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Risk-based Land-use Guide:

Safe use of land based on hazard risk assessment

L.C. Struik, L.D. Pearce, F. Dercole, J. Shoubridge, S. van Zijll de Jong, J.D. Allan, N.L. Hastings and J.J. Clague

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Risk-based land-use guide: Safe use of land based on hazard risk assessment

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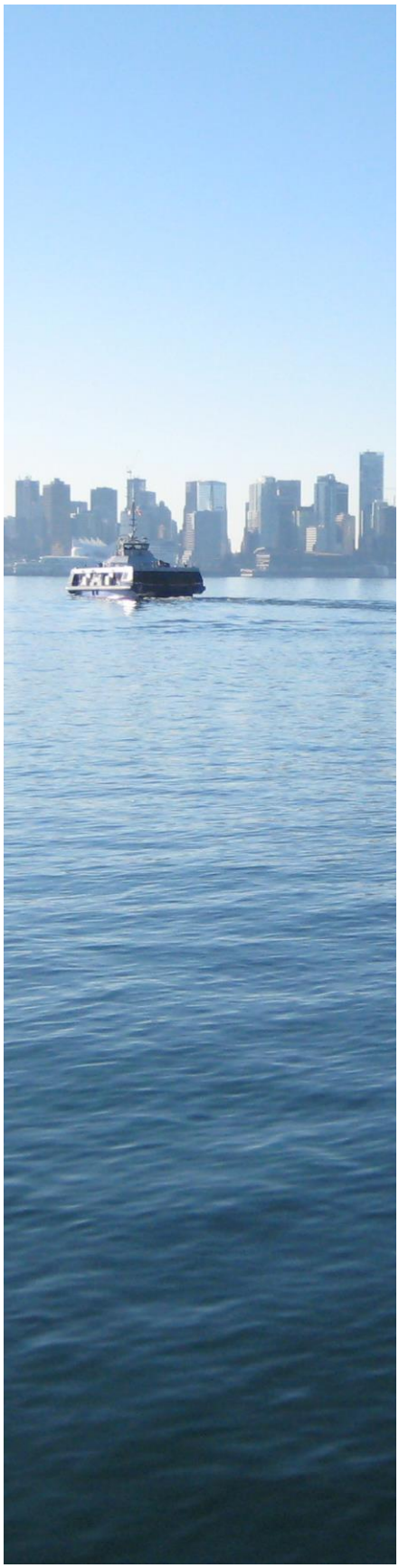


Overview

This guide assists municipal staff to determine whether land use proposals will be safe for their intended use.

This guide explains three key actions intended to assist municipal staff determine whether land use proposals will be safe for their intended use (Appendix A). It explains:

- How to integrate hazard risk management into existing land-use management instruments,
- How to determine if the hazard risk of a land-use proposal is acceptable,
- How to consider reducing the risk to tolerable and acceptable levels.

Recommendations in this guide, like other land-use guides[1,2] are founded on a community's understanding of its risk from hazards. It describes goals of achieving acceptable risk. It does not prescribe how to achieve those goals. It provides concepts of measuring risk from a hazard, and how to use that measure to determine the most cost-effective way to achieve acceptable risk.

The guide can be used for all hazard situations, natural or man-made. As such its recommended practices can be applied to situations where a hazard's frequency and intensity could be altered by climate change. In those situations, the risk analysis is conducted using that hazard's projected event frequency and intensity.

Why use this guide

British Columbia legislation provides instruments that municipalities can use to provide for safe use of their land. This guide describes tools and methods that can be used to satisfy that legislation. Some existing local bylaws provide examples of application for safe use of flood plains and wildfire zones. British Columbia municipalities that have used the Local Government Act to institute flood zone development permit controls, can ensure, through engineering studies, that the "… land may be used safely for the use intended."[3] Section 920 of the Local Government Act has a longer list of natural hazards for which a municipality may designate development permit controls. Appendix B summarizes British Columbia legislation pertinent to safe land development. Appendix C describes the general governance structure for risk reduction in British Columbia. This guide is not a definitive interpretation of legal and regulatory instruments. It provides context

[1] RCC. 2011. Promoting use of disaster risk information in land-use planning. Regional Consultative Committee on Disaster Management, Guideline 3.2, Asian Disaster Preparedness Center, Thailand, 40p. Online access at Prevention Web, Document name "24664_24664rccguideline3.2landuseplanning.pdf"
[2] Schwab, J.C., 2010. Hazard Mitigation: Integrating Best Practices into Planning. American Planning Association, Planning Advisory Service, Report Number 560, 145p.
[3] BC Local Government Act [RSBC 1996] Chapter 323, Part 26 — Planning and Land Use Management, Division 7 — Zoning and Other Development Regulation, Part 910, Section 5b.

for the safe use of land and is based on the concept of land use that will have low risk of economic, social and environmental loss from hazard events.

Most of the tools and methods in this guide can be used anywhere in Canada to evaluate the risk of using land exposed to hazards. Although the guide is targeted to municipal staff, it can be used by staff in other levels of government and the private sector.

Applications

The Guide is designed to help evaluate and ensure the hazard safety of strategic development plans and development permit applications. To accomplish this goal the municipality should have certain practices and knowledge in place to support the evaluation and monitoring.

Guide concepts

The Guide provides four sections. Each describes elements for evaluating both strategic and specific development land-use proposals for their level of safety from hazards. These four sections mimic standard divisions of process and labour within a municipality. The risk management process itself is divided into six parts. The guide incorporates those six risk management parts into the four sections.

Section1: Set-up of existing resources and information necessary to complete an effective evaluation of the land-use proposal's safety.

Section 2: Assess the risk posed by hazards affecting the proposed land use.

Section 3: Establish a mitigation process to reduce identified risks to acceptable levels.

Section 4: Put in place a mechanism to monitor developments to ensure they continue to be safe for the intended land use, and that land-use management instruments, such as risk reduction principles in local and regional growth strategies, plans, and regulations, are effective.

Desired State

Acceptably safe land-use decisions, where "acceptably safe" can be reproducibly determined to engineering and community standards.

The information in these four sections allows planners and disaster risk management professionals to identify, understand, analyze and communicate

risks[4] and to develop options that allow them to better manage risk. "Risk-based," means Council Officers - working with communities - recommend choices based on a comprehensive understanding, and analysis of hazard risk, and communities' acceptance of consequences.

The guide integrates risk reduction principles with local and regional land-use management instruments such as the following:

1. Regional Growth Strategy (RGS),
2. Strategic Plans (e.g. Official Community Plan, associated Area or Town Centre Plans),
3. Development Permit Areas,
4. Design Guidelines,
5. Zoning and Subdivision regulations,
6. Operational Plans (Transportation, Capital, Emergency Management).

Principles of risk-based land-use management

1. All existing community data, information and knowledge are transparent and accessible.
2. Community is engaged throughout the process.
3. Use and improve the best processes that support land-use decisions.
4. Risk-based land-use evaluation needs to be embedded in all land-use proposals.
5. Risk management practices need to be proactive and sustained.
6. Strategic planning processes and the development application processes must include and/or recommend risk-based land-use evaluations.
7. Understand, balance and respect your community priorities.

[4] Black, R; Bruce, J; & I D M, Egener. (2010). *Adapting to Climate Change. A Risk-based Guide for Local Governments Volume 1. National Resources Canada*. p. 1.

Introduction

Before using the guide it is important to understand how it incorporates hazard risk management into municipal land-use management.

This guide provides land-use planning and permitting teams with a framework of informed practice information gathering and analysis. By following its practice, teams can develop a solid foundation to recommend sound decisions about proposed land use in their communities. The term 'community' is used throughout so the guide would be recognized as applicable to many scales and types of group living. As the guide focusses on medium to large municipalities, it primarily means municipality or city.

The guide demonstrates how municipal staff can make land-use recommendations that proactively seek to reduce hazard risk. This guide incorporates the risk management process into strategic planning proposals and development applications. It uses existing municipal knowledge, tools and processes. Land-use issues rather than structure-specific issues are the focus here. Structure-specific issues are ones generally managed by building codes.

How to use the guide

The guide is divided into four sections that feed four operational parts of municipal land-use management processes. These sections are:

1. **Necessary Information and Required Resources**. This section describes the instruments that should be in place to evaluate a proposal for its risk, and to evaluate options to make the proposed development safe. These instruments guide day to day operations within the municipal legal framework.
2. The **Proposal Evaluation section outlines how** to determine if a land-use proposal poses too much risk. It describes how to use the instruments laid out in section 1 to assess the risk of using the land as proposed in a strategic plan or a development proposal.
3. **Making a Recommendation**. This section identifies the required factors to consider when making recommendations about how to use the land safely, where "safe" is based on the level of risk the community will accept. These recommendations rely on the guidance and regulations established in the municipal instruments of section 1.

4. **Monitoring and improvement**. This section provides tools to ensure the land development is, and remains, safe. Included are regular inspections of the development to ensure the land-use meets community risk standards. It includes examination of the efficacy of municipal instruments and to modify them where necessary to achieve safe land-use.

This guide uses risk management as an iterative tool and core concept. As such, the risk management practice adopted in the guide will be described up

front in a general way, and then in more detail as it is integrated through the evaluation of land-use proposals.

This guide introduces a land-use risk management practice based on the international standard for risk management[5]. The risk management scheme's steps provide a method to make a defensible and sustainable risk-based land-use plan and recommendation.

Risk management scheme targeted to land-use

> "Steps can be repeated to include new information or new analyses, as these become available. At the completion of each step there is a decision to be made …"[6]

The scheme is laid out as a sequence of steps of knowledge required and decisions needed. The knowledge or decision of one step is needed in later steps. Once new knowledge is attained at any step, it may trigger the re-evaluation of the quality or scope of knowledge previously attained or the decisions already made. As such risk management is iterative. A community may already have much of the requisite knowledge and decisions in hand and could enter the scheme wherever new knowledge and decisions are required. The scheme's steps are used to evaluate what the community has available and what it still needs to make a risk-based land-use decision.

Land-use risk management

The Guide's risk management scheme is derived from the CSA risk management standard (CSA 2009). That standard was modified to make it more accessible to those dealing with hazards that threaten the safe use of land. The Guide's scheme introduces key concepts of setting risk management priorities, establishing risk tolerance levels, and the concepts of hazards, exposure and vulnerability. Like the CSA standard, the Guide's risk management scheme is divided into six parts. Those parts outline a work flow and a knowledge flow to achieve acceptable risk. The scheme is the same for any scale, from national, regional, community and individual. Because of that, risks from a community analysis can be used to set the context for an individual development analysis. Risk throughout this guide is defined as the probability of a consequence (loss). The parts of the land-use risk management scheme and their sub-components are summarized in figure 1. The figure's images provide a visual definition of key risk management terms. As required, written definitions are available in the Guide's glossary (Supplement A).

[5] Canadian Standards Association and International Standards Organization, 2009: 31000 Risk Management Standard. International Standards Organization.
[6] Black, R; Bruce, J; & I D M, Egener. (2010). *Adapting to Climate Change. A Risk-based Guide for Local Governments Volume 1. National Resources Canada.*

