# *Guide to considering natural hazard risks in land use planning and building control*

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# CONTENTS

# 1 RISK – THE CONTEXT

Natural hazards can impact significantly on the social, environmental, and economic costs associated with the use and development of land. Events such as flooding, bushfires, storms and landslides impose costs on individuals in terms of life or private property loss, or for the community by way of environmental damage, infrastructure loss, reduced wealth, or loss of social confidence. Mitigating the consequences of a natural hazard event requires a range of treatment options, including emergency management, emergency response, construction standards and land use planning.

This guide outlines how to manage the risk presented by natural hazards within the land use planning system in Tasmania. It applies a 'hazard treatment approach' to land use planning as a tool to mitigate the risk presented by natural hazards. Land use planning is one of the tools available to government that can increase community resilience against the impacts of natural hazards. Other tools include emergency response and recovery, the building standards, and community awareness. Land use planning allows governments to strategically consider the hazard when planning settlements, and set policy on acceptable risk and controls that increase the ability of individuals and the community to resist and recover from a hazard event.

Planning can be defined as "…*the process of making decisions to guide future action"* (PIA 2010). This planning process is one part of a broader system that also includes emergency management and building standards. In this context, this guide sets out a structured method for making decisions on exposure to a natural hazards event (***likelihood***), to understand what these assumptions may mean for planning and development (***consequence***), and provide a method for identifying when avoidance should occur and when appropriate controls on use and development are required (***tolerance***).

Through the development of the guide, it is expected that the Tasmanian Government will be in a stronger position to:

- promote a broad understanding of the existence of hazards and risks in any given location;
- provide certainty through strategic planning as to where development can achieve appropriate levels of tolerance;
- provide certainty in the development process including what information is required of developers and when;
- provide guidance on what is considered to be a tolerable level of residual risk to the community; and
- impose planning controls that are proportional to the level of exposure to a natural hazard and the type of development.

The guide contains four sections:

- **Section one:** reviews the approaches to the risk management of natural hazards.
- **Section two:** outlines the risk tools that are used as part of a hazard treatment approach. This approach seeks to use a combination of elements associated with risk assessment, precautionary and emergency response approaches.
- **Section three:** provides details of the tools used in the hazard treatment approach.
- **Section four:** outlines the steps involved in implementing the hazard treatment approach.

## 1.1 *Balancing Costs and Benefits*

Mitigating risks from natural hazards is not about totally avoiding or eliminating the risk. Natural hazards are a feature of our environment and, in most instances, the potential impacts of natural hazards can be managed. Individuals, developers, communities and governments must balance the costs associated with managing the impacts of natural hazards against the benefits arising from development. In some cases, the costs (including the costs of mitigation) may outweigh the benefits and the community may determine that it is prudent to avoid development.

The background paper titled: "The overarching principles for the consideration of natural hazards in the planning system" (DPAC 2011) broadly sets out the current policy context for natural hazards and suggests a set of foundation principles for the Government's intervention in land use planning and development for the purposes of managing risks from natural hazards (a summary of the principles is included at Appendix A). This guide is consistent with the principles detailed in the background paper in that it:

- promotes ownership of private risks by an individual or business;
- ensures that the impact of a natural hazard is identified very early in the planning process to avoid encouraging development where the risk is so high that mitigation is problematic and the costs outweigh the benefits;
- advocates a structured decision-making process when considering a development (and potentially in the transfer of land);
- helps governments (at all levels) to inform/educate the community, industry, and government officials about natural hazards;
- clarifies the approach to managing both public and private risks;
- assists in the prioritisation for investment in research and mitigation of natural hazards by individuals, businesses and governments; and
- enables governments (at all levels) to identify and avoid actions that give rise to unacceptable public and private risks to individuals or the community.

## 1.2 *Risk Management*

The risk management process is a suite of tools that helps to focus the attention of decision-makers on the potential costs of unpredictable events and, in the context of natural hazards, ensure that public exposure to a known natural hazard is within tolerable limits (Saunders and Glassey 2009).

Risk management processes for natural hazards are broadly outlined in the *National Emergency Risk Assessment Guidelines* (NERAG) and the *Australian Standard for Risk Management* (AS/NZS 31000 2009). The risk management process is shown in Figure 1.

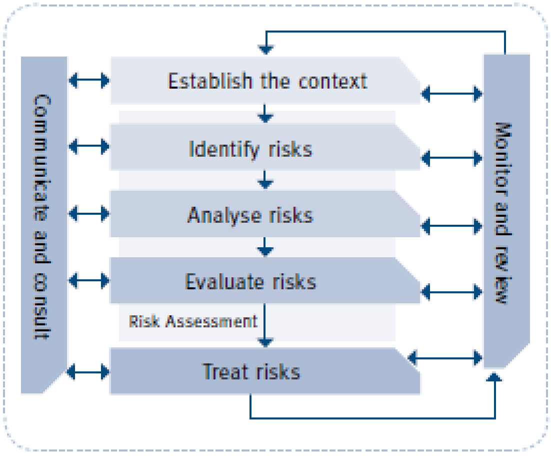


**Figure 1:** Risk management process (NERAG 2009)

The Australian Standard AS/NZS 31000 (2009) expresses risk in its simplest form as "*the effect of uncertainty on objectives*". In the context of natural hazards, risk can be described as the product of the chance of a hazard occurring (**likelihood)** and the impact of an event **(consequence)**, in which:

- **Likelihood:** relates to the uncertainty surrounding "... the chance of something happening ..." at a location, or conversely, how often a use or development is likely to be impacted by a natural hazard in any given location.

- **Consequence:** relates to the "... outcome(s) of an event affecting objectives…" or how the intended use of land may be impacted by any given natural hazard event.

There is no universal truth on when the likelihood of an event is too high or the consequence too great. Rather, communities and governments make judgements that inform an appropriate ***risk tolerance***. Here, risk tolerance is the judgement regarding when the combination of likelihood and consequence of a natural hazard becomes unacceptable in terms of potential costs to the community (public risks) or to an individual (private risks). Risk tolerance is further discussed in Section 2.3.

There are a number of methods[1] available for making judgements regarding tolerance to risk and the treatment of potentially intolerable risk, these are outlined in Appendix B – Approaches to the Management of Risk. The preferred approach to risk is the **hazard treatment approach**.

The hazard treatment approach seeks to use a combination of tools associated with risk assessment, and precautionary and emergency response methods. The approach seeks to meet the challenge of balancing short-term costs (additional studies or building works) with the long-term costs (loss of property, annual insurance, or emergency response and recovery) that are associated with natural hazard exposure.

This hybrid risk method encourages the use of detailed evidence where it is available, but also allows policy judgements to be made in the absence of clear evidence. The approach focuses the attention of governments on areas where risks are deemed intolerable, but also accommodates judgements that the risk in other areas is acceptable and in these circumstances, it is appropriate to rely only on an emergency response if required.

The hazard treatment approach relies on mapping 'hazard bands' based on the likelihood of a hazard occurring. The mapping of hazard bands is based on available information. The collection of further data by the public or private sector can be prioritised in areas of high development demand to support their objectives. Proxies for hazard likelihood are used in areas where detailed hazard modelling has not been (and may never be) undertaken.

The adoption of the hazard treatment approach recognises, in part, that a legitimate role of governments is to protect public value by making judgements regarding risk, even in the absence of detailed risk information. Policy judgements regarding both hazard likelihood and appropriate control measures can be developed through active engagement with stakeholders to ensure that they reflect community attitudes towards risk and tolerance to risks.

[1] This builds on the work completed by Klinke and Renn 2002, who identified three approaches to managing risk (risk assessment, applying the precautionary principle, and managing through hazard treatment) by adding emergency response as a method to manage risk in land use planning.

# 2 HAZARD TREATMENT – TOOLS

Applying the **hazard treatment** approach requires a capacity to assess or make judgements on likelihood, consequence and risk tolerances in strategic land use planning, and use and development control.

## 2.1 *Likelihood*

Likelihood is "...used to refer to the chance of something happening, whether defined, measured ... qualitatively or quantitatively..." (ISO Guide 73-2009, Risk management - vocabulary). For natural hazards, it is the chance of a natural hazard event happening or how often a natural hazard impacts something of public or private value.

Likelihood has two components: magnitude (extent or severity) and recurrence (probability or how often).

The 2010 National Emergency Risk Assessment Guideline (NERAG) provides guidance on describing likelihood levels for a hazard event occurring from **almost certain** to **almost incredible** with the associated frequency and annual exceedance probabilities (AEP) shown in Table 1 below.

**Table 1:** Likelihood table (NERAG 2009)

| Likelihood level | Frequency | Average recurrence interval | Annual exceedance probability[2] |
|---|---|---|---|
| Almost certain | Once or more per year | <3 years | >0.3 |
| Likely | Once per ten years | 3 – 30 years | 0.031 – 0.3 |
| Possible | Once per hundred years | 31 – 300 years | 0.0031 – 0.03 |
| Unlikely | Once per thousand years | 301 – 3,000 years | 0.00031 – 0.003 |
| Rare | Once per ten thousand years | 3,001 – 30,000 years | 0.000031 – 0.0003 |
| Very rare | Once per hundred thousand years | 30,001 – 300,000 years | 0.0000031 – 0.00003 |
| Almost incredible | Less than once per million years | >300,000 years | <0.0000031 |

Likelihood expressed in terms such as AEP can be used to make planning assumptions regarding both *magnitude* and *recurrence* (see Box 1). It is not, however, always possible to express likelihood (recurrence and magnitude) in such clear terms. The capacity to make assumptions regarding magnitude and recurrence relate very strongly to:

[2] Annual exceedance probability is expressed in this table as a proportion of one.

