risk and technical risk assessments will be used in determining risk tolerability, risk thresholds, or risk management outcomes is important. It requires a process that uses valid ways (i.e. best practice engagement methods) of eliciting community input, appropriate analysis and use in decision-making. A process for decision-making should be transparent (e.g. documenting how different stakeholder views are incorporated); support insights from a range of knowledge bases (including mātauranga Māori); and allow for collaborative decision-making on the levels of risk which are deemed acceptable, tolerable or intolerable (e.g. combining the input of many stakeholders to make the best decision for the community). For technical risk assessments, a process includes the incorporation of science, research, evidence and historical records; loss modelling; hazard, data, analysis and mapping; dynamic hazard exposure and vulnerability mapping; and integrating mātauranga Māori, risk tolerance, and modelling.

Risk tolerance thresholds

Risk tolerance thresholds refer to 'acceptable,' 'tolerable,' or 'intolerable' levels of risk.

Risk thresholds must be determined independently of any individual risk assessment. Risk thresholds should reflect societal views and priorities, e.g. how many deaths or what level of damage becomes unacceptable, regardless of the hazard or risk. Results from individual risk assessments are compared to these thresholds to guide risk management through existing policy frameworks.

Risk tolerance criteria should be monitored over time, to review any changes in risk tolerance as, for example, events of a time dependent nature evolve, new information emerges, or market conditions change, etc.

Levels of assessment

Risk tolerance needs to be considered at national, regional and local levels, and some of the considerations will overlap (see Figure 4 and Appendix A), as discussed below.

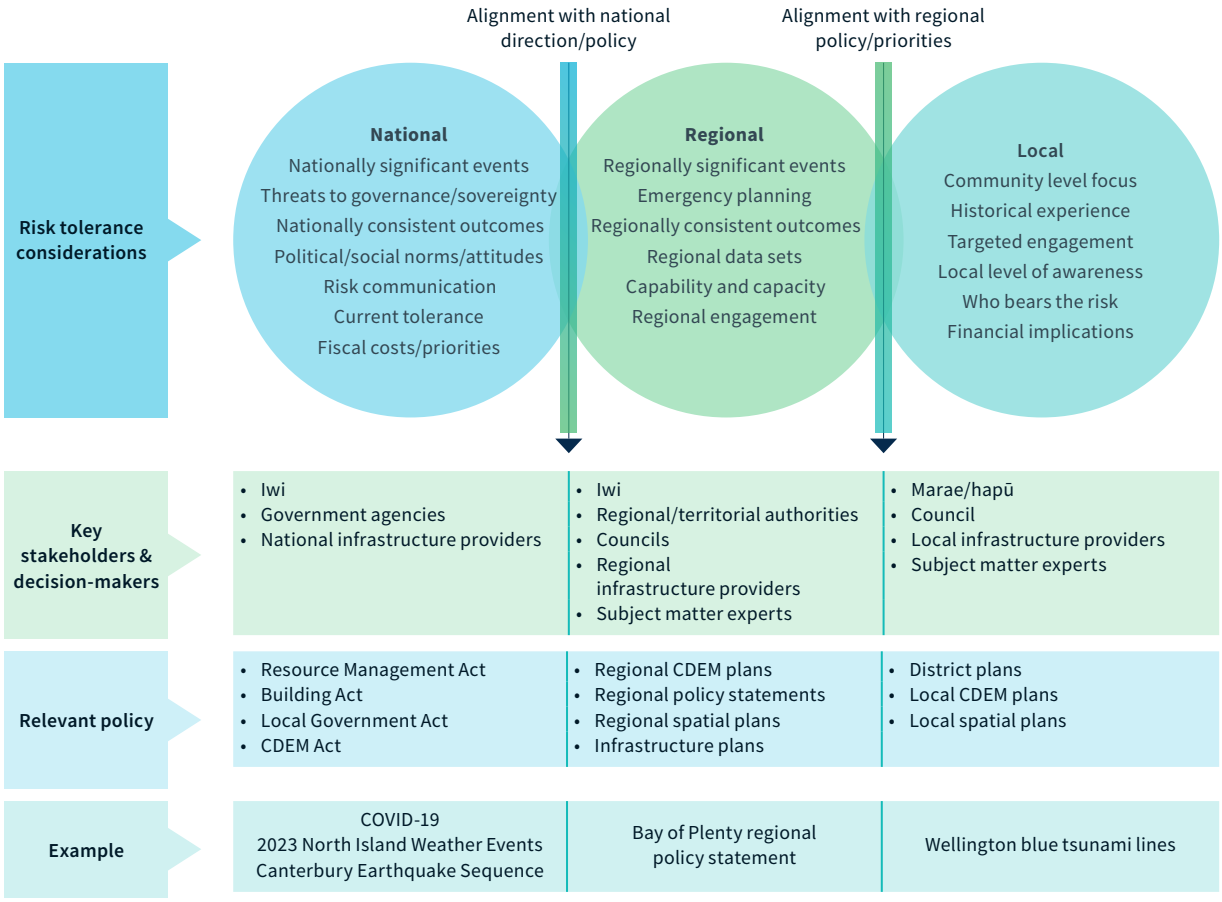


Figure 4 Example of national, regional and local risk tolerance considerations.