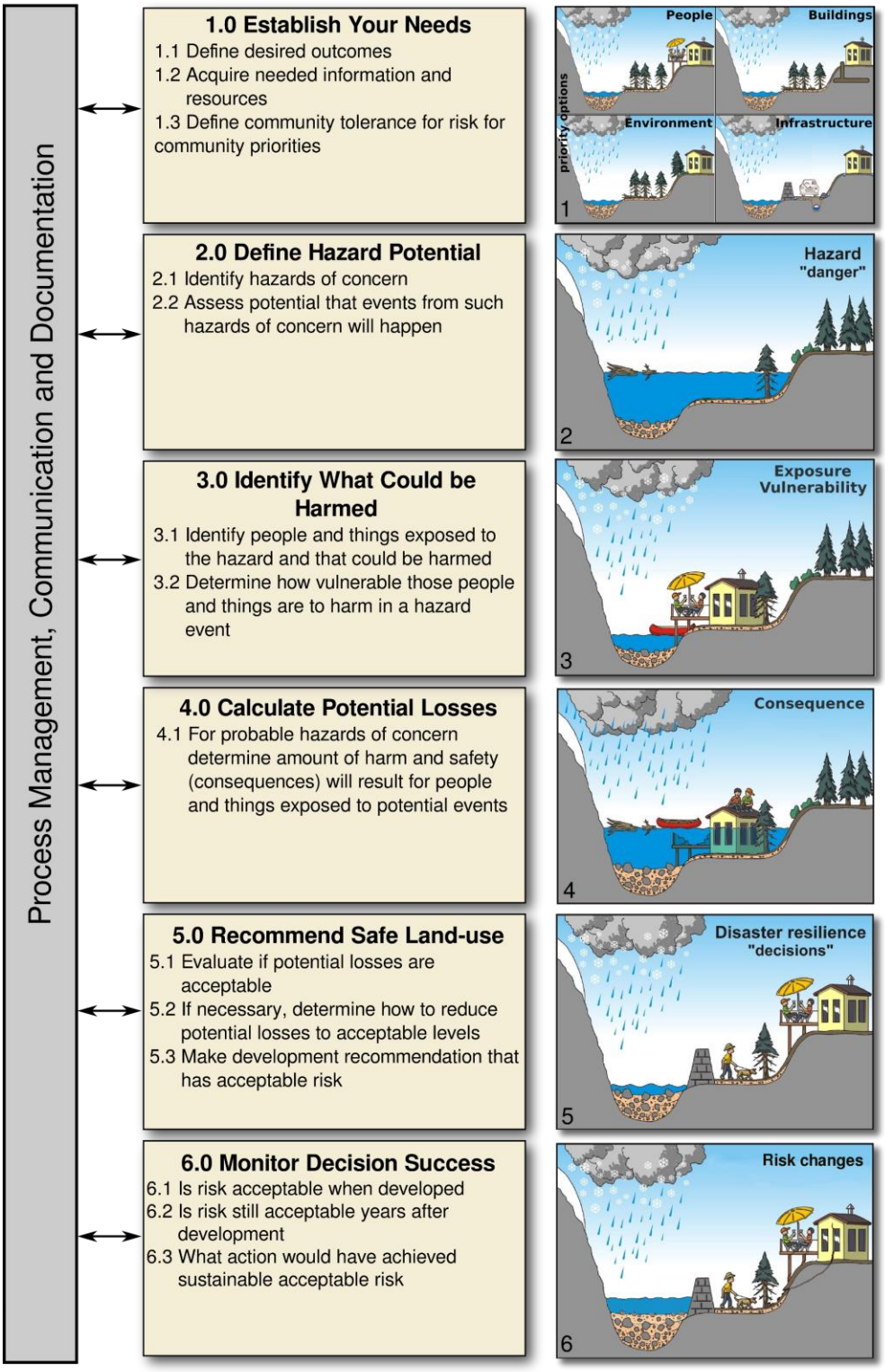
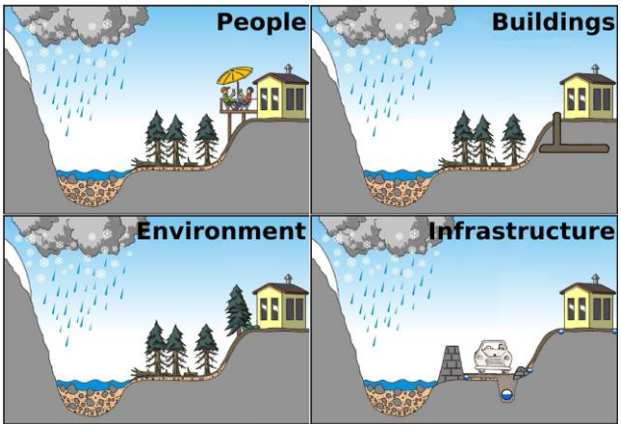


Figure 1. Land-use Risk Management Framework, where risk is the probability of a consequence

The Guide's scheme includes the overarching principle to work together as a team of experts and stakeholders to accomplish the risk management goal. The risk management team needs members with specific and related expertise, and access to subject matter experts, and community members. Details of team, stakeholder and expert contributions are given in the sections that derive the overall distribution and magnitude of the municipality's risk, and how to conduct specific risk assessments. The following descriptions give more context to each risk management step of the annotated risk management overview diagram (Fig. 1).

Step1. Establish needs



1.1 Define desired community outcomes.

What is of highest priority for the community to keep safe (e.g. people, buildings, environment, infrastructure, economic activity). These can include cultural or historical icons. Example: a community developed a close relation with a particular grove of trees. The grove essentially became sacred and all effort was made to preserve it.

1.2 Acquire needed information and resources.

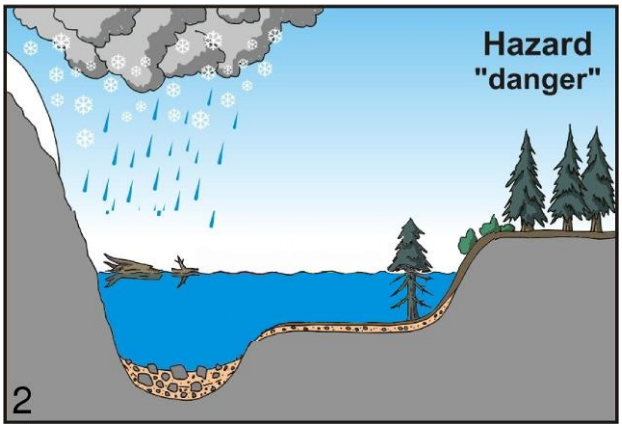
These include three key components:

1. Information, tools, experts and stakeholders required to conduct a reproducible risk assessment.
2. Legislation and regulation requirements and guidelines for safe development, and
3. Operational processes that ensure safe development.

Your land-use risk management team should seek out the risk reduction principles and processes within existing legislation, local and regional growth strategies, plans, regulations, and such. Where necessary, within those instruments, establish missing risk reduction principles and processes.

1.3 Define community tolerance for risk for community priorities.

For each safety priority the community identified in step 1.1, establish how much risk the community would accept: in other words, establish how much loss the community would be willing to accept. For instance; for potential infrastructure losses from flooding, the community would accept annual losses of 0.00005% of annual community revenue.



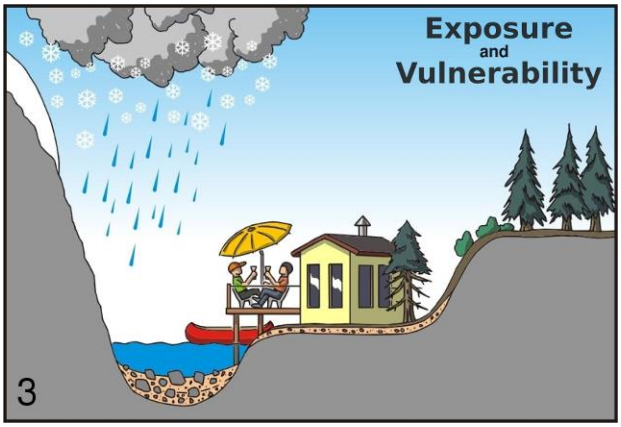
Step 2. Define hazard potential

2.1 Identify hazards of concern.

Make a short list of the hazards that threaten the community. This includes natural hazards that have not created an historical event, such as large earthquakes that may occur every 800 years, and which have scientific evidence of being a threat to the community. It includes the potential of industrial and other accidents.

2.2 Assess the potential that events from such hazards will occur.

Determine the probability of the magnitude of the occurrence of an event caused by each hazard of concern. These define the hazard scenario(s) that would be used in risk calculations.



Step 3. Identify what could be harmed.

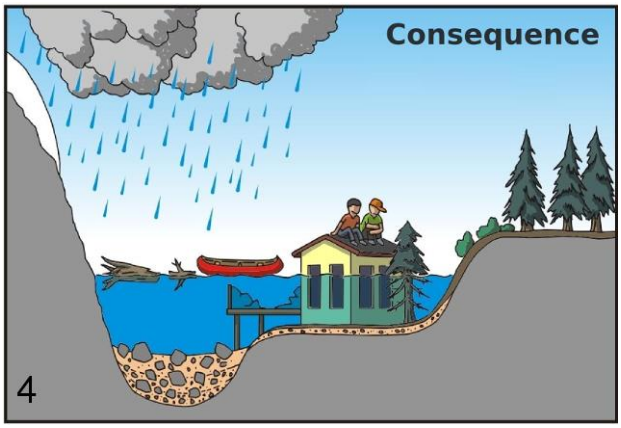
3.1 Identify people and things exposed to the hazard and that could be harmed.

Those people and things that would be exposed to a potential hazard event can be derived from a map of their distribution in your community. Things include buildings, infrastructure, meetings places, parks, trees and the like.

3.2 Determine how vulnerable those people and things are to harm in a hazard event.

This is a complicated part of determining potential losses and risk. This has been done for a few hazard types for North American buildings and infrastructure, and somewhat for people. Vulnerability is the potential for a life (people included) or an object (buildings, infrastructure and other things) to be harmed or damaged to some degree during a particular type of event. For example; what damage would a 2 story wood-frame house built in 1990 in British Columbia suffer if flood water were to reach 1.5 metres above the floor of the first level and stay there for 2 days. That probable damage is the vulnerability of such a house to flood water of that type.

Step 4. Calculate potential losses



4.1 For probable hazards of concern determine the amount of harm and safety (consequences) that will result for people and things exposed to potential events.

Such a loss determination is one step in a full risk analysis. The losses are those created by a particular hazard event (model or real) that impacts people and things exposed to the features of the event. The losses are therefore the potential losses from such a potential event. The measure of the potential is the combination of the potential of the event occurring (e.g. 1 in 100 years), the potential of the vulnerability being realized and the potential of the exposure. A rigorous risk assessment would include loss calculation for multiple events of various potential.

Step 5. Recommend safe land-use

5.1 Evaluate if potential losses are acceptable.

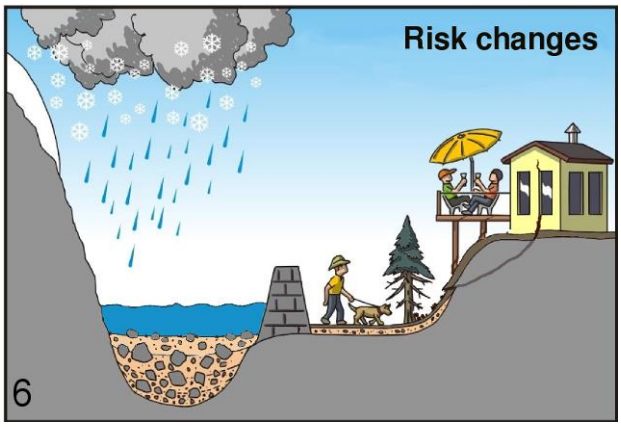
This exercise compares the potential losses calculated for a particular event to the losses that the community said were acceptable for such an event, as determined in step 1.3. This task determines if the community would tolerate such losses: in other words, find them acceptable.

5.2 If necessary, determine how to reduce potential losses to acceptable levels.

This activity tests ways to reduce the potential losses to acceptable levels. Those ways may include changes to the proposed development to reduce its vulnerability and exposure, and by reducing the hazard. For example, illustration 5 of figure 1 shows how the exposure was changed by building the house above the flood plain, and a low level flood hazard was reduced by building a dike.

5.3 Make development recommendation that has acceptable risk.

From the tests of ways to reduce the potential losses (and thereby the risk), the optimum mitigation options are recommended.



Step 6. Monitor decision success

6.1 Determine if the completed development is safe (has acceptable risk).

Inspections and evaluations would find out if the completed development is actually as safe as planned. For instance: have the mitigation choices been successful and has the hazard been changed by the development.

6.2 Determine if the completed development continues to be safe.

Through a regular multi-year Inspection and evaluation process find out if the hazard, exposure and vulnerability of the development have changed and increased or decreased the risk. Mitigation works such as retaining walls may have weakened, been plugged, become blocked or otherwise become ineffective, increasing the hazard (e.g. raised creek bed behind the dike of illustration 6 of figure 1) A new hazard may have been created (e.g. slump on the side of the bank of illustration 6 of figure 1). The structure many have been renovated in such a way as to increase its vulnerability to a particular hazard,

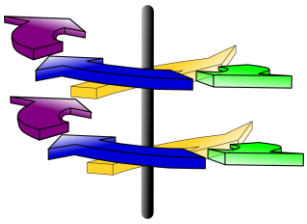
6.3 What action would have achieved sustainable acceptable risk?

Through the evaluation of the potential changes in the development and its regime, and better science and technology, determine how better to maintain acceptable risk in this or other future developments. Review the full risk management process for better ways to achieve acceptable risk.

The Risk management process above has been elaborated as a risk management activity flow chart (Fig. 2 and poster). The graphics from that figure are used through the sections of the guide to provide a clearer sense of sequence to risk management preparation and land-use proposal evaluation, decision making and review.

Risk management is iterative. The iteration happens mostly in two ways: 1) estimates of the hazard, exposure, vulnerability and potential consequences of events often provide focus on what is important to the community, and that causes re-evaluation of all the parameters and the value of acceptable risk for each hazard; and 2) community-wide (and regional) risk assessments demonstrate which areas of the community are most at risk, which may spur local risk assessments in those areas and the implementation of local risk-reduction policy and action. The local risk-reduction action will change the overall community risk. That change of

community risk will not necessarily be equal to the change of the local risk. Actions that decrease a local risk can end up increasing or decreasing risk elsewhere. Therefore it is useful to rerun risk assessments at intervals when the community changes or the hazards that affect that community change.



Risk management iteration

Section 1: Necessary Information and Required Resources

Establish the community's overall hazard risk. Use this information to build an integrated hazard risk-based land-use management framework. The framework is the integrated use of each community land-use instrument to support safe land-use.

Getting started

Putting together the city's documentation that supports land-use hazard risk management

All cities are at risk

All communities are at risk from various hazards and have means in place to deal with them. To deal effectively with hazard risk, its management should be integrated throughout community land-use practice and its instruments. Achieving such integration starts with an understanding of the community-wide risk (a municipal risk map). That understanding is then used to develop practice in each appropriate community land-use instrument that will reduce that risk to acceptable levels. With such a community-wide understanding of the risk, and a community strategy for dealing with it, it is possible to examine and better manage the hazard risk of individual development proposals. It is possible to manage and reduce the risk of individual developments without a community-wide risk management strategy. It is more complicated, because each case then requires individual strategic and practical justifications for action to reduce the risk. If a community-wide hazard risk management practice is not yet in place, site specific risk evaluations should be done anyway and this Guide will also show what is needed to do that.