- the ability to predict triggers that lead to a natural hazard event;
- the ability to make assumptions regarding the linkages between a trigger and the natural hazard event; and
- the complexity between the preconditions for an event, the trigger, and a resulting hazard occurrence and magnitude.

Table 2 below, outlines how the understanding of triggers and the linkage to a hazard event drives different approaches to judging likelihood. In general, the following approaches can be used for assessing likelihood:

- *Modelled event* calculated as an AEP or similar measure (outlined in Appendix C) can be used where the trigger event can be predicted for a given location and where there is a relatively direct link between the trigger event and the hazard (eg flood, storm, coastal inundation).

  These measures can be used to model both recurrence and magnitude for planning purposes.

- *Areas of hazard susceptibility* can be used where the preconditions for a hazard event are reasonably well known, but the linkage to a trigger event and the resulting hazard is difficult to model without a full site assessment. In these areas neither recurrence nor magnitude can be modelled on a regional or statewide basis.

  For example, the preconditions for landslide are reasonably well known; the land needs to be sloped, and have a certain geology prone to failure (generally speaking). The risk of land sliding during heavy rain, however, will depend upon many inter-related factors that cannot be assumed and can only be evaluated by a site assessment.

- *Exposure to a reference event* should be used where the preconditions for a hazard event are

***Box 1: Example of assessing recurrence and magnitude using AEP***

Assume that it is assessed (through modelling or the recording of historical events) that there is, on average, a 1 per cent chance every year that a flood will reach, for example, three metres above the natural surface of the riverbed. Generally speaking, this measure allows planners and developers to make the following judgements for planning purposes:

- In any 100-year period, it should be assumed that land below this point will be inundated more than once (recurrence); and
- In any 100-year period, it should be assumed that floodwaters will rise three metres above the riverbed (magnitude).

Similar calculations can be modelled for other recurrence levels (eg 5%, 20%, 50% AEP) or for other magnitudes (ie four metres relates to 0.5% AEP and two metres relates to 5% AEP).

either not known or relatively dynamic (eg vegetation condition or dryness) and where trigger events cannot be reasonably predicted for a given location.

For example, the preconditions for a bushfire (eg soil and vegetation dryness, and weather conditions) are reasonably predictable within a seven-day period but can be difficult to judge on timeframes appropriate for planning purposes where consideration may be required over the lifetime of a development (eg 30, 50 or 100-year periods). Similarly, predicting the frequency of a trigger event (eg lightning strike or intentional ignition) is almost impossible to predict with any accuracy.

Table 2: Examples of approaches to assuming likelihood

| Hazard | Trigger event predictability | Predictability of preconditions to an event | Linkage between preconditions, trigger, and the hazard | Approach to likelihood |
|---|---|---|---|---|
| Flood | Can be predicted. Largely triggered by rainfall that can be accessed through historic records and modelled for future events. | Reasonably predictable around soil dryness, river morphology or vegetation condition. | Relatively direct linkage between preconditions, rainfall and flooding events. | Can be expressed in terms of annual probability (eg ARI[3] or AEP[4] – see Appendix C). |
| Landslide | Moderate capacity to predict the trigger event. The trigger event can include rainfall, loading, and leaking pipes. In general, rainfall events can be accessed through historic records and modelled for future events. Other triggers are unable to be modelled. | Can be made based on broad assumptions around slope, geology, soil depth, land use, vegetation coverage, and construction at the toe/top of the slope. | Large uncertainties regarding the linkages between triggers and a landslide event. | Can be assessed by identifying areas of hazard susceptibility. Measures cannot be used to assume magnitude or frequency without a detailed site assessment. |

[3] Annual recurrence interval

[4] Annual exceedance probability

| | | | | |
|---|---|---|---|---|
| Bushfire | Difficult to predict. Many possible triggers including accidental or deliberate man-made ignition, lightning strikes or industrial cases (eg electricity arching). | Able to be modelled although bushfires are highly dynamic due to changes in soil and vegetation dryness, fuel load, etc. | Large uncertainties regarding the linkage between the trigger and preconditions. Linkages include weather conditions, availability of fire suppression assets, topography downwind of the point of ignition, fuel reduction measures, etc. | Likelihood can be judged through an assessment of the potential exposure to a reference event. (eg exposure to a fire of defined character in the area). |

Choosing an appropriate measure of likelihood is a critical part of the successful implementation of the hazard treatment approach. The choice of likelihood measure will significantly impact on the ability to define natural hazard bands (see Chapter 3) and the successful implementation of the hazard treatment approach will help to build confidence that controls are reasonably well aligned to the threat from the natural hazard. The measures and level likelihood will also heavily influence the nature of controls that will need to be imposed in the band.

## 2.2 *Consequence*

Consequence is the "...outcome of an event affecting objectives" (AS31000 2009). For the purposes of this guideline, 'event' relates to a natural hazard and 'objectives' relates to the intended use or development of land.

As detailed in Table 3, NERAG provides a tool for assessing consequences in terms of people, environment, economy, public administration, social setting and infrastructure.

Table 3: Exposure impact category definitions

| Impact category definitions | |
|---|---|
| People | Relates to the direct impacts of the emergency on the physical health of people/individuals and emergency services' (ie health system) ability to manage.<br>Mortality defined as the ratio of deaths in an area of the population of that area (expressed per 1 000 per year). |
| Environment | Relates to the impacts of the emergency and its effects on the ecosystem of the area (including fauna and flora). |
| Economy | Relates to the economic impact of the emergency on the governing body as reported in the annual operating statement for the relevant jurisdiction and industry sectors as defined by the Australian Bureau of Statistics. |
| Public administration | Relates to the impacts of the emergency on the governing body's ability to govern. |
| Social setting | Relates to the impacts of the emergency on society and its social fabric, including its cultural heritage, and the resilience of the community. |
| Infrastructure | Relates to the impacts of the emergency on the area's infrastructure/lifelines/utilities and their ability to service the community. |

The challenge for assessing the likely consequences for development from exposure to a natural hazard is that they will depend very heavily on circumstances that cannot be predicted accurately, such as the time of day, the day of the week, the response to the event (eg emergency mitigation measures) and the behaviour of individuals. Assumptions must be made, therefore, based on the nature of the use or development, and how it relates to the impact categories identified by NERAG.

Considering consequence in the hazard approach requires the development of consequence statements, which describe the assumed impacts on different types of use. Generally, consequence statements are considered separately for categories of use classified as 'hazardous' (such as chemical storage facilities) and 'vulnerable' (such as schools and hospitals). As outlined at Appendix D, Asset Classes 3 to 5 are considered vulnerable and hazardous.

Consequence statements are not accurate assessments of the actual consequence for a type of use. Rather, they are policy judgements regarding how to assume consequence for the purposes of assessing the appropriate use of land through the land use planning system. At particular levels of risk, the State may require a more detailed analysis of the actual consequence inherent in a particular development. Flexibility is often built into the planning system to allow the assumptions regarding consequences to be tested for individual development applications, if warranted.

## 2.3 *Risk Tolerance*

Risk tolerance is defined as the "...readiness to bear the risk after risk treatment in order to achieve its objectives" (ISO Guide 73 2009). In the hazard treatment approach, acceptable risk tolerance is the point at which the State judges that it is no longer necessary to intervene in the use of land to mitigate risk, but relies on response and recovery. All other areas of land would be judged to have an intolerable exposure to the hazard unless the use and development is treated to make the residual risk tolerable.[5]

Judging when an acceptable risk becomes intolerable is a 'wicked problem' (Rittel and Webber 1973). It is the boundary point at which the State intervenes in the normal regulation of use of land because the benefit of a use or development to either a private individual or the broad community may not outweigh the cost that development places on the community or the environment.

The hazard method seeks to set the boundary between acceptable and intolerable risk. Figure 2 illustrates zones of acceptable, tolerable and intolerable risk while having regard to likelihood and consequence. Of note is the spectrum between acceptable, tolerable and intolerable risk that exists because both the quantification of risk is very difficult and controls placed on the risk may change it from being intolerable to tolerable for different types of use.

[5] Judgements regarding residual risk should consider the impact of treatment options beyond land use planning (eg the action of landowners, capacity of emergency responders, or regard to building standards).