National level

Nationally, there are various policies, codes, and standards that manage natural hazard risk. Consistent approaches and implementation for risk tolerance and thresholds should ideally sit in national legislation, for example, the Building Act 2004 and the Resource Management Act 1991. When assessing a known or new risk at the national level, or where new policy instruments are required to manage the risk, key aspects to consider include:

- current Government priorities
- general political appetite
- implications for other priorities and policies (e.g. regulatory impact)
- scope and scale of impact
- cultural impacts
- impact on governance and sovereignty
- fiscal priorities, budgetary or other financial implications
- community expectations of how government should manage the risk
- impacts on communities, including experience of past events/impacts
- what is currently tolerated, and will this change in the future (e.g. with the climate change impacts)
- political will vs public perception and acceptance
- how the risk will be communicated or is communicated (e.g. how the probabilities of the Covid-19 pandemic were described, before and during the management of the pandemic).

Examples of when the risk tolerance assessment should be used nationally include when deciding on managing a national risk that either frequently occurs across many areas with low impact (and high overall associated cost), or a less frequently occurring risk that has high consequence and high associated costs; and supporting national policy development, adaptive planning, community relocation decision-making, and pre-event land use recovery. Management of these types of risk(s) needs to be prioritised and a risk tolerance assessment supports pragmatic decision-making and prioritisation based on the above bullet points.

Regional level

Risk tolerance criteria should be determined by the appropriate national-level policy, and then applied with a regional focus considering the stakeholder tolerances in the regional context. For example, ensuring building requirements, emergency management planning, engineering options, insurance, regional data sets, community appetite for the risk threshold or the risk management, and expert opinion are all considered.

A key aspect of using the risk tolerance methodology regionally is the level of engagement required. Engagement with territorial authorities, regional councils, Māori, infrastructure providers, private sector stakeholders, and others should be ongoing, and regularly monitored. Taking a regional approach to assessing risk tolerance extends consistency from national policy to the sub-national level.

Local level

Locally, risk tolerance criteria are directed by regional-level policy and any outcomes reached from their risk tolerance assessment. The key and most important difference with the local approach to assessing risk tolerance is that the assessment has a community level focus. Local risk tolerance criteria are informed and developed with cross-community engagement with marae, hapū, community service providers, and different community representatives (e.g. disabled, youth, elderly, religious, and other subject-matter experts) using best available local data.

Before engaging with communities, the level of understanding of the risk across the community should be assessed. Without this, working through a decision on tolerability will become complex, and misunderstanding may arise within the community about what the risk represents. Risk tolerance needs to be set through a transparent reconciliation of expert, community and political or institutional perspectives. Caution should be exercised on the inappropriate aggregation or averaging of results without reconciling perspectives.

Things to consider when engaging with the community include, but are not limited to:

- who is bearing the impacts of the risk management decision?
- has there been any exposure to previous events?
- what is the age range of the communities? This relates to decisions about aged care facilities, schools and play facilities, alongside other related community needs.
- have cultural views been considered?
- what are the expectations for their whānau and community?
- what are the levels of awareness and understanding of risk, risk management, and the impact of the hazards on the things a community values?

An example of when the risk tolerance assessment would be used locally is when making decisions on options for climate adaptation using the dynamic adaptive pathways[8] approach. A community's tolerance for sharing the costs based on a set level of protection, the expected life of that protection, and what other actions will still be required all need to be assessed. The community's risk tolerance will influence which options are decided upon and the associated adaptive pathway triggers and thresholds.

Managing uncertainty

Uncertainty always exists where data and information are used to make decisions. This is often more complex when dealing with natural hazards due to the unpredictability of natural hazard events, and the way in which these events interact with the things we value (e.g. people, the built environment, and the economy). Quantifying or qualifying uncertainty has been an ongoing challenge in national, regional and local risk assessments for some time. Uncertainty will always exist, but it should not impede action. Therefore, finding a way to articulate uncertainty is an important part of this work.

8 Dynamic adaptive planning specifies actions to be taken immediately to be prepared for the near future, and actions to be taken now to keep options open to adapt if needed in the future (www.deltares.nl/en/expertise/areas-of-expertise/sea-level-rise/dynamic-adaptive-policy-pathways)

In addition, by effectively communicating uncertainty we can support decision-makers to make more robust decisions and create alternative plans of action, if required. Research has shown that effectively communicating uncertainty can also increase trust in both the communicator and the risk or science information. Effective elements include describing the uncertainty's source (where it comes from and why it exists), what is being done to reduce it if it is possible to do so, why it may not be reducible at this time, and if it can be reduced, when, and what is required. These elements should be adapted for the context, audience, and the time available for communication.