All cities have means in place to deal with their risk

This section, 1, describes how to integrate community land-use risk management practice throughout land-use management instruments. It describes how each practice and instrument contribute to the other and why they are recommended. Some of that description will expect that a community-wide risk assessment is already done, or will recommend how one can be used to establish the practice and instruments. Risk management is not linear. It has internal cycles that inform the next and previous steps, improve the practice, change the practice and target particular needs. Stakeholder participation in the cycles reinforces distributed risk reduction responsibility for achieving acceptable hazard risk.

Sections 2 and 3 describe the risk assessment and land-use recommendation practice for specific development proposals, whether they are neighbourhood strategic plans or for construction. Those sections rely on the risk management platform established in Section 1.

The development of the integrated community risk management practice is a hazard risk management project, and will follow the six risk management steps outlined in the introduction.

That hazard risk management project will:

1. Identify the level of risk the community members and structures face from various hazards of threat.
2. Establish what the community considers priorities for protection.
3. Establish the level of risk that is acceptable for protecting those priorities.
4. Develop a method to ensure the priorities are protected into the future. That method determines how to use the existing land-use instruments to achieve protection. New instruments may be made. Such activities have much in common with those that deal with risks posed from slow onset issues that threaten sustainability: issues such as a changing climate, pollution and depletion of non-renewable resources.

Required Resources

Area Stakeholders

Subject Matter Experts

Regulations

Practices

The anticipated outcome of the project is a hazard risk evaluation that helps to assess land-use development proposals and contributes to the cycle of community planning.

The information outputs generated in the risk assessment provide municipal councils and the community efficient access to information about any identified hazard and risk. With this information, stakeholders can participate in a feedback loop with the land-use planning and permitting departments.

What to do and How to do it

Get a mandate, or use an existing one, to develop or enhance an integrated land-use risk management practice for your community. Within your municipal government and with the provincial government refer to existing accepted plans and policies, such as the Official Community Plan, Strategic Growth Plan, and legislation, for policies that support risk management. British Columbia's legislative context for hazard risk is outlined in Appendix B. For communities without such a mandate, conduct a community-wide hazard risk assessment to establish the existing level of community risk. This assessment will provide a platform to evaluate the benefit of integrating risk management throughout the land-use planning and management process.

For this section you will be setting up work teams to establish the integrated hazard risk management platform for the community. The first team defines the

project. The second team conducts the project. The second team generally consists of the first team to which other people have been added to accomplish the project outputs and outcomes.

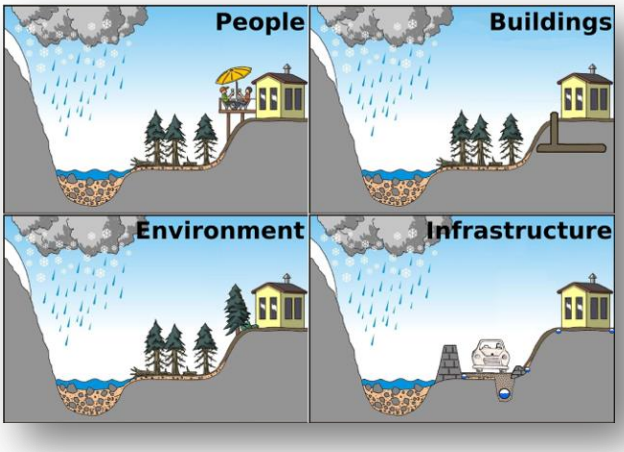
Identify the teams

1. Identify a **Hazards Risk Management Team** and key stakeholders and agencies that should be involved or that could be affected. Identify the Team Lead who will likely be the Subject Matter Expert (SME) relevant to the analysis. The process has several steps and parts of the team will be in play at various times. Keep the full team apprised of developments.
    1.1. The team includes:
        1.1.1. Staff who are responsible for and have expertise in each land-use instrument the community uses. The Guide identifies the key instruments (see below).
        1.1.2. Staff who will conduct a community risk assessment; included are those responsible for managing hazards, asset and demographic information specialists, and those who will manage and do the risk assessment
        1.1.3. Community and agency stakeholders who can help identify the priority community assets and define the criteria for how much risk would be tolerated for each of those priorities.
2. Scope the project and **create the work plan (Appendix D for example)**
3. Establish **record keeping** protocols and a resource repository
    3.1. Thorough and easy to retrieve records of decisions and processes contain information that makes it possible to determine if the risk has changed and that the processes reduce risk.
    3.2. The records support the credibility of the risk management system.
4. Outline a **communication plan**. Establish what information needs to be gathered and shared, and how conversations can be made effective. *Ensure that the communication protocols are cost effective, transparent, and based on dialogue and consideration. It is important to establish general and specific rules of engagement.* Include a public education and awareness section to ensure community engagement.
    4.1. An engaged citizenry will improve chances of developing the risk tolerance criteria. It will provide educational and awareness opportunities, which will enrich the conversation, which in turn will improve chances of establishing community roles and responsibilities for risk reduction. Citizens can be a wealth of energy and support for the process.

Step1. Establish needs

Step 1 of land-use risk management builds the platform of common understanding from which the community makes its risk-based land-use decisions. It defines what the community wants to keep safe and to what level. It enhances or creates the legislative, regulatory and planning concepts for how to keep those priority parts of the community safe. Appendix E provides support for community consultation.

1.1 Define desired community outcomes.



In this step, the community decides, through open dialogue, which parts of the community have the highest priority for being kept safe. Those parts may be people, buildings, environment, infrastructure, economic activity, and cultural and historical icons, etc. Except in rare cases, these priorities are categories rather than individual.

Optimally, these priorities should be linked to a particular hazard. Each hazard targets people and assets differently depending on the community layout and resources.

Examples:

- Valley floods and interface forest fires take days to weeks to develop and are predictable with access to appropriate resources. It is much easier to save lives for those events. Rather than focus risk management priorities on saving lives from flood and interface fire events, the community may want to tackle higher loss components such as structural damage and business continuity.
- Landslides and earthquakes are much less predictable. Persons may not have the time to escape and could be harmed. Structures would be damaged and other aspects of the community disrupted. The community may decide that preserving people's lives and structures is a high priority in landslide and earthquake events.

Deciding community safety priorities is recommended because in a subsequent step the community will determine how much risk it would be willing to tolerate for each of these priorities. It is more important to identify one or two top priorities from such a priority inventory to begin with. After iterations of

the risk management cycle other categories from the list can be included. Taking on too much at once can overwhelm the community and threaten the viability of the process. Small steps are more useful than no steps.

Establish the level of importance for each of these priorities. The degree of importance will be used to assist in developing how much risk is acceptable for each category. These priorities and the measure of the community's tolerance for their risk will be the focus of the community risk management platform (Appendix F). In this guide we look at how decisions about land-use influence those risks and suggest how to integrate land-use with other decision criteria.

Case Example: The District of North Vancouver, of British Columbia, chose their priority to be keeping people safe from landslides. They then evaluated how much risk to a person's life would be acceptable due to a hazard threat (step 1.3 in this process). The District of North Vancouver established this priority and their risk tolerance based on existing criteria in Hong Kong[7].

1.2 Acquire needed information and resources.

In this step relevant information is amassed to assess the community's hazard risk. The information to gather depends on the status of the community's risk management process.

Risk managers are looking for several different types of information. A more complete description of the instruments that can be used for land-use risk management follows this overview list:

- **Governance-based resources** that contain decisions the community has made on how it plans to assess and manage its hazard risk. These generally are policy and regulation decisions in strategic plans, bylaws and regulations.
- **Information** for calculating the risk, often done as a calculation of the consequences of probably hazard events. These include hazard scenarios, people and asset inventories and the vulnerability of those people and assets to the hazard of concern.
- **Priorities** set by the community for addressing hazard risk. These are derived from analysis of the community's hazards. They have previously

[7] Dercole, F. Natural Hazards Risk Tolerance Criteria; Report to council District of North Vancouver, File: 11.5225.00/000.000, November 10, 6p (online access).

been determined for most communities in British Columbia as part of the community's HRVA (Hazards Risk and Vulnerability Analysis).

- **Communication protocols and tools**. These include how the community wants to be involved in hazard risk management and the methods for accomplishing that. Citizen engagement in risk management provides many benefits, and initially challenges. Appendix E provides support for engaging the community in risk management. It summarizes processes and tools developed at Natural Resources Canada[8] and other sources.

If your community has previously assessed its hazard risk (created a risk map) and set up a comprehensive system to catalogue that information and to manage that risk, then this step is a reminder of the platform to work from. If done for the first time, this step provides an opportunity to gather policy and information relevant to your risk management and develop them into a long-term integrated system. Within legislation, local and regional growth strategies, plans, regulations, and the like, look for existing risk reduction principles and practice. Section 1 is intended to review the land-use management instruments to ensure they are used effectively to manage the risk.

The following resources are useful to review. Planning documents and legislation seek to ensure that hazards are identified. The planning documents clearly state that local government work to ensure hazards do not increase the potential vulnerabilities in a community. Review the existing land use patterns to ensure the proposed risk based land use management program adequately addresses any gaps or opportunities previously identified.

Governance-based resources

The following governance-based resources are useful to frame what to achieve from a land-use risk assessment, and in turn how they can be informed by the risk assessment. They have or should have policy and regulatory decisions and instructions for managing safe land use. Use that information to understand what has to be done, and what can be done, to reduce disasters. The following provides ways to use governance-based resources to achieve and maintain acceptable hazard risk with the city (Appendix L). They are not comprehensive and should be viewed as starting points.

[8] Journeay, J.M. 2014. *Disaster Resilience by Design: A framework for integrated assessment and risk-based planning in Canada.* Geological Survey of Canada, Open File 7551, 336p.

Regional Growth Strategy (RGS), (Local Government Act of BC, RSBC 1996, s. 848-871)

What it is meant to do and what it includes:

- A regional growth strategy is meant to promote human settlement that is socially, economically and environmentally healthy, and that efficiently uses public facilities and services, land and other resources.
- Includes suggestions that settlement patterns be decided so they minimize the risk from natural hazards, which would require a municipality to analyse the risk of future potential build outs.

How to use the Regional Growth Strategy:

- Assess the hazard risk of strategic growth plans and adjust them accordingly to achieve acceptable risk. In short, this is done by determining the consequences of a hazard event on the planned structures, infrastructure and people. Rerun the analysis for revised plans to determine the one with acceptable risk. Journeay[9] provides an example of such an analysis for the District of Squamish, British Columbia.
- Assess the hazard risk of the existing community structures, infrastructure and people to determine areas that have unacceptable risk. Use that assessment to evaluate how to reduce the risk to acceptable levels while accommodating community growth.
- Imbed strategic growth decisions based on the various risk assessments into the Regional Growth Strategy. Describe how you would design and redesign high risk areas of the community over time to reduce their risk to acceptable levels.
- Use those design decisions in the Strategy as recovery plans should a disaster occur.

Official Community Plan (OCP) (Local Government Act of BC, RSBC 1996, s.875-879)

What it is meant to do and what it includes:

[9] Journeay, J.M. 2014: *Disaster Resilience by Design: A framework for integrated assessment and risk-based planning in Canada*. Geological Survey of Canada, Open File 7551, 336p.

- They are developed with community members and state the municipality's objectives and policies to guide decisions on planning and land use management.
- Official Community Plans must include statements and maps of provisions that restrict the use of land subject to hazardous conditions.
- Official Community Plans are generally renewed every five to ten years and support the Regional Growth Strategy.

How to use the Official Community Plan:

- As part of each Official Community planning cycle assess the hazard risk of the existing community structures, infrastructure and people to determine areas that have unacceptable risk. Use that assessment to evaluate how to redevelop the high-risk areas to reduce the risk to acceptable levels while accommodating community aspirations. Journeay et al. provides an example of such an analysis for the District of North Vancouver, British Columbia. Shoubridge and Stevens analyse the use of Official Community Plans in Metro Vancouver for hazard risk reduction and planning effectiveness.
- Imbed into the Official Community Plan redevelopment and land-use management planning decisions based on the various risk assessments.
    - Imbed the regulations and maps of Development Permit Area for Hazards into the Official Community Plan. See 2013 District of North Vancouver Official Community Plan for an example of imbedding Wildfire, Landslide and Flood Development Permit Areas. (District of North Vancouver Geoweb website)

Development Permit Areas (DPA) (Local Government Act of BC, RSBC 1996, s.919.1) (See Appendix H for further description of DPAs and a sample DPA for wildfire)

What it is meant to do and what it requires:

- Development Permit Areas are meant to define areas of the municipality that have targeted development criteria. They are used to ensure that particular land-use objectives are met. For example: Development Permit Areas can be established to protect development from flooding, protect sensitive environments along streams and define the character of development.
- They require a justification for their designation.

- They require a map that defines their areal extent. For a DPA for flooding, the areal extent would be defined by the boundaries of the flood zone of concern.
- They require guidelines on how any new development would respect the permit area intent.