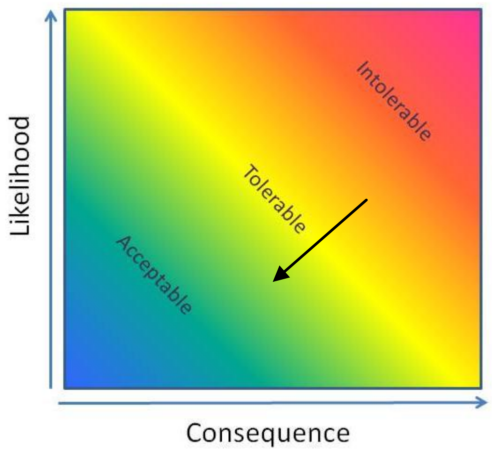


Figure 2: The range of risk tolerance

*Acceptable risk* (or negligible risk), as defined by the Australian Geomechanics Society (AGS), is "...a risk, for the purposes of life or work, society is prepared to accept as it is with no regards to its management. Society does not generally consider expenditure in further reducing such risks justifiable" (AGS 2007a).

Acceptable risk can be assumed for each of the categories outlined in Table 4. For example, the AGS and Keey (2000) define acceptable risk for loss of life as a risk of less than 1 in 100,000 deaths in society. Complexities arise, however, when attempts are made to align measures of acceptable risk across all areas outlined in Table 4 for each development application.

For the purpose of the hazard approach, acceptable risk is defined as the area outside the tolerable and intolerable risk zones, in which no hazard specific controls are placed on development. The boundary of acceptable and intolerable/tolerable risk is identified through a process of consultation with relevant stakeholders.

In areas of acceptable risk, non-planning measures will be used to mitigate the impacts of natural hazards (eg building controls, emergency response).

**Box 2: Tolerable risk in bushfire prone areas**

As an example of applying the As Low As is Reasonably Possible (ALARP) principle in Tasmania, it has been judged that in a Bushfire Prone Area, the risk can be made tolerable if:

- a development can meet a minimum separation distance from bushland for new or existing parcels of land; or
- a development is able to demonstrate through a hazard management plan how it will mitigate the impact of a bushfire through improved building standards, evacuation controls, access to water, and maintenance actions.

This is not to say that a building will not be impacted by bushfire, but that society is prepared to accept that the actions taken will reduce the risk to 'as low as reasonably practical', and will not place an unreasonable impact on society.

*Intolerable risks* are those risks that are considered unreasonable with regard to the likely costs to the public and to the individual. Theoretically, everywhere outside of areas of acceptable risk are areas of intolerable risk.

However, when controls on use and development are appropriate, governments judge that where the risk is moderate (defined in Chapter 3 as 'low' and 'medium' risk), routine measures can be employed to reduce intolerable risks to within tolerable limits. In this context, the AGS defines **tolerable risk** as "...a risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible" (AGS 2007a). In defining areas of tolerable risk, judgements are made that:

- use and development in the area is likely to provide net benefits to landholders and the general community; and
- while society cannot regard the risk as negligible, or as something we might ignore, society accepts that the risks can be properly managed through routine measures, including development control measures (such as siting of buildings and access requirements), building control and engineering, or emergency planning.

It is in the tolerable risk range that controls are placed on developments to mitigate the risk to As Low As is Reasonably Practicable (ALARP) (see Figure 3). Here, society is prepared to tolerate certain risks in order to secure the benefits of land use. This tolerance may change depending on the proposed use.

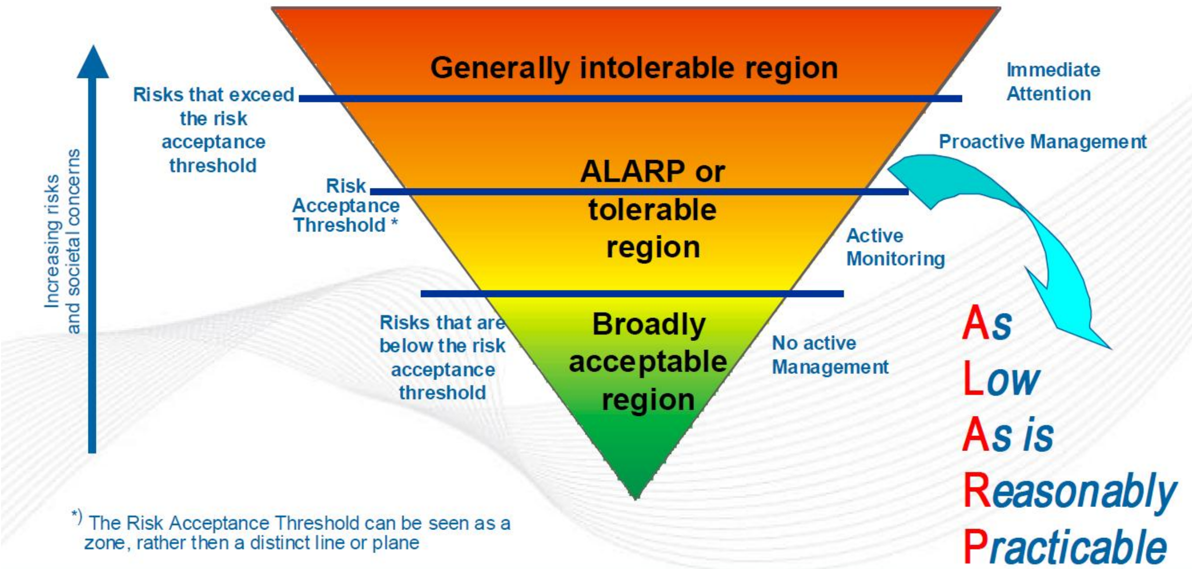


**Figure 3:** Illustrates how the As Low As is Reasonably Practicable (ALARP) principle applies to the hazard treatment approach (NERAG 2009)

Areas may remain where the risks are so high that they cannot be reasonably mitigated for most use and development (defined in Chapter 3 as 'high'). The starting assumption in these areas is that the cost to society outweighs the benefits of development in the area. These areas will generally be identified through strategic planning and zoned in a way that avoids most forms of use and development. In these areas, planning controls will generally prohibit development, especially for sensitive uses such as residential, educational, health, aged care, and hazardous. Where flexibility is provided to allow some use and development, the onus will be shifted to the developer to demonstrate that reasonable mitigation measures are available to reduce intolerable risks to within tolerable limits. The employment of experts to develop hazard management plans that prescribe the appropriate structural and behavioural risk mitigation measures required to reduce residual risk to within tolerable limits is likely to feature prominently in controls imposed on development and use.

To this point, it has been implicitly assumed that the underlying natural hazard does not change over time, except perhaps, if it is explicitly modified. However, a number of natural hazards are likely to unpredictably or systematically change over time. Examples include the following:

- the natural hazard caused by coastal erosion and inundation is likely to increase with rising sea levels, as a consequence of climate change;
- changes in vegetation due to changing land use, plantations, different agricultural practices or climate change may affect bushfire risks; and
- changes in extreme weather events, such as the intensity of rainfall, may affect landslip.

Particularly where natural hazards are changing systematically over time (eg due to sea level rise), a location that has an acceptable risk today may be faced with a tolerable risk in the medium term and an intolerable risk in the long term. Assets established in these locations will face a changing risk profile over the asset's lifetime. Where this occurs, it becomes necessary to consider the lifetime risks faced by the asset in this location, which, in part, depends on the expected lifetime of the asset. In these circumstances, decision-makers should employ the precautionary principle, where the risk level over time is uncertain. Additionally, the overriding balance of issues might support development but, given the nature of the changing risk profile, there may be a need to create buffers that protect the development over the long term even though the buffers might not be required in the short to medium term.

Climate change is the most significant, but not only, example of this dynamic natural hazard issue.

Defining risk tolerance

Generally, communities with low tolerance for risk will place significant controls in areas of low exposure to a hazard, while communities with high tolerance for risk will impose few (if any) controls on development in area of low exposure to a hazard. The proposed hazard treatment approach seeks to provide a baseline for this assessment by setting policy judgements regarding risk tolerance that can be applied on a statewide basis.

Under the hazard treatment approach, these judgements are made through the development of the Hazard Matrix. The Matrix contains a series of bands that provide a range of controls that increase proportionally as the hazard exposure rises. The purpose of each band is described in Section 3.

The underlying assumptions in setting controls for natural hazards have been detailed in the National Emergency Risk Assessment Guidelines (NERAG 2009), which suggest that high magnitude events have a very low frequency (such as a tsunami occurring in Tasmania), while low magnitude events have a high frequency of occurring (such as a daily high tide). The second assumption applies the precautionary principle and assumes that a hazard will affect all land susceptible to the hazard at some point in time. The assumptions enable the classification of hazards into hazard bands. The composition of the controls in each hazard band defines the risk tolerance to the hazard.

Controls and interventions include:

- Emergency management: is controlled through the Emergency Management Act 2006, with roles and responsibilities set out in the Tasmanian Emergency Management Plan 2006 (TEMP). The TEMP sets out the management arrangements for each hazard, including Prevention, Preparedness, Response, and Recovery.

- Building control: provides the minimum necessary standard for safety and amenity of buildings for the occupants. This can be achieved through the requirement to meet an Australian Standard (eg building in bushfire prone areas) or providing design guidance by identifying a site as being susceptible to a hazard.

- Land use planning: including strategic planning, use and development controls. Strategic planning includes placement of defences such as flood barriers, and avoidance of the hazard, such as not building on active landslides. Use controls include modifications to the zoning of land to guide vulnerable development away from hazards. Development controls focus on the form of the development, such as identifying a residential house envelope on a new parcel of land, or requiring a minimum level of services, such as water pressure in a mains water supply.