There are many different types of uncertainty which contribute to how risk is accepted or otherwise. For example, uncertainties associated with problem formulation, modelling, scenarios, data and interpretation can all affect the understanding of the hazard and risk, and affect decision-making – and the uncertainty of the natural system.

Appendix C provides the different types of uncertainties that can affect risk tolerance, their implications for risk tolerance, and options for how they can be managed. In addition to the options available to manage specific uncertainties, the precautionary principle should be used: where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation[9].

Setting risk thresholds and criteria

There are many challenges with setting risk thresholds, such as deciding which life metrics to use, scalability and reconciling varying risk tolerances. Metrics for thresholds can be qualitative, quantitative, or both. Regardless, metrics need to be measurable, rely on information that is available, and the approach clearly documented. Descriptive criteria can be useful to ensure that the intent of the threshold is clearly understood. To help address these challenges, NHC has developed Tables 2 and 3 below to provide risk threshold criteria guidance, based on two example scenarios:

1. Pre-defined categories for short-term land use response and recovery after an event, i.e. land use recovery options based on damage following an event
2. Pre-defined categories for pre-event land use planning, i.e. long-term response to how planning provisions may need to change to allow for a more efficient recovery

Each of the examples in the tables include a category description, category example, criteria, risk threshold, and a metric for how the threshold can be measured. A risk tolerance assessment will be required to inform the thresholds and criteria.

9 UNGA. (1992). Report of the United Nations Conference on Environment and Development. Rio de Janeiro (BR): United Nations General Assembly (UNGA).

Table 2 Example of post-event damage categories, criteria, and risk thresholds for land use recovery.

Damage state	Category Description	Category Example	Criteria	Risk threshold	Metric
Minor damage	Repair to previous state.	Minor damage, no need for significant redesign/retrofitting. Private insurance is sufficient but uninsured may face hardship.	Risk to people and property is acceptable; activity can occur with limited repairs.	N/A	Assessment of life safety is less than 10^{-6} – 10^{-5} per year (AIFR).
Moderate damage – community interventions	Community-level interventions are effective in managing future risk.	Local government repairs and risk reduction initiatives are adequate to manage future risk.	Risk is accepted only if the benefit gained from repairs and protection is shown to outweigh the risk (using the 'As Low As Reasonably Practicable' principle). Tolerable only if risk can be mitigated at a cost proportional to the benefit gained.	The sustainable use of the land can continue with cost-effective risk reduction measures; and Communities can cope with the impacts from natural hazard events. The life safety risk and/or functionality of the land use can be managed to safeguard the future of the land use.	Area being assessed will need to develop or use their risk rolerance threholds based on local catchment charateristics. Area specific coping capacity indicators will need to be developed. Availability of insurance e.g. is insurance retreat a possibility? Assessment of life safety is between 10^{-5} and 10^{-4} per year (AIFR).
Moderate damage – property interventions	Property-level interventions are needed to manage future risk, including in tandem with community-level interventions. Potential for significant further assessment required.	Property-specific measures such as improved drainage and raising houses is necessary. Benefits accrue to property owners, but some may face affordability issues. Interventions may be required/ possible but insufficient information to provide initial categorisation.			
Significant future risk	Future risk cannot be sufficiently mitigated. In some cases, some current land uses may remain acceptable, while for others there is an unacceptable risk of injury or death.	In the face of enhanced climate risks, the property may face unacceptable risk of future flooding. Other property could be subject to unstable land that poses an ongoing risk.	Impacted by event(s); and Imminent risk to life; and/or Land damage makes rebuild technically or economically infeasible; and/or Unacceptable future risk to assets (life, land, property, infrastructure etc) and compelling evidence (such as land damage assessments and recurring events such as repeated flooding) means that no other solution can reduce risk to acceptable or tolerable level at an acceptable cost.	Resilience of the land use has or will soon be exceeded beyond sustainable risk reduction measures, with continued use of the land no longer sustainable; and/or The coping capacity of a community or property has been exceeded, or will soon be exceeded; and/or Life safety and/or functionality of the building is threatened beyond risk reduction measures; and/or The consequential effects of the development on the environment will be irreversible. 'X' number of events leading to one or more of the points above have occurred in 'Y' years Not just risk to life, other considerations need to be included for all assets at risk e.g. infrastructure, land and property. Monitoring of the natural hazard and climate change risks is required to allow changes in risks to be managed.	Area being assessed will need to develop or use their risk rolerance threholds based on local catchment charateristics. Area specific coping capacity indicators will need to be developed. Availability of insurance e.g. is insurance retreat a possibility? Assessment of life safety is between 10^{-5} and 10^{-4} per year (AIFR). Tolerance to risk needs to be assessed, monitored and reviewed over time.