How to use Development Permit Areas:

- Establish a "Development Permit Area" for each hazard of concern to the community. Use these areas to require basic hazard and risk mitigation criteria for new developments. Guidelines and regulations include prescribed mitigation strategies to address hazard, exposure and vulnerability that may include land-use restrictions. Be clear about the reasons for the area designation and guidelines and regulations for development and redevelopment that address those reasons
- Define the permit area based on a hazard assessment that will establish where potential hazard events of a certain magnitude occur. For instance, establish a flood Development Permit Area based on the boundaries of the 200-year flood plain, and define the development regulations you know will mitigate the risk from that flooding. Subdivide those permit areas into sub-areas where appropriate. For instance, for floods, use divisions based on hazard probability, e.g., 100-, 200-, 500-year flood potential and establish that each has development and redevelopment guidelines and regulations based on risk analysis
- Imbed the description and requirements of the Development Permit Area for Hazards into the Official Community Plan. See the District of North Vancouver 2013 Official Community Plan for examples. The Official Community Plan will explain the intent and operation of each Development Permit Area for a hazard.
- Review the efficacy and relevance of Development Permit Areas for hazards within the Official Community Plan cycle. Hazards can change and the definition and regulations of the Development Permit Area will need to change with them. Changes in the climate, for example, will increase or decrease climatic based hazards such as wind storms, forest fires, floods, and extreme temperatures.
- Add new Development Permit Areas for other priority hazards as knowledge about that hazard's risk and community capacity permits and where warranted.

Development Permits (Local Government Act of BC, RSBC 1996, s.920 and Vancouver Charter, RSBC 1953, s565A)

What they are meant to do:

- Ensure through the statements of the permit and the municipal monitoring process that a proposed development meets the city bylaws, regulations, requirements, development conditions and municipal plans.
- Development permits have different uses in the Local Government Act and Vancouver Charter. In the Local Government Act they refer specifically to developments proposed in Development Permit Areas and are used to define development requirements or variations from the guidelines within each type of permit area. In the Vancouver Charter they are required for each development and include development requirements of the city zoning bylaws and describe accepted variations from those bylaws.

How to use them:

- Include risk assessment in the development permitting process.
  - Where the development proposal falls in areas of high hazard threat, require that the proposal undergo a risk assessment. Metro Vancouver is all susceptible to several hazards including earthquakes and storms. For example: most buildings are required under the building code to be resistant to falling or collapsing under the forces of a 7.3 or less magnitude earthquake. Risk assessment can consider other elements of the earthquake risk, such as business disruption, housing loss, social service costs, infrastructure losses and the like.
  - Sections 2 and 3 of the guide focus on this type of development permit risk assessment and risk mitigation process.

Design policies & guidelines

What they are meant to do:

- These provide design characteristics for developments in areas for which the city has established development bylaws.
- They can require that the design of buildings in hazard zones be proven to reduce or eliminate the risk of damage from a hazard event (e.g. Vancouver Charter, s306.1cc).

How to use them:

- Design guidelines can be embedded within or linked to the existing community OCP, DPA, zoning bylaws, subdivision bylaws and strategic plans. For example:
  - High-flow drainage systems in heavy rain areas on slopes
  - Aligned roofs in areas that endure heavy winds

- Design and building regulations can be enacted in bylaws to ensure the safety of person and property (Local Government Act, Vancouver Charter).

Zoning bylaws and regulations (Appendix I)

What they are meant to do:

- Regulate the specific development and use of parcels of land in the jurisdiction.

How to use zoning:

- Zones can specify mitigative strategies to minimize disaster risk identified in the community risk analysis.
- Zones may restrict land-use to activities that are low risk for particular hazards (example: the Don Valley Parkway in Toronto, Ontario where the flood plain for the Don River was zoned park land).
- Zones may require certain engineering studies to confirm developments have acceptable risk for particular hazards.
- They may, like Development Permit Areas, have specific mitigation measures required of developments to achieve acceptable risk for particular hazards.
- Use the Official Community Plan to designate new zoning opportunities rather than pre-zoning areas. Pre-zoning locks in conditions which may be later found to have unacceptable hazard risk.
- Within existing zoning bylaws that do not have the necessary requirements for establishing acceptable risk from particular hazards:
    - Variance to the zoning development restrictions can be traded to establish agreements for risk mitigation to achieve acceptable hazard risk.
    - Phasing of developments could provide several opportunities to include conditions on where and how the structures are built and how they are used that reduce hazard risk.
        - Example: registered covenants can be used to restrict future changes to land use that could increase hazard risk.
    - Community hearings provide an opportunity to share knowledge about the risk and risk reduction opportunities.
    - Design guidelines can be used to embed risk reduction criteria.
- Consider other tools to mitigate hazard risk within the realm of zoning management:
    - Road, transportation and parking building and maintenance practice.
    - Land-use requirements.

- Phased development.
- Water and storm water management.
- Site layout including set-backs.
- Multi-jurisdictional agreements to leverage initiatives (e.g. reducing vulnerability by dealing with homelessness and inadequate housing)

Subdivision bylaw and regulation

What they are meant to do:

- A subdivision bylaw regulates the size and shape of parcels of land and the characteristics of their associated services, and may provide different regulations for different land-use and zones of the city.

How to use them:

- Subdivision bylaws may be used to require a subdivision proposal to include mitigation of risks associated with a hazard. An example is section 11.5 of the City of Vancouver Subdivision Bylaw 5208 that requires remedy of flood conditions on the new property before approval.
- Subdivision bylaws may be used in conjunction with design policy and guidelines to direct preferred development.
- Provisions for risk mitigation can be established within the bylaw based on the city strategy for establishing acceptable hazard risk throughout the city. That strategy would have been derived from minimizing the risk determined from the community-wide risk assessment.
- Provisions for hazard, exposure and vulnerability mitigation can be established within the bylaw based on the property's inclusion in a Development Permit Area for Hazards.

Transportation plans

What they are meant to do:

- Identify transportation services that will meet the future economic, social and environmental needs of the community.
- Develop strategies to achieve the transportation service goals.

How to use them:

- Include instructions in Transportation Plans on why and how hazard risk assessment was used to determine and make acceptable the level of hazard risk of strategic transportation plans.

- Incorporate strategic transportation decisions that would reduce risk and increase resilience and that result from community-wide and neighbourhood risk assessment.
    - Such decisions may prescribe certain transportation system construction methods or materials, or
    - Such decisions may require certain conditions be met with respect to the transportation system and allow the construction criteria to be designed to satisfy those conditions. Examples of conditions are:
        - That a transportation route must function for evacuation under all potential hazard events.
        - That a particular transportation system must function for emergency response through all potential hazard events. The term "system" is used in this example to not get hung up on making individual parts unbreakable, rather to ensure that responders can do their job without a transportation impediment.

Capital plans

What they are meant to do:

- These plans are the municipal development and goods acquisition plans for the specified planning period. They record what municipal facilities will be built or replaced, which infrastructure will be installed or replaced and what equipment will be acquired or replaced.

How to use them:

- Each facility and the infrastructure of the capital plan can be evaluated for its hazard risk and designed to make the risks acceptable. Use both the community wide and individual risk assessments to determine the most acceptable designs.
- Capital replacement plans are an opportunity to prioritize high-risk facilities and infrastructure for redevelopment and replacement. High-risk facilities and infrastructure would be identified in the community-wide risk assessment.

Emergency management plans

What they are meant to do:

- Identify and assess the potential emergencies that could affect their jurisdiction.
- Guide policy and effective operation of the jurisdiction's emergency management organizations.

How to use them:

- Review the emergency management plan to ensure that land-use decisions address emergency response capabilities, capacities and evacuation plans. For example:
  - Community neighbourhoods may have designated shelter and supply facilities as part of their design.
  - Exceeding certain neighbourhood densities may require addition of evacuation routes, and response and emergency service capacity to maintain acceptable risk.
  - Redevelopments may change the ratio of vulnerable populations and therefore require changing the emergency management plan.

Information

Risk is the potential of something harmful happening[10]. To estimate that risk, your group needs information about what could be harmed (exposure), how much it could be harmed (vulnerability) and the conditions that could cause that harm (hazard). For risk to a city, that means having information about its people and assets and where they are (exposure), how susceptible to harm they are from a certain event (vulnerability), and the potential conditions of a hazard event (hazard scenario). The following overview summarizes information needed and the practice that would make it accessible.

What you need:

The type of information needed depends on the risk assessment methodology. The amount of information available generally controls how useful the risk assessment will be. Appendix J reviews a few types of risk assessment methods and a few specific tools. Journeay[11] compared risk assessment tools from North America, Europe, Australia and New Zealand. Although that review was done in 2007, it provides a useful starting point to research a method suitable to your need.

Every risk assessment method requires information about the hazard, exposure to the hazard and vulnerability to the hazard. The vulnerability information is unique to the hazard.

[10] Risk is used here as it is normally perceived – as negative. Some risk analysts and the ISO 31000 Risk Standard say that risk can be positive, which is an outcome of the risk equation. Since risk is a function of the potential of a consequence and a consequence can be positive, then it was concluded that risk can be positive. Rather than vary from how we perceive risk, here we call the potential of a positive consequence, a potential benefit. The English language does not have a single word for the potential of a benefit that would be the opposite of risk (potential of a harm).

[11] Journeay, J.M. 2014: *Disaster Resilience by Design: A framework for integrated assessment and risk-based planning in Canada*; Geological Survey of Canada, Open File 7551, 336p.

Hazard information

Risk assessment methods need a hazard scenario. A hazard scenario is a description of the hazard consequence of a potential hazard event. The scenario does not concern itself with the trigger of the event. A flood scenario would be described primarily by measures of the depth of the flood water at a certain location. More detailed analyses of flood risk would use the velocity of the water flow, amount and type of debris in the water, temperature of the water and atmosphere and possibly other measures. An earthquake scenario would be described primarily by measures of ground shaking at a certain location. More detailed analyses would use the potential of the shaking to trigger a landslide, liquefy soil and disrupt the ground, and for the earthquake or triggered landslide to cause a tsunami.

Hazard scenarios can be deterministic, as described above, or probabilistic. Deterministic scenarios are discreet events: for instance, the maximum credible event is best used for risk assessment done for land-use planning. Probabilistic scenarios are summaries of all possible hazard events of a particular type. For instance for earthquakes, the probabilistic scenario is the sum of the possible shaking that could occur for a particular site from potential earthquakes.

How to get what you need and share it:

Hazard scenarios are derived from hazard assessment. Hazard assessment determines the potential of a particular hazard event to occur. Hazard assessments rely on information about the hazard in the area of interest. An expert in that hazard generally creates the scenarios, assessments and hazard description. Any hazard risk assessment requires a hazard scenario.

Limited hazard assessments are available from various federal and provincial government agencies. Of these, earthquake potential maps are available for all regions of Canada[12]. Earthquake-shake maps need to be derived. Flood potential maps are locally available. Flood depth scenarios need to be created. Most other hazards need to be assessed for your city and a hazard scenario derived.

Hazard scenarios are used repeatedly over time to evaluate various proposals and measure changes in community wide risk. They can be modified with new information about the hazard as that becomes available. As such, it is cost-effective to create a hazard scenario digital library to manage the collection and provide access for staff and citizens. Such libraries can be as simple as a catalogue of the

[12] Adams, J. and Halchuk, S. 2003. *Fourth generation seismic hazard maps of Canada: values for over 650 Canadian localities intended for the 2005 National Building Code of Canada*. Geological Survey of Canada, Open File 4459, 155 pages, doi:10.4095/214223.

computer directories where the scenarios are stored. That catalogue could be done as part of the municipal GIS database.

Exposure information

Information about the people, buildings, infrastructure, and environment that could be exposed to a hazard is your city GIS database. The intersection of the hazard area with the city's GIS map will show what could be exposed to the potential hazard. Information about exposure is unique to the hazard. For instance a house may be in a flood plain and therefore exposed to a potential flood. The amount of exposure of the house depends on its height relative to the flood water. A house beside the river in a 200-year flood plain may have 2 metres of floodwater above its ground floor. It would be more exposed to the flood than a house in the same flood plain and at its outer edge. The house at the outer edge may have a few centimetres of flood water above its ground floor.

How to get what you need and store it:

To assess the risk of the entire community your GIS database should have all the city assets and people that are your priorities for keeping safe or sustainable. The risk assessment tool in part determines the components of the assets and people needed. Some tools can determine the risk of most assets and people and others are specific to certain components.

Vulnerability information

Vulnerability information is used to determine the potential harm a structure, person or other life could suffer in a hazard scenario. Vulnerability is hazard dependent. Vulnerability can be thought of as the fragility of a person or structure. A typical Metro Vancouver house is vulnerable to flood water because it is made of wood and drywall. The amount of vulnerability depends on the height of the flood water and the duration of the water in the home. At a minimum, the amount of damage the home will suffer is therefore proportional to its vulnerability to the flood water and its exposure to the flood water (the height and duration of the flood water). The same house would have a different vulnerability rating with respect to a potential wildfire. Although the house interior could be easily ruined by flood water, the exterior may be clad in fire retardant material, giving it a low vulnerability to wildfire embers and heat.