Figure 4 is a visualisation of the relationship between emergency management, building control, and land use planning (strategic settlement and use control). The vertical axis represents the benefit each type of control represents, while the bottom axis represents the intervention as composite of the controls. The colouring on the graph represents the hazard changing from low likelihood – high magnitude events to high likelihood – low magnitude events.

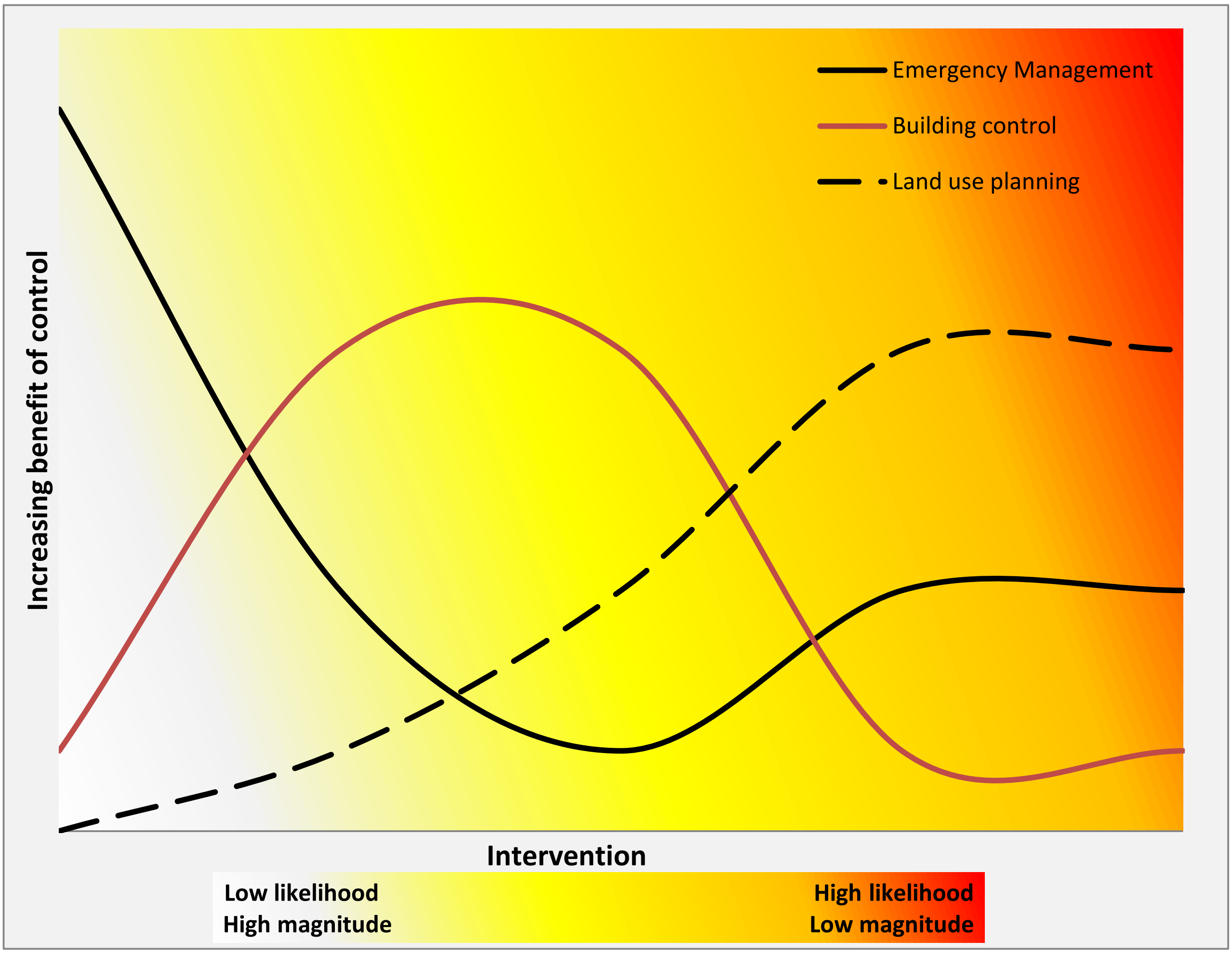


Figure 4: Visualisation of the type of intervention

The hazard treatment approach provides the framework with which to make judgments on the controls and assumptions regarding the threat posed by a natural hazard. In defining this balance through the hazard treatment approach, the State provides a clear 'statement of tolerance to risk in any given location. The process for implementing the hazard treatment approach is outlined in Chapter 3.

# 3 HAZARD TREATMENT

This chapter outlines how assumptions of hazard likelihood, consequence, and risk tolerance are brought together in a form that can be used to directly inform land use planning decisions at both the strategic and development control stages. It introduces the concept of hazard controls and describes how controls can be used to populate a hazard matrix, which describes the hazard likelihood, consequence and controls.

## 3.1 *Purpose of Hazard Treatment*

All land use planning in Tasmania is based on objectives outlined in the *Land Use Planning and Approvals Act 1993* (LUPAA). The relevant Resource Management and Planning System (RMPS) objectives for the mitigation of natural hazards in LUPAA are:

- *to provide for the fair, orderly and sustainable use and development of air, land and water; and*
- *to promote the sharing of responsibility for resource management and planning between the different spheres of government, the community and industry in the State.*

Under the RMPS, sustainable development is defined as:

> 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 while:
>
> (a) sustaining the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations;
>
> (b) safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
>
> (c) avoiding, remedying or mitigating any adverse effects of activities on the environment.

Objectives of the Planning Process under LUPPA also include the following:

- to provide sound strategic planning and coordinated action by State and local government;
- to establish a system of planning instruments to be the principal method of setting objectives, policies, and controls for the use, development and protection of land;
- to secure a pleasant, efficient and safe working, living and recreational environment for all Tasmanians and visitors to Tasmania;
- to protect public infrastructure and other assets and enable the orderly provision and coordination of public utilities and other facilities for the benefit of the community; and
- to provide a planning framework that fully considers land capability.

These objectives provide a foundation for the purpose of intervening in the use of land to both avoid and mitigate the impacts of an individual hazard. The hazard treatment approach seeks to further the objectives of the RMPS and the planning process by ensuring a consistent approach to the management of the risks from natural hazards for (new) land use and development. This purpose can be summarised as:

> …to ensure that use and development is appropriately located, designed, serviced and constructed to reduce the risk to human life and property and the cost to the community caused by [hazard].

The above purpose intentionally includes consideration of both the location of the use (considered through settlement planning, zoning and infrastructure development) and the nature of the development (through development control and building standards). The hazard treatment approach should be used to guide decision-making at both the strategic planning level and the mitigation level, where conditions are placed on individual developments.

## 3.2 *Implementing the Hazard Treatment Approach*

As noted in Section 2, risk tolerance is set by making judgements (policy decisions) regarding the level of controls that are to be placed on use and development that would be exposed to different risks. Under the hazard treatment approach, these judgements are made through the development of a Hazard Matrix.

A completed Hazard Matrix can be used to inform current planning processes. It can also be employed as the basis for the development of specific planning instruments at State, regional or local levels.

To construct a Hazard Matrix, it is necessary to define:

- *Hazard bands (likelihood)*: regions where it is presumed that natural hazards exist at a relative high, medium, low or acceptable level.
- *Control level*: agreement to generalised statements regarding the presumed consequences associated with natural hazard bands.
- *Strategic planning level*: agreed measures that should be employed through the strategic planning stage to determine whether the benefits to the community of allowing consideration of development in certain areas subject, or likely to be subject, to a natural hazard, outweigh the costs to the community and individuals required to mitigate that natural hazard in the short, medium and long term.
- *Use or development controls*: agreed measures that should be imposed on use or development for the purpose of reducing risks in each hazard band; and

- *Life controls*: additional factors that should be considered with regard to the expected life of the development and the chances that the nature of the hazard will change over that period.

An example of the Hazard Matrix is provided at the end of this chapter.

## 3.3 *Defining Hazard Bands (likelihood)*

Under the hazard treatment approach, likelihood (as defined in Section 2.1) is summarised through the creation of hazard bands. The primary purpose of hazard bands is to provide a 'graded' base that enables decision-makers to consider strategic settlement planning, apply policy, and guide controls on development and use. Controls may not be appropriate in all bands.

As a starting point, four levels of hazard banding are described (the actual number of bands may vary for different natural hazards) that group the likelihood of an event occurrence. These hazard bands are:

1. Acceptable: it is presumed that the risk in the area is acceptable, as either the natural hazard does not apply at all to the area, or occurs with such low frequency that it is not considered a matter that needs to be addressed. Normal building controls and emergency management responses are considered adequate to address any residual risk.
2. Low: the hazard occurs in the area but the frequency is low enough, or the magnitude when it does occur is low enough, that it might be experienced by a significant portion of the community without concern. Also, where there is a reasonable expectation that a natural hazard may be present, based on the characteristics of the land and our understanding of the hazard. Precautionary controls that are proportional to the importance of the use and development may be appropriate, including requirements for further site assessment or building standards.
3. Medium: our knowledge of the hazard demonstrates that the likelihood is such that when it does occur the impact could be regarded as significant. Mitigation measures should be required to discourage vulnerable and hazardous uses from being located in these areas, or discretionary planning controls should be imposed on the form of a use or development through assessment against performance standards.
4. High: the hazard is frequent or severe, in that it creates conditions not normally considered manageable or tolerable without exceptional measures employed to respond to the natural hazard. It is to be presumed that most use and development would be unacceptable in this area. Any exceptional development would need to be considered on a case-by-case basis against rigorous tests and by demonstrating a need for, and community benefit of, locating in the area.