Table 3 Examples of pre-defined categories, criteria, and risk thresholds for pre-emptive land use planning.

Damage state	Title	Explanation	Risk threshold	Metirc	Planning response
Low	Permitted/ Controlled	Risk to people and property is acceptable; activity can occur with no or limited controls.	N/A.	Assessment of life safety is less than 10^{-6} – 10^{-5} per year (AIFR).	Enable development.
Moderate	Discretionary	Risk is accepted only if the benefit gained from repairs and protection is shown to outweigh the risk. Tolerable only if risk can be mitigated at a cost proportional to the benefit gained.	The sustainable use of the land can continue with cost-effective risk reduction measures; and Communities can cope with the impacts from natural hazard events. The life safety risk and/or functionality of the land use can be managed to safeguard the future of the land use. Infrastructure can be maintained and developed with effective risk reduction measures.	Area being assessed will need to develop or use their risk tolerance thresholds based on local catchment characteristics. Area specific coping capacity indicators will need to be developed. Availability of insurance e.g. is insurance retreat a possibility? Assessment of life safety is between 10^{-5} and 10^{-4} per year (AIFR).	Existing uses may need adaptive responses to reduce increasing risks e.g. Dynamic Adaptive Pathways Planning. Further development may require restrictions/mitigation measures/ resilient design. Changes of use do not increase risk.
High	Non-complying / Prohibited	Impacted by event(s); and Imminent risk to life; and/or Land damage makes rebuild technically or economically infeasible; and/or Unacceptable future risk to assets (life, land, property, infrastructure etc) and compelling evidence (such as land damage assessments and recurring events) that no other solution can reduce risk to acceptable or tolerable level at an acceptable cost.	Resilience of the land use has or will soon be exceeded beyond sustainable risk reduction measures, with continued use of the land no longer sustainable; and/or The coping capacity of a community, property or infrastructure has been exceeded, or will soon be exceeded; and/or Life safety and/or functionality of the building is threatened beyond risk reduction measures; and/or The consequential effects of the development on the environment will be irreversible. 'X' number of events leading to one or more of the points above have occurred in 'Y' years. Monitoring of the natural hazard and climate change risks is required to allow changes in risks to be managed.	Area being assessed will need to develop or use their risk tolerance thresholds based on local catchment characteristics. Area-specific coping capacity indicators will need to be developed. Availability of insurance e.g. is insurance retreat a possibility? Assessment of life safety is between 10^{-4} and 10^{-3} or greater per year (AIFR). Tolerance to risk needs to be assessed, monitored and reviewed over time.	Relocate from areas of intolerable risk. Prohibit future development that may increase the risk to life or property. Prohibit further intensification of existing uses. Investigate alternative land uses (if appropriate) that reduce risks to tolerable levels.

Using the methodology

This methodology should be used for the assessment of current and future risks. In all cases, the following must be considered and thoroughly documented:

- **What information has been used to ascertain the risk**. This should be based on the best available information such as scientific data and/or modelling. In the absence of scientific information, the most practicable information should be used, such as local knowledge or historic accounts. Any limitations of that information should also be documented.
- **The risk tolerance criteria used, which is appropriate for your sector** e.g. 'acceptable,' 'tolerable,' or 'intolerable' risk thresholds. These can be agreed and/or established thresholds validated through engagement before a specific risk assessment, or a part of a specific risk assessment, e.g. post event.
- What **timeframes you are assessing the risk against** e.g. district planning time horizons, governance timeframes, or hazard return periods.
- **Who will be impacted**. This could include councils, organisations, Māori, infrastructure providers and communities. Develop an engagement plan that outlines the known risk, and the assessment process being undertaken to determine how the risk will be managed, and how engagement outcomes will be used in the decision-making process.
- What **policies, codes, standards**, etc. can help manage the risk. Review current tools before committing to any option.
- Different **interventions available for managing the risk**. This may look like an options matrix and include looking across various sectors and policy initiatives.
- An **agreed and documented review period**. Understanding of hazard, risk, and risk tolerance will change over time, as will the effectiveness of policies and risk management approaches. There should be commitment to an appropriate review period for risk assessments, risk tolerance assessments, and evaluation of the policy effectiveness.
- Any **uncertainties should be articulated** and ways to address these in the future proposed.

The result of the risk tolerance assessment should be a clear risk classification (i.e. 'acceptable,' 'tolerable,' or 'intolerable'). Policies aligned with risk tolerance thresholds will enable consistent and effective management of the risk. Engagement on the available policy options will then direct the implementation of the chosen risk management response.