The potential of a structure suffering harm in a hazard scenario based on its exposure and vulnerability is recorded in some risk assessment tools as a damage function. In other words, with certain conditions of exposure, vulnerability and hazard conditions, the damage function will provide the percentage of possible damage or harm.

How to get what you need and share it:

Some risk assessment tools come with vulnerability and damage function databases. Hazus-MH, which estimates losses from earthquakes, floods, hurricanes and storm-surges, has extensive databases of damage functions for most urban and some rural assets, and for people[13, 14].

City engineering departments have information about the vulnerability of city infrastructure. That information may need to be augmented with vulnerability measures for the specific hazards of concern to the community.

Human vulnerability indices and evaluation tools are available. The Social Vulnerability Index is a well-established tool[15]. New versions are currently being developed. Hazus-MH has a modicum of information about human vulnerability to earthquakes and hurricanes[14]. Dunning and Durden[16] compare several social vulnerability measurement tools for hazard scenarios (see Appendix G).

Vulnerability or damage functions (fragility curves), once built can be used again. They are linked to specific construction types, people characteristics and hazard types. Unless the construction types substantively change or people's characteristics change, the damage functions will be re-usable for future risk assessments. Each damage function developed for a new structure type can be added to the damage function database. Since most Canadian cities use the same construction types and have similar people and social conditions, it is possible to share the same damage function dataset across the country. It is for this reason that other risk assessment tools have successfully used Hazus-MH damage function database.

Priorities

Your municipality will have priorities for addressing hazard risk. They would have previously been identified by most communities in British Columbia as part of their HRVA (Hazards Risk and Vulnerability Analysis). According to Section 2.1 of the British Columbia Emergency Management Regulation, these HRVAs assist the British Columbia Emergency Program who:

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[13] FEMA. 2014. *Methodology for Estimating Potential Loss from Disasters*. United States of America, Federal Emergency Management Agency, Online access at FEMA, Hazus pages.
[14] Ulmi, M, Wagner, C L, Wojtarowicz, M, Bancroft, J L, Hastings, N L, Chow, W, Rivard, J R, Prieto, J, Journeay, J M, Struik, L C, Nastev, M, 2014. *Hazus-MH 2.1 Canada user and technical manual: earthquake module.* Geological Survey of Canada, Open File 7474, 245 pages, doi:10.4095/293800
[15] HVRI. 2013. *Social Vulnerability Index*. Hazards & Vulnerability Research Institute, Department of Geography, University of South Carolina, Columbia, South Carolina 29208, Online access, University of South Carolina, keywords "hvri, sovi_32".
[16] Dunning, C. M. and Durden, S. 2013. *Social vulnerability analysis: A comparison of tools*. U.S. Army Corps of Engineers, Online access, Document name "Social_Vulnerability_Analysis_Tools.pdf"

"… must

(a) prepare and maintain a hazard, risk and vulnerability study that identifies potential emergencies and disasters that could affect all or any part of British Columbia, …"

In addition to priorities for managing risk, the municipality would benefit by having a list of what it feels and determines is the most important to protect (for example: lives, schools, hospitals, public works yards, trees). The municipality would set maximum levels of risk it would accept for each protection priority. It would focus its risk assessment to ensure it understands the risk each faces. It would use that understanding to design mitigations that would achieve acceptable levels of risk.

How to get what you need and share it:

Ranking priorities based on hazard risk is a community affair. It requires a dialogue with the community about what it considers most important for protection: physical, social and operational. The dialogue has a minimum of two parts. The first part establishes the protection priorities and the second part establishes the degree of risk the community would accept for each of those priorities for each of the most threatening hazards.

Designing the dialogue can be done with responsibilities divided between those who design how to meet with the community and those who design how to have the conversation. Engage known and respected members of the community in the process. Share between these groups consistently to ensure each understands the information needs and impacts of the other. For those who design the conversation, consider two methods: one is map based and the other is concept based.

The conversation over maps gathers information about place based priorities. They may be such things as monuments, factories, social service sites, specific lifelines and community meeting areas (e.g. plazas, parks, a special tree). Support this conversation through a brainstorming session with maps large enough to easily pinpoint specific sites and charts to record the intent behind each proposal. Follow that with opportunities to set priorities. Using the sticky dot voting method[17] usually works well to highlight shared interests for follow-up.

The other conversation gathers information about concepts such as economic continuity, people's lives, transportation, homes, services, security and the like.

[17] Many references to the technique exist on line. Another alternative is electronic in-room polling or clickers. They provide degrees of yes or no and give information about polarity of choices. The sticky dots and the clickers require significantly different logistics.

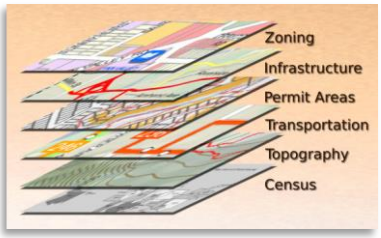
Although linked to the impact of the hazard on physical things, these give the community a sense of how to set priorities for protecting those things. For instance, it may be that above all else it is important to ensure the least deaths and injuries. That could be accomplished by minimizing the amount of time a person would be in a hazard zone, or by reducing the vulnerability of structures exposed to hazards, amongst many other ways. Charts are useful to record the brainstorm idea topics and their reasons for priority. Set the list of topics in priority order through some sort of voting. The sticky dot voting method would work well[17].

Once the list of priorities for safety is set, the level of acceptable risk should be set for each. For example, the District of North Vancouver decided, through community consultation, that landslides should not pose more of a risk to life than 1 in 10,000 for existing situations and 1 in 100,000 for new developments or significant renovations. In this case they decided that lives were their number one priority and set acceptable limits of risk for people exposed to landslide hazard. They may have accomplished the intent if they had ensured that all structures and infrastructure exposed to landslide hazard must be able to withstand a landslide for 1 in 100,000. These levels of acceptable risk are referred to as the "risk tolerance". Risk tolerance could be measured in other ways. For instance, for potential infrastructure losses from flooding, the community could accept annual losses of 0.00005% of annual community revenue. In addition to lives and revenue, other examples for measuring risk tolerance include degrees of: damage, structural integrity (e.g. building frame must remain intact), supply chain functionality, emergency services continuity, cultural heritage and recovery time.

A Risk tolerance measure can be established for any community priority

Once these priorities and the risk tolerances have been set, they should be shared through the community by a mass mailing and with an internet portal or the like. See the following section on communication for concepts and opportunities.

Communication



Communication protocols and tools encompass how the community wants to be involved in hazard risk management and the methods for accomplishing that. Citizen engagement in risk management provides many benefits, and initially, challenges. See Appendix E for support to engage the community in risk management. It summarizes processes and tools developed at Natural Resources Canada (Journeay 2014) and other sources.

How to get what you need and share it:

Begin to develop a **publically accessible library** of all maps, reports, analyses, guides, case histories (stories), decisions, policies, processes that apply to municipal hazard risk management. In other words, build a collection of regional

and municipal government and community hazard and risk knowledge and risk management systems. The easier it is to find and understand relevant knowledge, the more likely that knowledge will be used to make the best decision. Consider whether your library should be both digital and available through the internet and physical (printed copies) to provide community access.

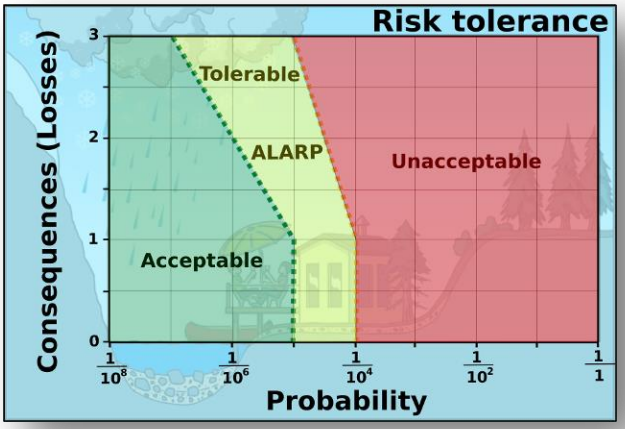
Identify existing **maps** and **mapping tools** – e.g., a community GIS. These are important in order to locate hazards and community assets that could be at risk and to ensure information is up to date and accessible. *Consider where GIS or spatial data is located and how it is accessed. Periodically review and decide how many types of information should be included. How do you make it user friendly?*

Case study

Following a damaging landslide, councillors dictated that future environmental, geo-hazard, soil and any other studies conducted regarding hazards and risks must be fully available to community residents. A volunteer Natural Hazards Task Force comprised of local residents was formed, educated by the community and consulted in hazard and land-use planning decisions. Decisions before council, which concerned hazard risk, were approved more quickly and with less public dissent.

Could, or should, your community appoint a Natural Hazards Task Force? Whom would you recruit to this Task Force?

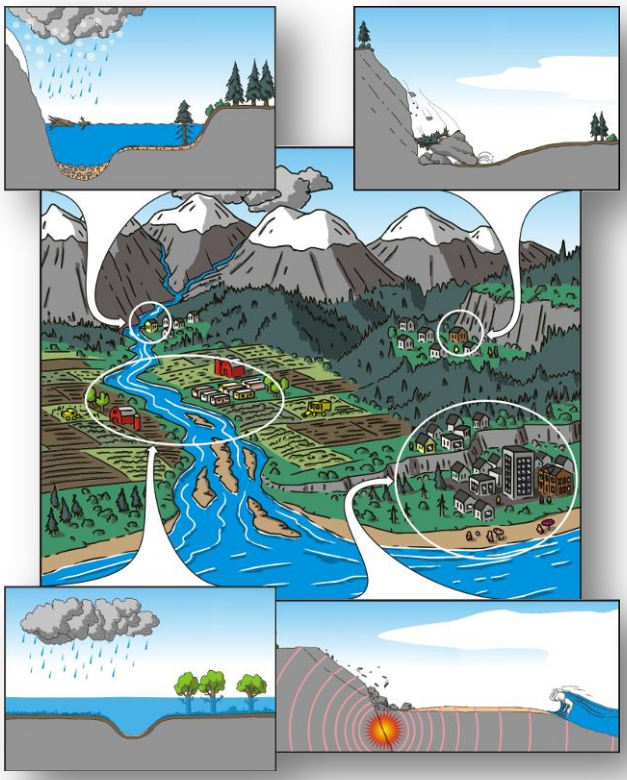
1.3 Define community tolerance for risk for community priorities.



For each safety priority that the community identified in step 1.1, establish the maximum amount of risk the community would accept (Appendix F). In other words, establish how much loss the community would be willing to accept should a hazard event occur. For instance, for potential infrastructure losses from flooding, the community may accept annual losses of 0.00005% of its annual community revenue. In the adjacent diagram a sample risk tolerance graph shows that such consequences (losses) are plotted against the probability of those losses. In the sample graph the units of consequence would vary depending on the priority. If the priority was preservation of life then the scale for consequences would be fatalities and the numbers adjusted accordingly. If the priority was residences, then the scale for consequences would be the number

of destroyed residences. The community decides which parts of the graph have the probability of losses that is acceptable, tolerable (as low as reasonably practical) or unacceptable. Such a graph is unique to each community priority, and in most cases, is unique to the hazard.

Porter[18] describes an approach to establishing risk tolerance criteria in a report on the District of North Vancouver's evaluation of their landslide risk. Porter and Morgenstern[19] describe landslide risk tolerance criteria within the context of landslide risk evaluation. Dercole[20] reports on development of the risk tolerance criteria for the District of North Vancouver.



Step 2. Define hazard potential

2.1 Identify hazards of concern.

Make an inventory of all possible hazards in your community. From the hazard inventory, make a short list of the hazards that most threaten the community. This includes natural hazards that have not created an historical event, such as large earthquakes that may occur every 800 years, and which have scientific evidence of being a threat to the community. It includes potential of industrial and other accidents.

The short list is used to set priorities for managing hazard risk.

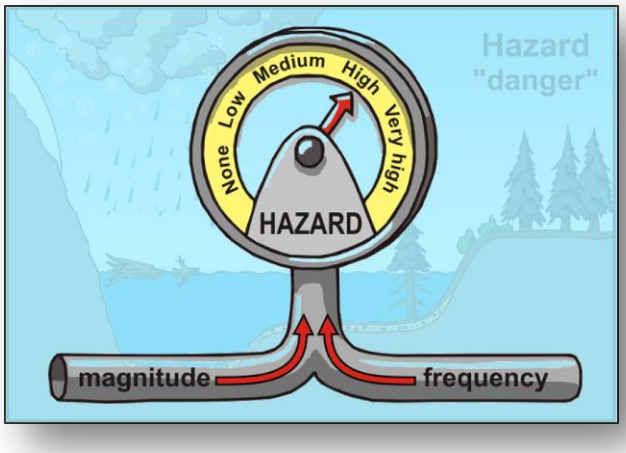
Gather the information through facilitated community workshops, focus groups, and hazard experts. They should all be involved in creating the hazards inventory. Appendix E provides examples of tools that can be used to support such community engagement. It may save time for the community to examine the full suite of hazard risk information in the series of meetings (hazards, exposed

[18] Porter, M. 2006. *District of North Vancouver Berkley landslide risk management: Phase 1 Risk assessment.* Internal Report, District of North Vancouver, 56p.
[19] Porter, M. and Morgenstern, N. 2013. *Landslide risk evaluation: in Canadian technical guidelines and best practices related to landslides: a national initiative for loss reduction.* Geological Survey of Canada, Open File 7312. 21p.
[20] Dercole, F. 2009. *Natural Hazards Risk Tolerance Criteria*; Report to council, District of North Vancouver, File: 11.5225.00/000.000, November 10, 6p. Online access. Copy available in Appendix F of this guide.

assets, vulnerabilities, and potential consequences). Appendix E provides an example of how this was done in the District of Squamish in 2007.