The number of hazard bands used depends upon the nature of the hazard and the need to differentiate the level of controls. The number of hazard bands may also depend on the ability to differentiate between degrees of likelihood based on the available evidence.

Clearly, defining hazard bands is critical to the hazard treatment approach and will heavily influence decisions regarding settlement planning and zoning. It is important, therefore, that hazard bands are defined in a way that is suitable for decision-making at both the strategic and development control levels.

**The challenge:** is to identify and define natural hazards in a way that can be related systematically to the likelihood of consequences.

**Action**: hold workshops that include emergency managers, local government, hazard experts, and policy officers to explore the risks posed by natural hazards and the range (and merits) of possible government and non-government interventions (see Section 4 of the Implementation Guide).

### *3.3.1 Setting the boundaries of the hazard bands*

How the boundaries between hazard bands are defined will depend upon the nature of the hazard and the current state of evidence. When setting boundaries between hazard bands, consideration needs to be given to the consistency with the treatment of likehood across all natural hazards (known as Boundary Application Criteria).

The defined boundary between hazard bands should be set in consultation with relevant stakeholders and in parallel with an assessment of the impact on communities throughout Tasmania. However, guidance for setting boundaries is:

- **Acceptable to low:** point at which risks can no longer be managed solely through non-planning measures (eg emergency response, recovery and building controls);
- **Low to medium:** point at which development controls (eg siting and building controls) are not adequate to mitigate risks, and controls on types of use (particularly for vulnerable and hazardous uses) become increasingly important; and
- **Medium to high:** point at which it can be presumed that use and development should not be located in the area due to the likely costs arising from natural hazards.

In many non-urban areas, use or development demand is unlikely to justify the collection of detailed evidence required to measure hazard likelihood and accurately define hazard band boundaries. To ensure that hazard bands can be drawn throughout Tasmania, boundary definitions may include two elements:

- an actual measure of likelihood relevant to the natural hazard; or
- an assumed proxy for likelihood where the evidence base is not available.

**The challenge:** is to define hazard bands that allow best known modelled evidence on hazard likelihood to map alongside proxies for the existence of a natural hazard (that use available data) where evidence is not available, or is insufficient. In considering how to set the boundaries between the bands, the following factors could be considered:

- The current pattern of impact from the natural hazard: where does the hazard currently impact? Likelihood.
- Our current response to the natural hazard: where, when and how often do we respond to this hazard? Response.
- The predicted change in the natural hazard and exposure from land use and climate change: change in likelihood.
- Current planning policy, strategies and controls: governance.
- Where will insurance companies insure for the natural hazard? Consequence.
- Current and projected settlement patterns: consequence.

**Action**: hold workshops that include emergency managers, local government, hazard experts, and policy developers to define the boundaries between bands of hazard likelihood (see Section 4 of the Implementation Guide) and the change in risks that may apply as natural hazards increase.

## 3.4 *Control Level*

At a broad level, the consequence of a natural hazard event on future use and developments is unknown. Therefore, governments must assume a level of consequence and make judgements on how to intervene in the use and development of land to avoid intolerable consequences.

The 'control level' column of the Hazard Matrix provides guidance on the nature of the controls that are required to bring risks from the natural hazard to within tolerable limits. The consequence statement should be broad; highlighting the differences in the level of intervention considered that will later inform the appropriate level of control for each hazard band. The column will indicate the type of work required to make the residual risk tolerable within the area, including strategic, statutory and non-planning tools. Mitigation measures may vary depending on whether the proposed development is a hazardous or vulnerable use, the level of likelihood, or the requirement for further research.

Consequence statements should have regard to the likelihood of the natural hazard within the band, the type and mix of government interventions required, and the types of development and controls required for each type of development. Table 4 provides guidance on the types of statements that may be considered for each hazard band.

Table 4: Guidance for the development of consequence statements for hazard bands

| Hazard band | Consequence statements |
|---|---|
| Acceptable hazard band | No damage is likely to occur from the hazard in this area, or the likelihood of any damage is negligible and manageable in the normal course of events.<br>Controls should not influence the use of land, with no planning or development controls required in this area due to the low level of 'hazard' for the natural hazard. |
| Low hazard band | Relatively minor damage may occur from the natural hazard, and relatively infrequently. Simple measures are available to keep the likely level of damage to acceptable levels.<br>The likelihood or lack of knowledge of the natural hazard is such that the residual risk to most types of development is *most likely tolerable* but some caution is required. The following advice is provided to ensure that residual risk is tolerable:<br>– routine site assessment is required to identify the existence of natural hazards and to inform any consideration of the need for controls; and<br>– vulnerable and hazardous use should be allowed where it can be demonstrated that the residual risk is tolerable.<br>Controls in place in the low hazard band should improve the ability of residents to resist the impact of a natural hazard event, and increase the resilience of the community. |
| Medium hazard band | Structures exposed to this level of natural hazard are likely to sustain repeated minor damage or infrequent major damage during their service life, unless significant mitigating measures are used. The following guidance is provided on the mitigation:<br>– detailed site assessments are required to describe the nature of the natural hazard; to make recommendations regarding the controls required to respond to the hazard; and to provide the development with a greater ability to resist a hazard event.<br>– Vulnerable and hazardous use should be avoided unless it can demonstrate it is in the public interest and needs to be located in this area, and the residual risk can be reduced to a tolerable level through a combination of use and development controls.<br>Controls in place in the medium band should discourage inappropriate development that is likely to significantly increase the costs of mitigating the natural hazards for the community; seek to improve the ability of residents to resist the impact of a natural hazard event; and increase the resilience of the community. |
| High hazard band | Without taking extraordinary measures, structures exposed to this level of natural hazard are likely to sustain repeated damage during the period they are in use.<br>Development should generally be prohibited unless evidence can be supplied that an exceptional departure from the controls is warranted. Significant control and assessment would be required, including the following:<br>– residential, vulnerable, and hazardous uses should be treated as prohibited, and allowed only where the need for the location can be justified. There is a requirement to demonstrate a suite of controls, including behavioural, physical and procedural, that will make the residual risk tolerable, and not be a burden on the community.<br>– minor developments should be allowed only where they can demonstrate appropriate levels of performance. |

Consequence statements will inform strategic and statutory planning instruments. The consequence statements should be in plain English and in a form that is understood without a comprehensive knowledge of planning law or language. The consequence statements speak to intent, or Government policy, and assist in the drafting of planning instruments.

For more information, Table 5 provides an example of consequence statements for each hazard band.

**The challenge:** is to translate the potential impact of the natural hazard into broad actions that are able to deliver a tolerable risk for different types of use.

**Action:** develop, in consultation with key stakeholders, a consequence summary statement for each hazard band that summarises the actions required for the different types of uses or developments.

## 3.5 *Strategic Planning Level*

Hazard consideration at the strategic planning level is critical to determining whether the benefits of allowing consideration of development in certain areas subject, or likely to be subject, to a natural hazard outweigh the costs to the community and individuals required to mitigate that hazard in the short, medium and long term.

Other strategic planning issues need to be considered alongside the natural hazard issue to enable an informed judgement that is based on holistic planning and balancing social, economic and environmental benefits and costs.

The strategic consideration of natural hazards could result in decisions about settlement planning, zoning, and the articulation of hazard layers through land use strategies. It can also provide an indication of the need to establish buffers, or areas of hazard expansion, over longer time frames than are expressed in planning schemes, which are generally focussed on a five to ten-year time frame.

As the controls at this stage represent a 'first cut' of limitation on use and development, they can be seen as a trigger for more detailed assessment of the hazard risk, which can be more directly translated into use and development controls.

**The challenge:** is to provide an adequate consideration of the range of natural hazards as part of a broad land use strategy, where determinations about overall community benefits can be made.

**Action:** determine the level of hazard information and consequence statements required for regional and local strategic planning exercises in consultation with key stakeholders.

## 3.6 *Use or Development Control*

Natural hazard controls are measures that are imposed on use or development for the purposes of reducing risk. The controls must always align with the consequence statement, as they are a more detailed expression of the actions that are considered necessary to reduce intolerable risks to within tolerable levels. It should be possible to directly translate these controls into standards that would be included with a statewide code or local government planning scheme (although some slight adjustment may be required during the drafting of, and public consultation on, a planning instrument).

The nature of the controls included in this column will directly impact on the likely cost to governments, industry and the community. Therefore, it is critical to consider the impact of the controls, while having regard to the coverage of the hazard band. Some adjustment of the hazard band boundary definitions and/or controls within each band may be necessary to strike the correct balance between the cost of intervention and the risk. In essence, this process is how the State established an agreed **risk tolerance**.

**The challenge:** is to translate consequence statements into clearly articulated development and use controls that can be adopted within planning and building instruments.