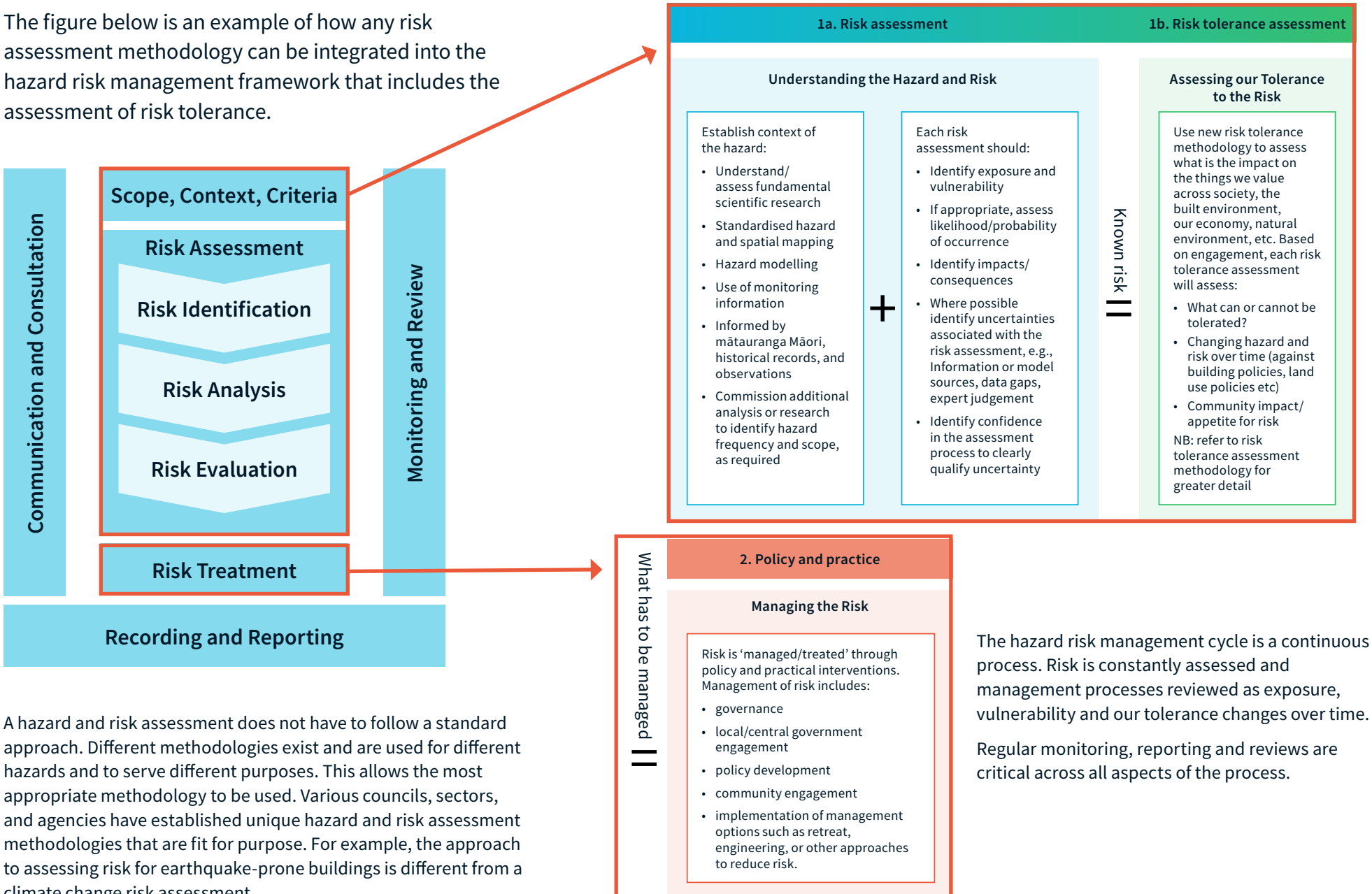
National, regional, and local policy options should be developed or adapted to align with the risk classifications. For example, an 'intolerable' risk should directly trigger policies that enable the appropriate response, such as avoiding or controlling the risk.

Groups affected by either the risk or the risk treatment option should be engaged on their preferred risk management approach associated with the resulting risk classification. Groups or communities who live with the outcomes of the risk management solutions must be empowered through the decision-making process.

Appendix C provides examples for how this methodology could be used to assess the tolerability of an Auckland Volcanic Field eruption.

Appendix A: Example of where ISO 31000:2018 sits in the Natural Hazard Risk Management Framework

The figure below is an example of how any risk assessment methodology can be integrated into the hazard risk management framework that includes the assessment of risk tolerance.