As a guide, use a list of all possible hazards[21] (Appendix K) to create the hazard inventory and your short list of concern. Rank the hazards in your short list by their perceived risk to the community. Consult hazard experts for their suggestions. The ranking may change when actual risks are calculated.

2.2 Assess the potential that events from such hazards will occur.



For each hazard of concern, determine how probable it would be for an event of a certain magnitude to occur (a hazard assessment). Use the hazard assessment to define the hazard scenario that would be used in risk calculation.

Hazard assessment and making a hazard scenario are best done by hazard specialists. How comprehensively they are done depends on which risk assessment method will be used. Hazard assessments and scenarios can be imagined and calculated by experts. Where risk assessment is part of the long term hazard risk management, it is more consistent and efficient to use calculated assessments and scenarios.

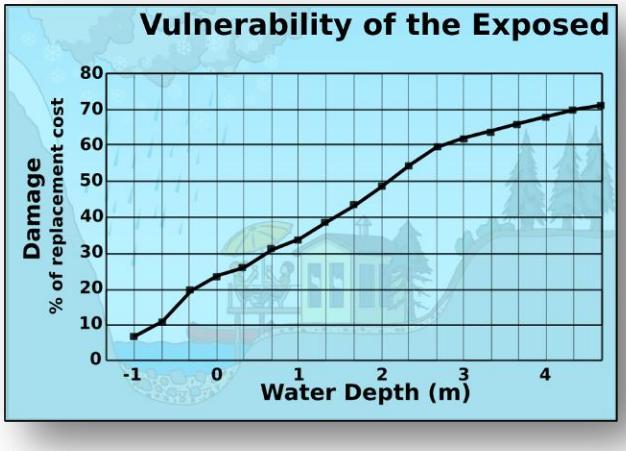
Using floods as an example: It is possible to calculate the probability that a certain maximum flood height will occur. Based on that flood height it is possible to calculate the extent of that flood water. Using that map of flood extent, the height of flood water and the elevation of the ground covered by the flood water, it is possible to create a map that everywhere shows the depth of flood water. That map of potential flood water depth (flood depth grid) is the flood hazard scenario.

[21] PEPBC (2003). *British Columbia Hazard Risk and Vulnerability Analysis Tool Kit*. Ministry of Public Safety and Solicitor General, Provincial Emergency Preparedness, Victoria: Queens Printer, 62p

Step 3. Identify what could be harmed.

3.1 Identify people and things exposed to the hazard and that could be (Appendix L, exposure).

Information about those people and things that would be exposed to a potential hazard event can be derived from a map of their distribution in your community. Include critical infrastructure and identify demographic data (e.g., ages of residents). Include information about each asset relevant to calculating the risk. *You may already have such an inventory in a GIS database used for community management. Consider your environmental assets.*



3.2 Determine how vulnerable to harm those people and things are in a hazard event (Appendix M, vulnerability).

This is a complicated part of determining potential losses and risk. This has been done for a few hazard types for North American buildings and infrastructure, and somewhat for people. Vulnerability is the potential for a life (people included) or an object (buildings, infrastructure and other things) to be harmed or damaged to some degree during a particular type of event. For example, what damage would a 2 story wood-frame house built in 1990 in British Columbia suffer if flood water were to reach 1.5 metres above the floor of the first level and stay there for 2 days? That probable damage is the vulnerability of such a house to flood water of that type. Examples for flooding in British Columbia are described by Church et al.[22]

[22] Church et al. 2012. *Professional practice guidelines – legislated flood assessments in a changing climate in BC.* Association of Professional Engineers and Geoscientists, 144pp.

Case study

As a research project to understand the earthquake risk for a large metropolitan centre, government and academic researchers, in partnership with local municipalities, amassed information needed to determine the exposure and vulnerability of the built environment. They created a GIS database of the location of each structure. For each structure they collected information about its construction that was pertinent to understanding its vulnerability to seismic shaking. For buildings, they collected information such as the structure's age (necessary to understand which building code would have applied at the time of construction), materials (wood, concrete, steel, brick, etc.), number of stories, and square footage. For roads, pipelines, bridges and power and water distribution centres they collected information such as their age, material of construction, and size. Each of these pieces of information was assigned as attributes to that structure in the GIS database.

That information about the construction, and construction history, of the structure could be plotted on graphs that would show how much the structure would be damaged under certain seismic shaking. That damageability is the vulnerability of that structure to a certain seismic shaking. For certain hazard types, software is available that already contain those damage functions, which measure the vulnerability.

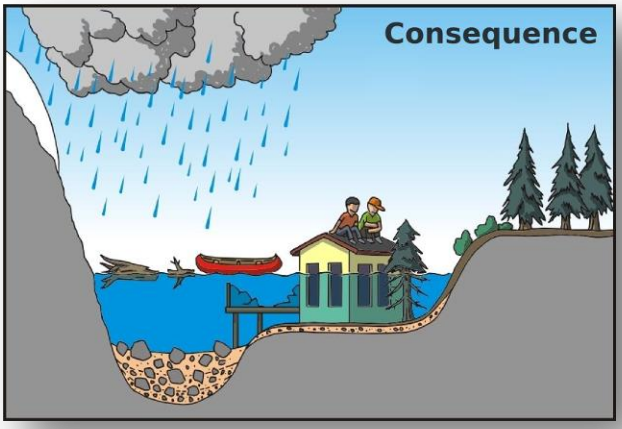
In that project, those researchers relied on the national census data for information about the distribution and nature of people throughout the municipalities. They used that Information in conjunction with existing tools that describe the fragility of people living and working in a city exposed to seismic shaking and in general for multi-hazard situations.

Those exposure and vulnerability databases and tools are now part of the partner municipality's on-going GIS capacity.

Step 4.0 Calculate potential losses

4.1 For probable hazards of concern, determine their probable consequences (amount of harm and safety).

> The consequences will be what happens to the people and things exposed to the hazard event. Those consequences are the potential losses.



Team members

Do they have expertise in the subject proposal?

Could they have governance, regulatory authority, or might they be affected by the proposal?

Such a loss determination is one step in a full risk analysis. The losses are those created by a particular hazard event (a model or real hazard scenario) that impacts people and things exposed to features of the event. The losses are therefore the potential losses from such a potential event. The measure of the loss potential is the combination of the potential of the event occurring (e.g. 1 in 100 years), the potential of the exposure and the potential of the vulnerability being realized. A rigorous risk assessment would calculate losses for multiple events of various potential.

4.2 Evaluate and interpret the risk assessment outputs to determine if they are realistic and useful.

The outputs are only as good as the data that is used for the determination and the quality of the assessment tool. No system is perfect. It is important to understand the flaws and how they influence the outputs. The usefulness of the outputs depends on the strength of that understanding.

As a simple example – if only the residential buildings in an area have their risk assessed then the risk assessment says very little about the risk to the business sector. It would, however, say a lot about the potential for losses to a large proportion of the community assets.

What to do and How to do it

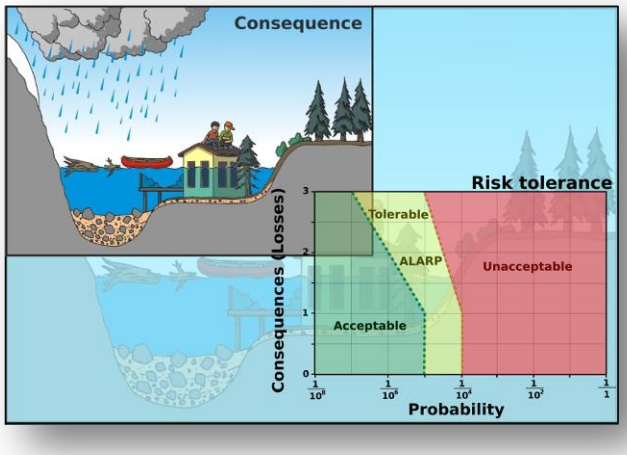
1. Determine the hazard from your hazard inventory for which you would like to determine the risk. For that hazard, determine the hazard scenario or scenarios you will use. You may wish to use a probabilistic scenario instead of one, or more, deterministic scenarios. A hazard specialist can help determine which scenarios are of value to address your particular risk concern. In this exercise it is expected that you will estimate the risk for the entire community. Therefore you will be using information about **all community assets and populations exposed to the hazard**. *These are what are at risk.*
2. Various tools exist to calculate hazard risk or the elements of hazard risk. The more quantitatively rigorous the tool, the more the outputs will be reproducible. Reproducible results are more transparent and therefore more easily defensible. Such tools require a large setup investment. They pay that back because it is easy to re-run the risk calculations with different hazard and asset input data. Ease of re-running the risk calculation permits efficient evaluation of risk mitigation options. The more

qualitative the tool, the less reproducible the results and the more difficult the calculation re-run. Most qualitative tools are based on the Delphi method. Appendix J describes the nature of risk assessment tools, provides examples and lists resources. With the risk calculation tool determine the areal extent of potential losses your community could suffer (the disaster scenario). The **disaster scenario derives** from the measures of potential losses from a hazard scenario affecting the community's people and assets. Loss measures can include life and injury, property damage, environmental damage, economic disruption, etc. The hazard scenario and exposure inventory are shown as maps and the disaster scenario is most useful when displayed as a map of potential losses. Because your result should be reproducible to be defensible for policy decisions, it is best to use a quantitative or rigorous qualitative risk analysis tool and to use a subject matter expert. A quantitative tool like HAZUS-MH will provide detailed maps and reports of the distribution of losses from earthquakes, floods, storm surges and hurricanes. A team of experts can create qualitative hazard and vulnerability inputs and through their analysis mimic the calculations done by programs such as HAZUS.

Step 5.0 Recommend safe land-use

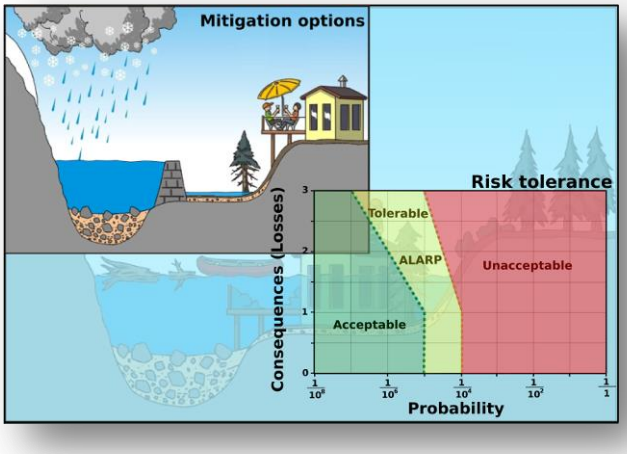
5.1 Evaluate if potential losses are acceptable.

This exercise compares the potential losses calculated for a particular hazard scenario to the losses that the community said were acceptable for such a hazard, as determined in step 1.3. This task determines if the community would tolerate the potential losses: in other words, would they find them acceptable.



5.2 If necessary, determine how to reduce potential losses to acceptable levels.

This activity tests ways to reduce the potential losses to acceptable levels. Those ways may include design changes to the development proposal to reduce vulnerability and exposure, and reducing the hazard. The hazard could be reduced by controlling the

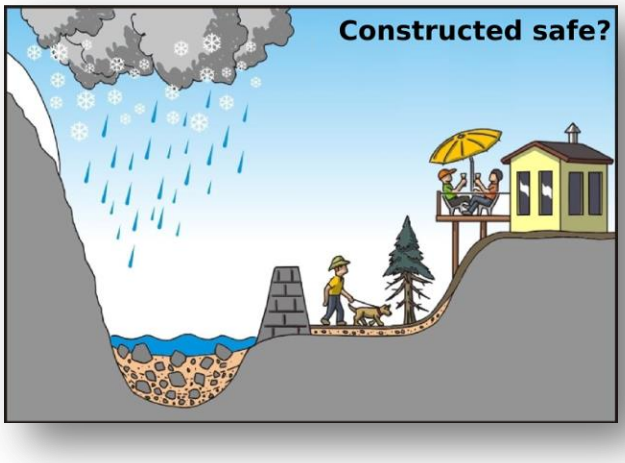


recurrence interval and magnitude of the hazard.

5.2.1 Identify **tools to manage risk (Appendix N)**. Establish how to use your collection of area-specific land-use tools to manage the risk you've identified. For example; in the figure associated with step 5.2, several land-use options are identified to manage mountain stream flooding. A levee is considered to hold back a 200-year flood, the flood plain is set aside for low-exposure use such as a park, and the housing is built on the bank above the flood plain.

Agree on how you manage possible risk transfer. Evaluate the local and regional laws and regulations and their application for risk mitigation. Do you need a new policy?