**Action:** prescribe appropriate development and use controls in consultation with key stakeholders.

## 3.7 *Use and Development Life Controls*

Climate change will impact on the nature and distribution of threats from natural hazards. This change should be considered if, during the expected design life of the development, the threat is considered significantly greater than the current threat.

Where available, maps of hazard banding should be used at the point in time that is closest (but after) the end of the development's expected life. For example, for a residential development with a presumed life of 75 years, the hazard banding relevant for the closest known point beyond 75 years should be used.

The Tasmanian Government will provide advice on the likely consequences of climate change on natural hazard profiles throughout the State.

**The challenge:** is to reasonably understand the future threat based on the best available science and ensure that guidance is available for planning purposes.

**Action:** the Tasmanian Government is to provide guidance on the likely impacts of climate change on natural hazard profiles throughout the State.

The Hazard Matrix, detailed below in Table 5, provides an example of how the three components (likelihood, consequence and control) of hazard mitigation can be linked to mitigate risks from natural hazards.

Table 5: Hazard matrix – Landslide (example for illustration only)

| Hazard band | Hazard exposure<br>(Likelihood of an event) | Control level<br>(Consequence) | Strategic planning level | Use or development controls<br>(Control) |
|---|---|---|---|---|
| Acceptable | Rare to almost incredible – a landslide is rare to almost incredible to occur in this area based on current understanding of the hazard, but it may occur in some circumstances.<br>Defined as:<br>Less than 0.3% AEP; or<br>Site is outside of Low, Medium, and High hazard bands or has been assessed by MRT[6] regional (1:25 000 scale) mapping as having very low to no susceptibility to landslides. | Development and use is not subject to landslide controls. | No impacts on land use strategies or change to zoning required. | No hazard specific controls.<br>No controls are required to bring the development into an acceptable hazard level. |
| Low | Possible to unlikely – this area has no known landslides, and has not been assessed by MRT regional (1:25 000 scale) landslide susceptibility mapping, but may be prone to the hazard occurring.<br>Defined as:<br>0.3 – 1% AEP; or<br>Slopes greater than 9 degrees; or<br>A position within a 12 degree shadow angle at the foot of a steep slope (greater than 25 degrees). | Planning controls may be necessary to reduce the risks associated with vulnerable and hazardous uses to ensure that risks are tolerable (as recommended by AGS).<br>No non-construction requirements necessary for residential or minor use or development. | Where broader planning considerations support the development of the area, some use (particularly for vulnerable and hazardous uses) and development controls may be required to qualify the general planning regulations. | Minor use and development (Asset Class 1) (except swimming pools) are permitted.<br>Residential use and development (Asset Class 2) generally permitted in planning regulations but may be subject to additional building controls.<br>Vulnerable and hazardous use and development (Asset Class 3-5) and swimming pools will require a landslide risk assessment and hazard management plan prepared by a geotechnical practitioner with expertise in landslide risk management, |

[6] Mineral Resources Tasmania (MRT)

| | | | | |
|---|---|---|---|---|
| | | | | to demonstrate that the development can achieve and maintain a tolerable level of risk (as recommended by AGS). |
| Medium | Likely – the area has known landslide features, or is within an identified regional (1:25 000 scale) landslide susceptibility zone, or has legislated controls to limit disturbance of adjacent unstable areas.<br><br><u>Defined as:</u><br><br>1 – 3% AEP; or<br><br>Site is outside of the high band, and has:<br><br>A declared Landslip B area; or<br><br>Mapped landslide features identified by MRT; or<br><br>An MRT regional (1:25 000 scale) landslide susceptibility zone.<br><br>A 'Landslide', 'Landslip', or 'Unstable Land' zone identified in a planning scheme. | Planning controls are necessary for all use and development to ensure that risks are tolerable (as recommended by AGS).<br><br>Any vulnerable or hazardous use, including swimming pools, will only be allowed in exceptional circumstances. | Areas rated as medium should be considered in terms of other planning issues, and where there is no compelling reason for including these in areas earmarked for future development, they should be zoned for rural, open space or environmental purposes.<br><br>In these circumstances, zoning that clearly acknowledges the natural hazard in the zone purpose statement should be applied. | Development in declared Landslip B areas is controlled under Part 10, Division 1 of the *Building Act 2000* and by Part 2, Division 1 of the *Building Regulations 2004*.<br><br>Minor use and development (Asset Class 1) (except swimming pools) are permitted subject to a site assessment prepared by a geotechnical practitioner with expertise in landslide risk management.<br><br>Residential and all vulnerable or hazardous use and development (Asset Class 2-4) can be considered on a site-specific basis that justifies its location and is subject to a landslide risk assessment and hazard management plan prepared by a geotechnical practitioner with expertise in landslide risk management, demonstrating that a tolerable level of risk (as recommended by AGS) can be achieved and maintained.<br><br>Asset Class 5 use and developments are generally prohibited; however, if there is an overriding community benefit, an exceptional circumstance and performance-based solution may be appropriate. |

| | | | | |
|---|---|---|---|---|
| High | Almost certain – the site is within a declared Landslip A area, or there is potential danger from a recently active or currently active landslide.<br><u>Defined as:</u><br>Greater than 3% AEP; or<br>A declared Landslip A area; or<br>A recent or active landslide identified by MRT; or<br>Slopes greater than 42 degrees. | All use and development would require significant investigation and an engineered solution to mitigate the natural hazard and enable the development to achieve and maintain a tolerable level of risk, however, the mitigation measures may never achieve comprehensive levels of security and safety. | Strategies should discourage all development except vital community infrastructure in these areas. Strategies must indicate appropriate zoning and overlays to provide a clear message to the public and the drafters of local government planning schemes to ensure use and development is generally prohibited except under special circumstances. | Minor use and development (Asset Class 1) (except swimming pools) are discretionary subject to a landslide risk assessment and a hazard management plan prepared by a geotechnical practitioner with expertise in landslide risk management, demonstrating that a tolerable level of risk (as recommended by AGS) can be achieved and maintained.<br>Other use and development (Asset Classes 2-5) are generally prohibited; however, if there is an overriding community benefit, an exceptional circumstance and performance-based solution may be appropriate.<br>Most development is prohibited in declared Landslip A areas and is controlled under Part 10, Division 1 of the *Building Act 2000* and by Part 2, Division 1 of the *Building Regulations 2004*. |

# 4 GUIDANCE TO IMPLEMENTATION

A resource for the implementation of this guide is available and provides detailed support for the development of hazard matrices through a series of stakeholder workshops. In summary, it is recommended that hazard matrices are developed through the following sequence of actions:

1 Pre-workshop

1.1 Develop a preliminary definition for the natural hazard and identify how to map the hazard.

1.2 Develop preliminary hazard bands, including the thresholds and consequence statements.

2 Workshop one

2.1 Review and discussion of the definition of the natural hazard.

2.2 Agree on draft hazard boundaries (or options) and consequence statements.

3 Post-workshop

3.1 Assess the coverage of hazard bands in each local government area (LGA) and summarise the nature of existing development and use, as well as known areas of development demand in hazard bands (for each option is necessary).

4 Workshop two

4.1 Review the hazard boundaries and coverage of hazard bands.

4.2 Review the consequence statements.

4.3 Consider controls.

4.4 Agree to natural hazard definitions and HAZARD Matrix.

5 Develop supporting material

# APPENDIX A – PRINCIPLES

## Foundation Principles

The following set of principles is proposed for the purpose of defining the role of governments in intervening in the use of land for the purposes of reducing risks and increasing the shared responsibility associated with natural hazards.

1. **Private risks associated with natural hazards are the responsibility of individuals and business.**

   The role of governments is largely limited to building and defending 'public value'. Individuals and business must take responsibility for the choices they make and for the risks they knowingly expose themselves to.

2. **Governments should encourage public and private risks to be factored into investment decisions.**

   Clear pricing of the risk from natural hazards in the purchase and ongoing maintenance of property can be an effective mechanism for mitigating risk. Governments should continue to work towards ways of ensuring that the long-term costs of natural hazards are factored into both the purchase price of property and/or the costs associated with the maintenance of property.

3. **Governments can support individuals and business to understand and manage private risks through the collection of evidence, provision of information, and facilitation of collective action.**

   Information is a powerful tool for ensuring that people understand the costs associated with natural hazards. In many instances, governments are in the best position to collectively invest in an improved understanding of natural hazards and risks and inform the community about the consequences of them.

   In many cases, collective work to manage natural hazards may be more cost effective and technically effective than individual action. In some cases, individual action may be totally inappropriate. Governments should provide frameworks to support the implementation of collective action by individuals or business.

4. **Governments should ensure that private investment minimises unacceptable public risk.**

   It is rare that private sector investment decisions are made in a way that is completely disassociated from public risk. Governments should ensure that private investment does not give rise to unacceptable risks in terms of costs for the broader community.

   Governments should signal their tolerance to public risk from natural hazards as early as possible in the private sector investment cycle to maximise public value. Governments are well placed to provide the signals on when the potential public burden from a private investment decision is becoming too great by giving guidance on the type and composition of government intervention, ie emergency management, building control, or land use planning.