A hazard and risk assessment does not have to follow a standard approach. Different methodologies exist and are used for different hazards and to serve different purposes. This allows the most appropriate methodology to be used. Various councils, sectors, and agencies have established unique hazard and risk assessment methodologies that are fit for purpose. For example, the approach to assessing risk for earthquake-prone buildings is different from a climate change risk assessment.

The hazard risk management cycle is a continuous process. Risk is constantly assessed and management processes reviewed as exposure, vulnerability and our tolerance changes over time.

Regular monitoring, reporting and reviews are critical across all aspects of the process.

Appendix B: Types of uncertainties that can affect risk tolerance and how they can be managed

Uncertainty type	Plain English description	Examples	Implications for risk tolerance	Examples of how the uncertainties can be managed
Aleatory (Stochastic)	Uncertainty caused by the random nature of natural systems that can't be predicted exactly.	When an earthquake will happen, how strong a storm will be, if a volcano erupts.	Decision-makers may have a high tolerance/acceptability for low likelihood events despite high consequences; must prepare for a range of possible outcomes.	Use probabilistic models, build flexible infrastructure, invest in early warning systems.
Epistemic	Uncertainty from not knowing enough or lacking data.	Incomplete knowledge of fault lines, underground conditions, or model gaps.	Tolerance (and decisions) might change as more is learned.	Improve data collection, research, and modelling; invest in scientific studies.
Model Uncertainty	Uncertainty because models simplify real life and assumptions are made in their development. Alternative models (and approaches) often also exist. The uncertainties can increase as more assumptions are made.	Choosing between different flood models, estimating future climate trends.	Lower confidence in results may reduce risk tolerance.	Test multiple models, conduct sensitivity analysis, update models with new data. Follow structured approaches to identify, quantify (or qualify), and prioritise the model uncertainties.
Scenario Uncertainty	Uncertainty about which future situation will actually happen.	Changes in land use, climate change direction, or economic shifts.	Risk tolerance may change over time depending on future outcomes.	Use multiple scenario planning, develop adaptable strategies, monitor trends over time.
Decision Uncertainty	Uncertainty from how people or leaders make decisions in the face of risk.	Political choices, public risk behaviour, response delays.	Poor decisions can worsen outcomes.	Engage communities, train leaders, build decision support tools, run simulations and exercises, understand potential impacts of different decision pathways. Consider systems thinking type approaches.
Communication Uncertainty	Uncertainty from how risk messages are shared or misunderstood.	Misreading maps, language gaps, lack of public trust.	Tolerances may be higher or lower where information is misunderstood; may increase panic or inaction.	Use clear, multilingual communication, community education, and build public trust. Develop an understanding of decision-maker perspectives and knowledge to develop needs-led communication. Evaluate any communication for comprehension and decision efficacy.
Data Uncertainty	Uncertainty from missing, old, conflicting, or bad-quality information.	Outdated population maps, missing flood data, rough terrain info.	Decisions are less reliable.	Collect updated, high-quality data; adopt data quality standards where possible (include interoperability), validate sources; use conservative assumptions where needed.

Appendix C: Example – Auckland Volcanic Field eruption

The following example uses a scenario to show how a risk tolerance assessment can be included within risk management in New Zealand. It is an illustrative desktop example only; it draws on a hypothetical Auckland Volcanic Field eruption scenario and existing risk management tools.

Engagement is required to understand the coping capacity of the communities and the ways that the consequences will be experienced across these communities. Engagement was out of scope for completing this illustrative example but should be conducted as part of a risk tolerance assessment to ensure that the risk thresholds are reflective of community values.

Auckland, New Zealand's most populated city, is built on the Auckland Volcanic Field (AVF). The AVF is a monogenetic volcanic field, which means that the next eruption is likely to result in the formation of a new vent.

Therefore, it is not known when, and from where, the next eruption will occur. This presents challenges for risk management as the ability to reduce exposure through avoiding 'high-hazard' areas is limited because these 'high-hazard' areas are not known and cannot be defined. The extremely high levels of development across the region and within the AVF also prevent other risk management mechanisms such as planned relocation. However, a risk tolerance assessment should still be used to guide risk management options.

The outcome of the assessment is that the volcanic risk is tolerable, with risk treatment options in place. The probability and uncertainty associated with an AVF eruption, and the risk reduction and readiness initiatives that can be implemented, mean that this risk can be tolerated at a (social and economic) cost proportional to the benefits afforded to Auckland and New Zealand.

Auckland Volcanic Field eruption scenario

1. Understanding the hazards:

Days in eruption sequence	Minor eruption	Volcanic earthquakes
320	**VEI 1**	**1000+**

- Auckland Volcanic Field (AVF) eruption. 320-day eruption sequence from a new volcanic vent in Mt Eden*.
- Volcanic hazards (Figure AC.1) include lava, ballistic projectiles, ash, and volcanic earthquakes (up to ~Mw4.5)

* Hayes et al., (2018). The DEVORA scenarios: multi-hazard eruption scenarios for the Auckland Volcanic Field. Lower Hutt (NZ): GNS Science. 138 p. (GNS Science report; 2018/29). doi:10.21420/G20652.