5.2.2 Make a development recommendation that has acceptable risk. Using the risk assessment tool, the suggested mitigated hazard, exposure and vulnerability scenario can be evaluated to determine if its risk is acceptable. If it is acceptable, then that land-use and structural mitigation for the development proposal could be recommended for approval. Stronger or weaker mitigation proposals could be developed and recommended. Risk reduction methods are not unique to particular developments, nor are presently accepted methods the best or worst. Each is worth evaluating on its own merit.

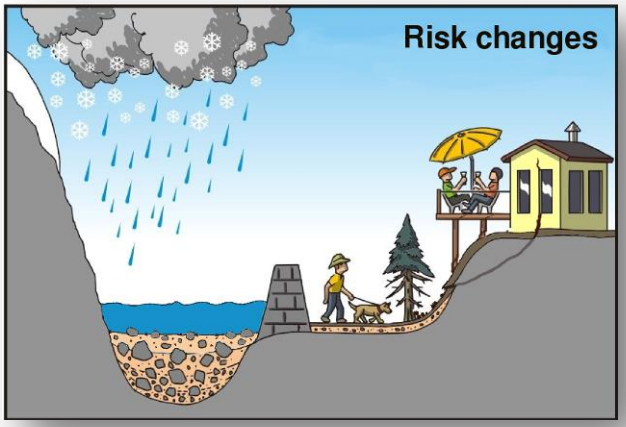


Step 6.0 Monitor decision success

6.1 Is the risk acceptable when developed is completed?

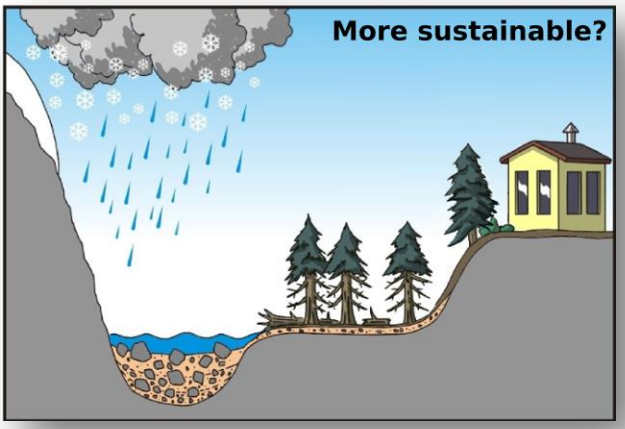
Inspections and evaluations would find out if the completed development is actually as safe as planned. For instance: have the mitigation choices been successful and has the hazard been changed by the development (Appendix O)?

6.2 Is risk still acceptable years after development?



Through an inspection and evaluation process conducted regularly every 5 to 10 years, find out if the hazard, exposure and vulnerability of the development have changed and increased or decreased the risk. Such evaluations can be done as a one off, as systematic neighbourhood drive-throughs, as citizen reports to an online site, as contracts, summer engineering-student tasks, research projects or some combination of these or other ideas. The idea would be to concentrate in areas of known hazard risk and for projects that had recognizably diverse and potentially controversial mitigation decisions. Mitigation works such as retaining walls may have weakened, been plugged, become blocked or otherwise become ineffective, increasing the hazard (e.g. raised creek bed behind the dike of illustration 6.2 of Fig. 2). A new hazard may have been created (e.g. slump on the side of the bank of illustration 6.2 of Fig. 2). The structure many have been renovated in such a way as to increase its vulnerability to a particular hazard.

6.3 What action would have achieved sustainable acceptable risk?



Through the evaluation of the potential changes in the development and its regime, and improvements in science and technology, determine how better to maintain acceptable risk in this or other future developments. Review the full risk management process for better ways to achieve acceptable risk.

Periodically redo the **risk assessment** for your municipality to understand the changes in its risk. Determine strategies for reducing the risk to acceptable levels. Test those strategies by re-evaluating the community's risk based on each viable strategy. Determine if the strategy would achieve acceptable losses based on your risk tolerance.

An evaluation of your existing community risk:

- Allows a community to focus strategic risk reduction planning in higher risk areas;
- Provides a platform for community decisions about disaster risk reduction policy goals, and
- Provides a context for new development given policy goals and strategies for disaster risk reduction.

A historical review will identify any trends of hazard risk. Consider how the implementation of mitigation strategies will affect any risk trends.

If the risk issue is not resolved within the current step then the team needs to go back or flag it for future review. If the risk management strategy is developed it can be used to guide official community plans and establish acceptable risk for individual development proposals.

Case study

The municipal government allows homes to be built in forested areas but the Fire Chief wants to require all new homes to have sprinklers, metal or asphalt roofs and to ensure trees are cleared around the home to *FireSmart* standards. The Planning Director favours publishing guidelines suggesting the above requirements but not forcing anyone to comply as it increases the cost of home ownership and discourages new home buyers from moving into the community. The arborist is pushing for regulations prohibiting the unnecessary cutting of trees.

What would you recommend be done?

Checklist – Section 1

At this stage your community would understand its community-wide hazard risk. It would have a strategy for how to reduce and maintain its risk to acceptable levels. It would have a plan for how to incorporate those risk reduction strategies into its land-use management instruments and the actions of its citizens and stakeholders. It would have decided on tools that it would use to assess hazard risk for its high priority risks. It would be ready to receive development applications and to evaluate their hazard risk within its risk reduction strategies.

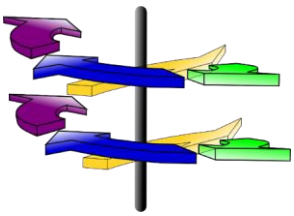
Review the following checklist to evaluate the community's land-use hazard risk management framework.

Setting up the framework is primarily about building local capacity to reduce risk. Building capacity takes time and community investment. It involves all

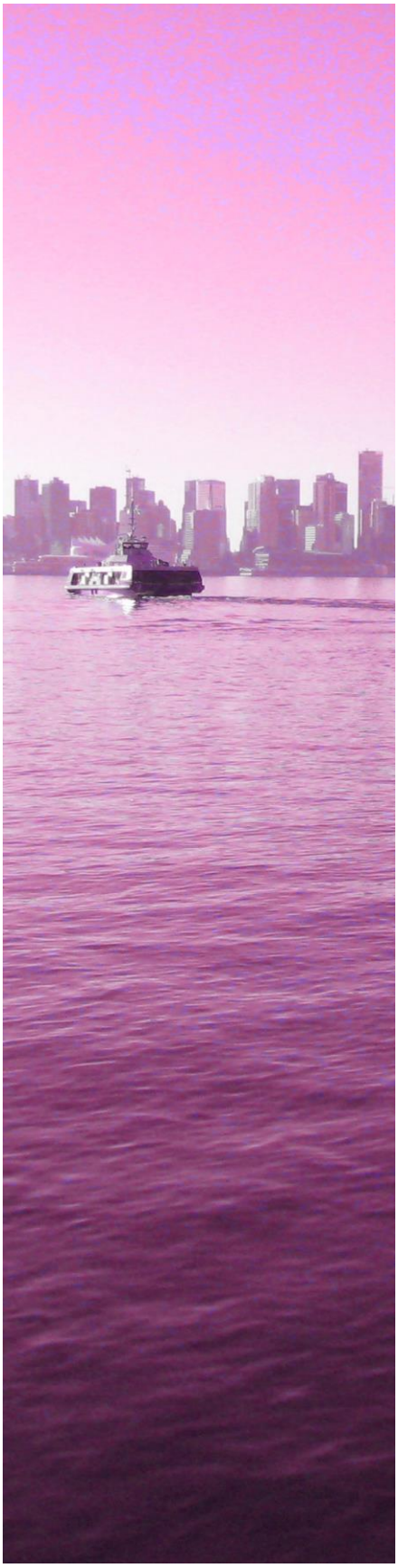
stakeholders, including local leaders, and vulnerable groups. Focus on promoting a participatory approach to risk management strategy and policy development process. These will lead to reduced land-use risk and a more sustainable community.

1. Priorities and knowledge defined and gathered for the risk management framework
   - ☐ Team identified.
   - ☐ Terms of reference and budget are determined.
   - ☐ Preliminary analysis to identify and include stakeholders is completed.
   - ☐ Communication Plan for community engagement is in place.
   - ☐ Collections of documents and necessary resources have been initiated.
   - ☐ A public hazard risk-based resource library has been started.
   - ☐ A plan is developed to link and integrate municipal governance, strategies, plans and practice for hazard risk management.
   - ☐ A preliminary hazard and risk scenario assessment has been developed (See Appendix J).
   - ☐ Risk tolerances have been established for priority hazards
2. Priority hazards were identified
   - ☐ Workshop program and anticipated outcomes developed.
   - ☐ Hazards have been identified and their potential likelihood determined (hazard assessment).
   - ☐ Priority hazards have been identified to set the priority for risk assessment.
   - ☐ Scenarios of potential hazard events have been developed (these may need to be specific to the risk assessment tool that will be used).
   - ☐ Hazard inventory, priority, assessment and scenario information documented, catalogued and made accessible.
3. Community assets and people exposed and vulnerable to hazards were identified
   - ☐ A map of assets and people exposed to the potential hazards has been made.
   - ☐ Relevant data has been gathered about each type of asset and person necessary to determine their hazard vulnerability.
   - ☐ Community institutions and their roles in disaster risk reduction and response have been mapped.
4. Community hazard risk was assessed
   - ☐ Risk assessment tool has been identified and accepted.
   - ☐ Community hazard risk has been evaluated.
   - ☐ Risk assessment assumptions, method and results have been documented, catalogued and made accessible.

5. Strategic action has been taken to reduce identified unacceptable risk to acceptable levels and to maintain those levels
   - ☐ Used the historical timeline of disaster data to understand what social, economic and environmental conditions created existing risk and what could change future risk.
   - ☐ Used understanding of those conditions to develop and assess viable changes to land use and land-use policy that would reduce risk to acceptable levels over time. Developed and decided on risk mitigation.
   - ☐ Instituted those risk mitigation decisions throughout the integrated land-use management framework. For instance: Official Community Plans include risk mitigation criteria processes and criteria that must be met by future development permit applications.
   - ☐ Impacted community groups have been engaged in the evaluation and have access to the results.
6. Monitor risk
   - ☐ Increased community-based risk assessment capability and capacity.
   - ☐ The risk-based resource library has been updated.
   - ☐ Inspection protocols include a checklist to identify changes in the hazard, exposure and vulnerability.
   - ☐ Citizens involved in the inspection process.
   - ☐ Processes in place to use the inspection information to change hazard, exposure and vulnerability conditions so the risk is maintained as acceptable.
   - ☐ Processes in place to use the inspection information to improve strategic and operational risk management.
   - ☐ Community disaster risk reduction institutions recognised.
   - ☐ Community disaster risk reduction institutions supported by local government.
   - ☐ Local government feeds community disaster risk reduction institution discussions into the district and regional plans.



Risk management iteration



Section 2: Evaluation of the Land-use Proposal:

Using the land-use risk management framework established in section 1, assess the risk of individual strategic land-use plans and development proposals.

This section describes how to use land-use risk management to evaluate the safety of a strategic land-use proposal or a development permit application. In this section you primarily use steps 3 and 4 of the land-use risk management scheme - determine the exposure and vulnerability of the development to a viable hazard scenario and assess the risk.

Development Permit Area

A legislative tool used to trigger specific mitigation and scrutiny

From Section 1 of the guide your community would have established an integrated risk management strategy and protocol. It would have information about its hazards, exposure and vulnerability of concern. It would have established Development Permit areas for hazards, and made regulations for development within those areas. The community level risk analysis developed in section 1 provides the neighbourhood hazard risk context to the proposal. It also provides the land-use management framework for operational and strategic decisions about safe development in various parts of the city.

Guidance for evaluation of the proposal comes from answers to the following questions

- Does the proposed plan or development have the relevant information for a hazard risk assessment?
- Does the community have all the relevant knowledge and tools in place to evaluate the proposal's risk?
- Are subject matter experts available within the team or does the necessary knowledge exist in the developed resource library?
- Does the land use proposal fall in a **Development Permit Area** (DPA) or designated hazard zone and if so at what level of hazard potential (DPA sub-area)?
- Does the proposed development design meet the existing mitigation options for the area's hazard?
- Is a full risk assessment required?
- Is the risk of the land-use proposal within acceptable levels for the safety for your risk tolerance priorities (e.g. life, protection of property, socio-economic stability and emergency management)?
- Does the development design protect and support vulnerable populations within the hazard area?

What to do and How to do it

1. Document and share the process. Good documentation:
   1.1. Provides transparency.

1.2. Increases community hazard risk awareness.
1.3. Increases efficiency of future evaluations.
1.4. Supports risk management improvement decisions.

2. Determine that you have all the information needed for an evaluation of the land-use proposal's hazard risk
   2.1. Does the proposal have enough information about the exposure and vulnerability to the existing hazards of its assets and users?
   2.2. Do the necessary hazard assessments and hazard scenarios exist? – If not, does the proposal warrant conducting a quantitative or qualitative hazard assessment that can be used r to estimate the hazard risk?
   2.3. Are the infrastructure requirements adequately understood - e.g., access/egress, sewer, electrical, water, communications, emergency services, business continuity plans?
   2.4. Would the development transfer risk by changing surrounding hazard, exposure and vulnerability?