5. **Governments should avoid investment, regulation, or policy that gives rise to unacceptable public or private risks.**

   The development of government policy, regulation (or investment) should have regard to the risks from natural hazards and their impact on sustainable development, current or future private risks.

6. **Governments should have regard to, and support individuals and business to consider, how natural hazards may change in the future, including through climate change.**

   Arrangements for the mitigation of natural hazards need to be flexible to respond to climate change, improvements in evidence, the development of better mitigation options and tools, or changes to vulnerability.

# APPENDIX B – APPROACHES TO THE MANAGEMENT OF RISK

## Risk Assessment Approach

The **risk assessment** approach is evidence based, relying on the quantification of exposure, likelihood, design and safety (Saunders et al 2011). Under this approach, the state or local government has responsibility to undertake a risk-based assessment of land use and development opportunities to provide a baseline for decision-making. This approach relies on five steps including: objectives, information, alternatives, impact assessment and evaluation (see Randolph 2004). This is consistent with the complete application of the National Emergency Risk Assessment Guide (NERAG) to natural hazards and the risk assessment guide developed by the Australian Geomechanics Society (AGS 2007a).

The risk assessment approach is suitable for considering the risks generally from natural hazards (eg State Risk Assessment) or for assessing the risks associated with individual assets. The process delivers a rigorous and transparent understanding of the risks, potential mitigation measures, and judgements regarding residual risk.

The advantage of the risk assessment approach is that it provides high levels of certainty with regard to the adequacy of measures employed to treat risks. The process is highly transparent.

However, disadvantages of the risk assessment approach include the following:

- all inputs to the risk assessment must be measurable;
- the potentially high cost of evidence collection where current information is inadequate to carry out a full risk assessment; and
- a shortage of hazard specialists who are able to assess risk in government, industry and private sectors.

## Precautionary Approach

The **precautionary** approach[7] is also evidence-based planning. However, it differs from the comprehensive risk assessment approach as it passes the responsibility for the assessment of risk from the government to the individual. The incentive for the private sector to invest in risk management processes is provided by an assumption that (within reason) a risk exists unless it can be shown otherwise.

The advantage of this approach is that it comprehensively addresses the risks from natural hazards, allows risks to be considered at a local level, and transfers the costs of any additional investigations from the community (government) to those that are likely to directly benefit from the improved information.

The disadvantages of adopting the precautionary approach include that it:

- requires everybody, on a case-by-case basis, to consider risks from natural hazards even when the risks are likely to be low;
- places a greater responsibility on individuals to quantify and argue the relative levels of risk through the development application process, and on the planning authority to make judgements on tolerance to risk because the level of risk has not been previously documented by public authorities;
- reduces the ability to strategically plan for natural hazards through settlement planning because a hazard assessment has not been conducted on a broad scale;
- increases the potential for inconsistent responses between and within planning authorities as a consequence of multiple case-by case assessments that produce a 'mosaic' of decision-making outcomes on risk for a particular hazard;
- reduces confidence and transparency for the developer or the planning authority because there is no prior knowledge available on the natural hazard;
- externalises the cost of risk assessment to the applicant, reducing the potential for economies of scale to be achieved through a community assessment (ie economically inefficient); and
- promotes a greater perception of 'red tape' in the planning process because an additional assessment 'test' has been placed in the development application process.

[7] The Intergovernmental Agreement on the Environment, 1992, defines the 'precautionary principle' as meaning where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

## Emergency Response

**Emergency response** focuses on managing natural hazards as and when they arise. This approach relies very heavily on awareness and acceptance of risks, and the capacity to respond to and recover from an event.

Emergency response can be an appropriate approach in some circumstances. For example, it may be more cost effective in some areas to rely on 'just in time' flood protection measures (such as sand bags) to protect property from minor, low-frequency flooding events. This approach may be most cost effective for existing development in relatively low risk areas, where retrofitting reasonable engineering solutions is cost-prohibitive.

While appropriate in the situations cited above, disadvantages of the emergency response approach include:

- nobody responds to the natural hazard until during or after the event;
- it removes the consideration of natural hazards in strategic land use planning or when assessing land capacity;
- it relies on emergency services and governments to have the capacity to both respond to the event and, in many instances, assist with recovery; and
- it relies on a capacity to price the costs of natural hazards so that market forces 'steer' development away from areas of high risk.

The Council of Australian Governments (COAG) report on natural hazards and the National Disaster Resilience Strategy encourage governments to move away from a strong reliance on emergency response approaches (see for example, Middelmann 2007).

## Hazard Treatment Approach

The **hazard treatment** approach seeks to use a combination of elements associated with *risk assessment, precautionary* and *emergency response* methods. The approach seeks to meet the challenge of balancing short-term costs (additional studies or building works) with long-term costs (loss of property or annual insurance) associated with natural hazard exposure.

This hybrid risk method encourages the use of detailed evidence where it is available, but also allows policy judgements to be made in the absence of clear evidence. The approach focuses the attention of governments on areas where risks are deemed to be intolerable, but also accommodates judgements that the risk in areas is acceptable and that it is appropriate to rely on an emergency response.

The hazard treatment approach relies on the mapping of 'hazard bands' based on the likelihood of a hazard occurring. The mapping of hazard bands is based on available information and the collection of further data can be prioritised in areas of high development demand or when it can be justified by the private sector. In areas where detailed hazard modelling has not (and may never be) undertaken, proxies for hazard likelihood could be used.

Policy judgements regarding both hazard likelihood and appropriate control measures can be developed through active engagement with stakeholders to ensure that they reflect community attitudes towards risk and tolerance to risks.

## Summary of Hazard Approaches

Table 6 summarises each of the risk approaches, providing a brief outline of each and the relative costs and benefits.

**Table 6:** Risk approaches (after Saunders 2011)

| Risk Approaches | Summary | Cost | Benefit |
|---|---|---|---|
| Risk assessment | Government defines risk tolerance.<br>Development considered on the basis of government risk assessments at regional or local level. | High cost for government in the collection of evidence. | Comprehensive, with high levels of confidence.<br>High level of certainty.<br>Consistency. |
| Precautionary principle | Government presumes that all properties within defined areas are at risk from a hazard.<br>Assessment of development in defined areas required to include an assessment of the risks at the cost of the developer. | High cost to the private sector, which may be unreasonable in some areas.<br>Uneven risk decision 'mosaic'. | Comprehensive with high levels of confidence.<br>High level of certainty. |
| Emergency response | Relies on an emergency response or mechanism to assist individuals to recover from an event. | High cost for Government and community. | Low level of confidence.<br>High levels of uncertainty. |
| Hazard treatment | Draws on elements of the risk approach, precautionary approach, and emergency response.<br>Development controls based on agreed 'banding' of hazard likelihood based on best available knowledge.<br>Process involves consultation, multi-agency participation in developing policy.<br>Graduated imposition of assessment and control requirements. | Moderate cost for government and private sector. | Policy driven, high transparency, reasonable confidence, joint responsibility. |

# APPENDIX C – MEASURES OF LIKELIHOOD

Modelling the likelihood of a natural hazard involves a range of likelihood indicators. Below is an extract from the report prepared by Clive Attwater (SGS Economics 2011) into the information and evidence required to address coastal hazards through statewide planning instruments. The extract provides an overview of measures of likelihood that are a result of modelling. It summarises and discusses annual exceedance probability (AEP), average return interval (ARI), lifetime exceedance probability (LEP), probable lifetime count of flood events (PLCFE), integrated lifetime flood severity (ILFS), and net present value of lifetime flood damage (NPV-LFD).

Methods of specifying likelihood by reference to an acceptable level of risk as determined by a number of different indicators are as follows:

- Annual exceedance probability (AEP): the probability that a particular level will be exceeded in any year (eg an elevation or level that has a 1 per cent AEP has a 1 per cent chance of being exceeded in a given year). This would have reference to the conditions in that year. Therefore, this may be expressed as an AEP under current conditions, for some specified future sea level rise (0.8 m) or for some specified future time where the sea level rise has a distribution of possibilities or a specified expected level.

  Annual exceedance probability works intuitively for most people for relatively low frequency events but less well for events that happen more frequently, say, several times per year or even several times per decade.

  AEPs are static – that is, they apply for the year and conditions specified but would change (slightly) each year as sea levels change and so a single AEP number does not express well what the risk for an asset would be over its lifetime.

- Average return interval (ARI): The average number of years between occurrences of an event of a particular severity (as specified by a level or elevation) or greater. Non-hazard or risk specialists are prone to interpreting this to mean that if an event (ie 100-year return interval or one in 100-year event) has occurred recently that it will not happen again for that many years, which is not the case.

  ARI is static, like AEP, so does not easily respond to a moving hazard baseline.

- Lifetime exceedance probability (LEP): This builds on the concept of AEP but can allow for the fact that the AEP changes each year. It combines the series of (increasing) annual probabilities into a single number reflecting the probability that the level will be exceeded over a period of time (ie the expected lifetime of an asset) allowing for a rising sea level. This enables a lifetime risk estimate to be provided with a moving hazard baseline. To be calculated, the starting year, the starting sea level, the life of the asset (or end year) and the rate of sea level rise (or final sea level) need to be specified. The answer will be different if any one of these elements changes.