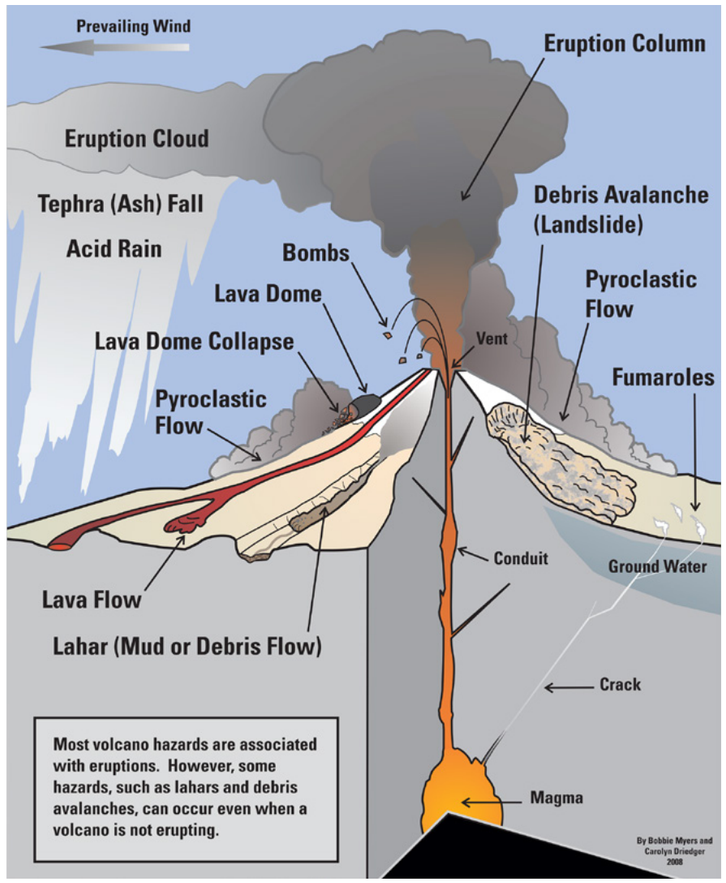


Figure AC.1 Common volcanic hazards. *Myers and Driedger, 2008, Geologic hazards at volcanoes: U.S. Geological Survey General Information Product 64, 1 sheet* [http://pubs.usgs.gov/gip/64/].

2. Understanding the risks:

Likelihood: 10% probability in 50 years

Exposure:

- 1.6 million people and the majority of Auckland's buildings are in the AVF.
- Residential properties in Mt Eden and the CBD as well as infrastructure (electricity, roads, water, and gas) are exposed to damage from volcanic hazards (Figures AC.2 & AC.3).

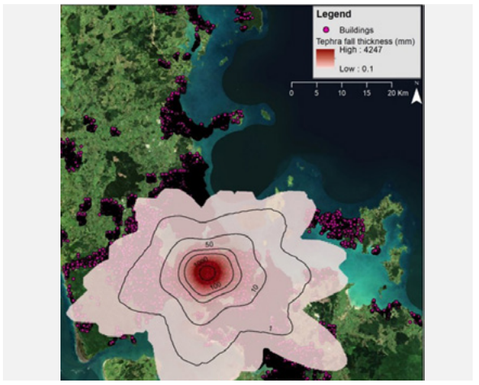


Figure AC.2 Ashfall coverage over Auckland. *Fitzgerald et al., 2020, Deconstructing the disaster: Volcanic loss models for Auckland.*

Vulnerability:

- Auckland has the highest proportion of non-English speakers in New Zealand, increasing vulnerability through reducing access to information about readiness, response, and recovery.
- Ash can cause breathing difficulties, damage electricity infrastructure, clog drains increasing the likelihood of flash flooding, and collapse gutters and widespan roofs.

Impacts/consequences:

- All buildings and infrastructure within ~300 m of the vent will be destroyed. The main lava flow will destroy buildings from Mt Eden to Judges Bay (Figure 3). Losses to the built environment estimated at **$21 billion**.
- Evacuation zones reduce capacity to repair infrastructure, resulting in widespread outages and disruption.
- National GDP will be severely affected as Auckland contributes the greatest proportion (37.9% in 2020).
- **No deaths** as monitoring of unrest enables proactive evacuation to protect life safety. Psychosocial impacts include **increased levels depression, anxiety and PTSD**.