LEP is relatively easy to understand for low likelihood events where the probability is significantly less than one but is less easily comprehended if an event is likely to occur multiple times over the life of the asset. While giving the total probability of flood events, it does not make evident that with a rising hazard baseline, the probability is low in the early years and relatively high in the later years.

- Probable lifetime count of flood events (PLCFE): This is the estimated likely number of events that the asset may face above the specified level in its lifetime. It is an easier statistic to generate and work with for some purposes and is effective over a wide range (from less than one up to quite large numbers of events). It requires the same four parameters to be specified as with LEP. Similar to LEP, it can also be calculated over a moving natural hazard baseline. However, the single combined number does not indicate that events are far more likely in the later years.

- Integrated lifetime flood severity (ILFS) or integrated lifetime flood damage (ILFD): While the previous two specifications can show the frequency or probability of a flood exceeding a certain level and affecting an asset over its lifetime with a moving hazard baseline, they do not show that all exceedances are not equal. What they are tracking is how often an inundation exceeds a certain height, but not by how much. A deep flood is of more consequence than a shallow one. It would be possible to track not only the exceedance frequency/probability, but also how many were minor, moderate or severe to give a lifetime index of the overall flood severity. If the response of the asset to flooding was also considered, this severity could be translated into damage. However, this latter calculation would depend on the characteristics of the asset and its vulnerability to flooding and ceases to be just a characteristic of the location.

  At this time, there is no agreed way of aggregating floods of different severity into an index. However, the lifetime probability or count for floods of different severity ranges could be tabulated easily enough into a series of three or four numbers.

- Net present value of lifetime flood damage (NPV-LFD): This measure moves well away from the characteristics of the location to considering the characteristics of the asset. This calculated value considers not only the likelihood of flooding and its severity but also its timing. If an asset is severely flooded when new, a large portion of its construction cost may be written off and have to be rebuilt before it has had much use. Alternatively, if an asset is destroyed by flooding in the last year of its expected service life, relatively little value is lost. Further, allowing for financial discounting, losses in the near future are more costly than losses in the distant future, as indicated in financial calculations by using a discount rate. Whereas with a static hazard this timing is entirely unpredictable, for a rising baseline it is strongly skewed toward the later years.

The NPV-LFD calculates the NPV of the cost of expected future flood events in annual (or to simplify, perhaps five-yearly) steps, recognising increasing risk over time from rising sea level, decreasing asset value and the financial discounting of events further into the future. In addition to the costs of damage to the asset, the calculation should also include cost of consequential losses (ie disruption to business, need for alternative accommodation, etc, until reoccupying a home) and cost allowance for injury or deaths arising from the event. Unlike a depreciating asset, these costs would not decline over time. This calculation provides the most realistic assessment of lifetime risks incorporating not only a moving hazard baseline but also the time effects of when the events are most likely to be experienced.

The NPV-LFD may be cumbersome and hard to communicate and is not recommended for general use. However, understanding how it varies with other simpler indicators, such as PLCFE or LEP, can be highly desirable in selecting appropriate levels when using these other simpler measures; for impacts on different uses (eg dwellings, schools, hospitals, etc); and for acceptable responses to hazard exposure – ie where an asset is regularly exposed but has some form of accommodation to deal with the hazard (eg is 'flood proof' to some degree).

Once an acceptable present day elevation under static risk and associated probabilities is established and an agreed scenario for future sea level rise is adopted, any of these indicators can be calculated relatively easily, with the exception of ILFD and NPV-LFD, which would also need to identify asset characteristics, their corresponding flood stage damage curves, and associated expected consequential losses.

# APPENDIX D – ASSET CLASSES

Table 7 is drawn from AS/NZS 1170.02002 – structural design actions. While only applicable in New Zealand, the table describes the relative importance of building based on community importance and the risk to life if structural failure occurs during or after a natural hazard event. The table would need to be modified to be appropriate to the Tasmanian context based on the consequence of failure tables in the standard and the Tasmanian Planning Schemes.

Table 7: Building importance levels

| Importance level | Comment | Examples |
|---|---|---|
| 1 | Structures presenting a low degree of hazard to life and other property. | Structures with a total floor area of <30 m2.<br>Farm buildings, isolated structures, towers in rural situations.<br>Fences, masts, walls, in-ground swimming pools. |
| 2 | Normal structures and structures not in other importance levels. | Buildings not included in Importance Levels 1, 3 or 4.<br>Single family dwellings.<br>Car parking buildings. |
| 3 | Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds. | Buildings and facilities as follows:<br>a) Where more than 300 people can congregate in one area.<br>b) Day care facilities with a capacity greater than 150.<br>c) Primary school or secondary school facilities with a capacity greater than 250.<br>d) Colleges or adult education facilities with a capacity greater than 500.<br>e) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities.<br>f) Airport terminals and principal railway stations with a capacity greater than 250.<br>g) Correctional institutions.<br>h) Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate more than 5000 people and with a gross area greater than 10 000 m2.<br>i) Public assembly buildings, theatres and cinemas of greater than 1 000 m2.Emergency medical and other emergency facilities not designated as post-disaster.<br>j) Power-generating facilities, water treatment and waste water treatment facilities and other public utilities not designated as post-disaster.<br>k) Buildings and facilities not designated as post-disaster containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries. |
| 4 | Structures with special post-disaster functions. | Buildings and facilities designated as essential facilities.<br>Buildings and facilities with special post-disaster functions.<br>Medical emergency or surgical facilities.<br>Emergency service facilities such as fire, police stations and emergency vehicle garages.<br>Utilities or emergency supplies or installations required as backup for buildings and facilities of Importance Level 4.<br>Designated emergency shelters, designated emergency centres and ancillary facilities.<br>Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond the property boundaries. |
| 5 | Special structures (outside the scope of this Standard – acceptable probability of failure to be determined by special study). | Structures that have special functions or whose failure poses catastrophic risk to a large area (eg 100 km2) or a large number of people (eg 100 000).<br>Major dams, extreme hazard facilities. |

# APPENDIX E – REFERENCES

Australian Emergency Management Committee, 2009 *National Emergency Risk Assessment Guidelines (NERAG),* Tasmania State Emergency Service, Hobart.

Australian Geomechanics Society, 2007a "Guideline for landslide susceptibility, hazard and risk zoning for land use planning", *Australian Geomechanics* 42(1): 13-36.

Arnstein, S R, 1969 "A Ladder of Citizen Participation", Journal of the American Institute of Planners **35**(4): 216-22AS 1170.

Attwater, C, 2011 *Review of information and evidence required to address coastal hazards- through statewide planning instruments for the Tasmanian Climate  Change Office*.  Hobart, SGS Economics and Planning.

Building Code of Australia, 2009, Volume 1, Class 2 to 9 Buildings (Commercial buildings), Australian Building Codes Board, pp 1-877.

Building Code of Australia, 2009, Volume 1, Class 1 and 10 Buildings (Housing Provisions), Australian Building Codes Board, pp 1-708.

Grislain-Letrémy, C, and Villeneuve, B, 2011 "Mitigation of Natural and Industrial Disasters: The Combined Roles of Insurance and Land Use Regulation." *Les Cahiers de la Chaire* 45: 27.

Health and Safety Executive, 1995 *Generic terms and concepts in the assessment and regulation of industrial risks*, Health and Safety Executive, Her Majesty's Stationery Office, London, England.

Keey, R B, 2000 *Management of Engineering Risk*, Wickliffe Press, Christchurch.

Klinke, A, and Renn, O, 2002 "A new approach to risk evaluation and management: risk-based, precaution-based, and discourse-based strategies", *Risk Analysis*, 22(6), 1071-1094.

Middelmann, M H, (ed), 2007 *Natural Hazards in Australia, Identifying Risk Analysis Requirements,* Geoscience Australia, Canberra.

Pilgrim, D H, (ed), 1987 *Australian Rainfall and Runoff – A Guide to Flood Estimation*, Institution of Engineers, Australian Capital Territory.

Planning  Institute of Australia, 2010 "What is planning?", Retrieved 6/10/2010 from http://www.planning.org.au/becomeaplanner

Randolph, J, 2004 *Environmental Land Use Planning and Management*, Island Press, Washington, USA.

Rittel, H W J, and Webber, M M, 1973 "Dilemmas in a General Theory of Planning", *Policy Sciences,* 4(2): 155-169.

Saunders, W, and Glassey, P, (Compliers), 2007 "Guidelines for assessing planning, policy and consent requirements for land-slide prone land", *Geological and Nuclear Science Miscellaneous Series 7*.

Saunders, W, and Glassey, P, 2009 "Taking a risk-based approach for landslide planning: An outline of the New Zealand landslide guidelines", *The Australian Journal of Emergency Management* 24(1): 11.

Saunders, W S A, Prasetya, G, and Leonard, G S, 2011 "New Zealand's Next Top Model: Integrating tsunami inundation modelling into land use planning", *Geological and Nuclear Science Miscellaneous Series 34*, 42p.

Standards Australia/Standards New Zealand 2002, Structural Design Actions – General Principles, AS/NZS ISO 1170.1, Standards Australia, Sydney.

Standards Australia/Standards New Zealand 2009. Risk Management – Principles and Guidelines, AS/NZS ISO 31000, Standards Australia, Sydney.