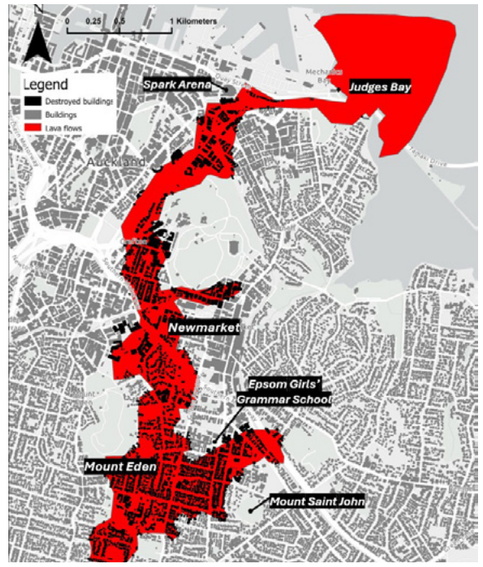


Figure AC.3 Lava flow extent after 320 days.

Auckland Volcanic Field Risk Tolerance Assessment Scenario

What is the decision for, over what timeframe?

This risk tolerance assessment will inform continued future development in Auckland.

~30 years

Spatial planning

What could, or did, happen?

Social	Economic	Governance	Natural	Cultural	Built
No deaths in this event. Breathing airborne volcanic ash can cause short-term symptoms such as a cough and sore throat. Increased instances of anxiety, depression, and post-traumatic stress disorder in the affected population.	Estimated buildings losses are $21 billion. The national and regional economy is severely impacted from direct losses and business closures.	State of emergency will be declared. Public pressure and scrutiny about evacuation orders will likely be high. Co-governance arrangements with iwi will be required to manage the formation of new land (from lava flows and vent formation).	Volcanic hazards will be concentrated in an urban area, limiting impacts to the natural environment. Ash has the potential to contaminate soil and cause health issues for animals.	Archaeological sites across Auckland are likely to be damaged.	Buildings and infrastructure close to the active vent area will be destroyed. Infrastructure disruptions and evacuation zones will affect the habitability and functionality of residential and commercial buildings.

Who is affected	What is the scale?	Who lives with it?
Impacts to habitability and functionality of homes will affect homeowners and renters. Iwi/hapū will be affected through impacts to archaeological sites and marae. Infrastructure providers will have to work to reduce service disruptions. Council will be affected through state of emergency and scale of damage.	Impacts from lava flows and ballistic projectiles will be at a local scale. Impacts from ash will be at a local and regional scale. Economic impacts will be at a national scale from direct damage ($21bn) and impacts to the national economy (Auckland contributes to 37.9% of GDP).	All of Auckland lives with the risk from the AVF, while all of NZ lives with the economic risk from this event. Impacts will not be felt equitability. Those that are underinsured or have no insurance will be severely affected. Some people will be more willing/able to take personal preparedness actions such as preparing a grab bag and storing food and water.

Is this ok?

Risk treatment and readiness initiatives must be implemented to manage the coping capacity of the community and ensure continued development in Auckland is tolerable.

Auckland Volcanic Field Risk Tolerance Assessment Scenario

How can the risk be treated?

Who decides?	Who pays?	Who lives with it?
Auckland Council would be required to decide and implement any significant risk reduction options such as planned relocation. Any decisions should be made through a community consultation process. Communities can choose to take preparedness actions, such as removing guttering and clearing drains, to reduce the likelihood of damage to their property. Infrastructure providers will have authority to implement readiness and risk reduction initiatives, such as clearing ash, during the event.	Risk treatment options before an event would need council funding. Planned relocation of Auckland would not be a fiscally viable risk treatment option. It is unlikely central government would provide funding in advance of an event. Individual homeowners and business owners must pay for their own risk transfer mechanisms. Ongoing seismic monitoring of Auckland is currently funded through GeoNet.	Individual homeowners and property owners are responsible for maintaining property (clearing drains and removing guttering) to reduce impacts. Infrastructure maintenance teams may have to enter high-hazard areas to clean assets to prevent disruptions during the eruption.

Which treatment option provides the best outcome?

The assessed risk is **TOLERABLE, with risk treatment options in place**. The probability and uncertainty associated with an AVF eruption as well as the risk reduction and readiness initiatives that can be implemented mean that this risk can be tolerated at a (social and economic) cost proportional to the benefits afforded to Auckland and New Zealand through continued development in Auckland.

Managing the risk

The following risk treatment initiatives must be implemented before and/or after an eruption for continued development in Auckland to remain tolerable:

- Evacuation planning to protect life safety.
- Development of co-ordinated clean up plans to reduce the disruption of ash.
- Infrastructure providers must have response plans to reduce the ingress of ash and for cleaning and maintenance of assets. These measures will reduce infrastructure disruption during the event.
- Provision of additional mental health services.
- Continued maintenance of roofs and gutters to reduce impacts of ash.

Natural Hazards Commission
Toka Tū Ake

Te Kāwanatanga o Aotearoa
New Zealand Government