3. Apply the community risk assessment methods to determine the hazard risk
   3.1. Determine if your quantitative or qualitative methods should be used.
   3.2. Can a hazard event consequence be determined from the measures of hazard, exposure and vulnerability at hand? If not, then what more information or expertise is needed?
   3.3. Calculate the estimated losses for each chosen hazard scenario, including damage, replacement costs, business disruption (including estimation of the length of time of disruption), injuries and losses of life. The estimated loss from each hazard scenario, the consequence scenario, can be plotted on a probability graph to create a risk profile.
4. Establish which of the consequence scenarios calculated in 2.3, the community wants to use to set policy and make development land-use decisions
   4.1. The community would then determine if the losses of that consequence scenario are acceptable according to its risk tolerance criteria.
5. With stakeholders and affected public establish their perceptions of the risk of the land-use proposal, and deal with the variance from the calculated hazard risk
6. It's important that the evaluation team reach consensus on the result of the hazard risk analysis. The results are used to determine potential mitigation options. Determine which factors led to disagreement and modify if appropriate (e.g., hazard scenario, exposure, vulnerability, consequence calculation method)
7. Consult with key people and communicate public awareness information on the data and evaluations to date. Perceptions and opinions may change as the

proposal and consequences become better understood. Document and record these opinions for use in the recommendation and improvement phases.

8. Determine if the probable losses estimated from the hazard scenario of choice are acceptable, tolerable or unacceptable by community regulation (in other words is the proposed development safe for intended use based on community law and policy goals).

Your risk analysis should provide estimates of the potential losses. Measures of loss should describe the full range of social and economic impacts of a potential disaster. Consistent measures of potential loss from a hazard event can be used to compare each different disaster scenario you have calculated using distinct hazard scenarios. Measures of losses and pre-existing conditions can be collated in various ways to reflect and evaluate the community's policy goals.

As example, the table in Appendix R shows how eighteen measures are used as indicators of six policy goals within social, economic and environmental sustainability from the risk reduction perspective. The indicators provide a succinct way to display and talk about the goals of the community in moving from a potentially high hazard risk present state to one of acceptable risk. Strategic and operational mitigation options to achieve those policy goals can be more clearly articulated and discussed using a subset of the measures of potential loss.

A graph of the indicators derived from the various disaster scenarios describes the risk profile of a hazard. A risk profile describes the range of potential consequences derived from the range of potential scenarios of a single hazard type. Such a graph is used to evaluate mitigation options. NRCan and the District of Squamish used such a method to evaluate strategic planning options for the District of Squamish Growth Strategy[23].

Expected results

- An estimate of the probable consequences (risk) to the community of the proposed land-use as measured by the cost and benefit that include impacts on people, property, economic, social and environment and is defendable.
- Stakeholder perceptions and opinions are understood, recorded and dealt with, for example: the risk analysis may need to be recalculated based on results from sharing stakeholder and public knowledge and vice versa, knowledge from the planning team following a meaningful dialogue.

[23] Journeay, J.M. 2014. *Disaster Resilience by Design: A framework for integrated assessment and risk-based planning in Canada.* Geological Survey of Canada Open File 7551, 336p.

- Consultations and presentations are communicated in formats understandable by the stakeholders.
- Risk information, including hazard scenarios, asset and people inventories, exposure, and vulnerability to hazards are added to the resource library.
- The proposed development is determined as safe or not safe for intended use, and has acceptable levels of risk of damage.

Case study

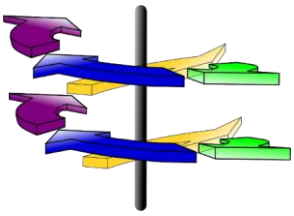
The municipal government proposes reconstruction of a community centre in a neighbourhood built on a flood plain protected by 49 year old dikes that are designed for the 1:100 year flood level established in 1955. The present community centre is one story and has its main floor at ground level. The centre has a gymnasium, fitness facility and meeting rooms. The proposed redevelopment would modernize the existing services on the ground floor and add meeting rooms on a partial second floor. A second proposal, 50% more expensive, would completely rebuild the centre, elevating the facilities above the 1:500 year flood level, which would make the ground level open and used for parking.

How would you evaluate the options and what information would you need?

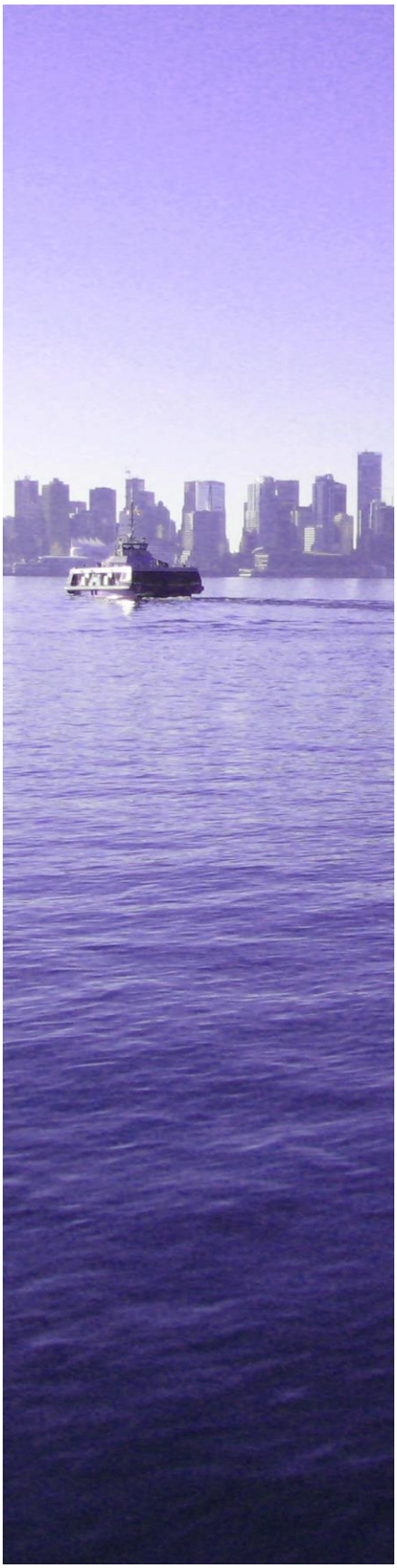
Check list

- ☐ Has the team agreed they have sufficiently accurate and complete data, and the required knowledge to make its decision?
- ☐ Have the probable losses been calculated (also referred to as the probable consequence or disaster scenario)?
- ☐ Has the team established the probable consequence scenario that they will use to evaluate against the community risk tolerance?
- ☐ Has the degree of variance from the community's level of risk tolerance been calculated?
- ☐ Have stakeholders within the community been adequately consulted?
- ☐ Has the team's analysis been endorsed by stakeholders?
- ☐ Have all formal reports and presentations been developed (interim reports document significant activity, decisions and agreements related to the project: project scope, asset valuation, risk estimation/consequence risk evaluation)
- ☐ Is there a record of all the interim reports, details and recommendations from the hazard analysis, risk mitigation, and supporting cost/benefit analysis tasks?

- ☐ Is there a report with approved recommendations, that provides responsible hazard risk management with a sound basis for subsequent risk management action and administration
- ☐ Has the resource library been updated?



Risk management iteration



Section 3 Land-Use Recommendations:

Recommend appropriate actions to achieve the safest use of the land. Base the recommendation on tested mitigation actions that will reduce the calculated hazard risk to the levels accepted by the community, as portrayed by the community's risk tolerance criteria.

This section focuses on how to use results of the risk analysis to develop recommendations for proceeding with the land-use plan or development proposal. If the proposal has acceptable risk, and does not increase the risk in the surrounding area, then it can be approved as safe for the intended use. If the proposal's risk is unacceptable then mitigation options can be offered or requested to reduce any identified risk to that of the community's acceptable level of tolerance. This section is based on step 5 of the land-use risk management scheme.

- What do you do when the proposed development has acceptable risk?
- What do you do when the risk is unacceptable?
- What are possible options for mitigating a risk?
    - control exposure of development(e.g., density transfer)
    - decrease existing vulnerabilities - for example:
        - raising building living spaces above flood plains,
        - stabilizing lifelines in liquefiable seismic zones,
        - adding fireproofing materials to buildings exposed to wildfire
    - control the hazard (e.g. divert debris flows, dewater liquefaction zones, bolt rock faces)

Control exposure
Decrease vulnerability
Control the hazard

- What process is in place to identify existing local mitigation strategies?
- What process is in place to identify regional mitigation strategies and to develop them along with other jurisdictions (consider potential situations of risk transfer)?
- What mitigation strategies could be considered? As examples:
    - Hazard mitigation
        - Is there a possibility to hold back and/or pump flood water?
        - Can storm runoff be managed to reduce the consequences of high volume water flow, such as landslide and debris flow damage?
        - Can threatened slopes be stabilized?
        - Can strategies for the safe storage and management of hazardous materials be developed?
    - Land-use mitigation (exposure)
        - Can other areas of land be used more safely?
        - Can land swaps or variance swaps be used to reduce local risk?
        - Can other uses pose less risk to the community?
        - Can access to the site be restricted?
    - Vulnerability mitigation
        - Can changes be made to the structural design of a building to make it resistant to the identified hazard?

- Can changes be made to infrastructure services to increase the resilience of the infrastructure? Consider mitigation strategies that can be easily adapted or modified to account for changes to risk in the short and long term.
- Have you considered embedding risk mitigation strategies into registered covenants?
- Can additional benefits be achieved through variance trade-offs?
- Has the regional and long term impact of mitigation strategies been evaluated to ensure that the risk is not transferred elsewhere – either based on the place or into the future?

What to do and How to do it

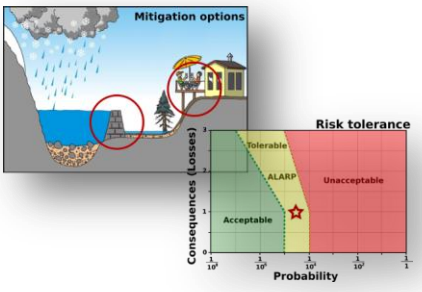
Step 5.1 Evaluate if potential losses are acceptable.

Compare the potential losses calculated for a particular event to the losses that the community said were acceptable for such an event. This task determines if the community would tolerate such losses, in other words, find them acceptable.

1. Where the risk is acceptable, pass the proposal to the next stage of the evaluation procedure with the recommendation that there is "no further necessity for risk remediation."
2. Where the risk is unacceptable, identify and recommend feasible and cost-effective measures that reduce and maintain the risk to acceptable levels.

Step 5.2 If necessary, determine how to reduce potential losses to acceptable levels.

Test ways to reduce the potential losses to acceptable levels. Those ways may include design changes to the development proposal to reduce vulnerability and exposure, and reduce the hazard. The hazard could be reduced by controlling the severity of the hazard.



1. Identify modifications to the proposal that could reduce the potential hazard consequences of risk
2. In addition to possible land-use and structural modifications, consider measures of risk management such as setting inspection intervals, monitoring criteria, additional planning e.g., emergency preparedness, response and recovery planning

3. Evaluate whether the costs of mitigation generate sufficient benefit for each possible consequence scenario
    3.1. Each mitigation option to the development proposal can be evaluated using the risk analysis tool and the potential reduction in estimated losses compared to the cost of mitigation and to the community criteria for acceptable risk
4. Work with stakeholders to evaluate their perception and acceptance and deal with the variance
5. Evaluate implementation costs for recommendations as they should be cost effective
6. Larger developments or proposals with larger potential consequences, could require elaborate implementation plans from which recommendations can be made

Step 5.3 Make a development recommendation that has acceptable risk.

1. From the tests of ways to reduce the potential losses (and thereby the risk), the optimum mitigation options are recommended.

Expected results

- Feasible recommendations have been agreed to
- Where required, a modification plan is developed
- A cost-effective mitigation implementation plan is developed where necessary
- Stakeholder groups have accepted the recommendations

Checklist

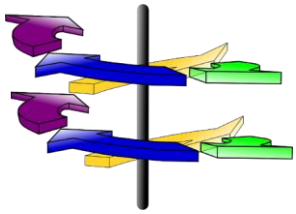
- ☐ If it has unacceptable risk, which practical mitigation options could make it acceptable?
- ☐ Which of those mitigation options has the most benefit for its cost?
- ☐ Has a feasible mitigation implementation cost been developed and agreed to?
- ☐ Has the resource library been updated?
- ☐ Have recommendations been agreed upon by stakeholders?
- ☐ Has a comprehensive implementation plan been developed and is it ready for distribution?
- ☐ Have all formal reports and presentations been developed documented community and municipal government officers increasing the awareness and potential impact of risks to the organisation?

- ☐ Interim reports, details and recommendations from the hazard analysis, risk mitigation, and supporting cost/benefit analysis tasks. This report, with approved recommendations, provides responsible hazard risk management with a sound basis for subsequent risk management action and administration. Cite Council officers' research. Reference any relevant legal requirements and restrictions (e.g. Emergency Management Act, Public Safety and Emergency Preparedness Act)

Case study

A rural, outlying area was originally established as a summer vacation home location. Over the years as the urban community grew and real estate prices soared, nearly all residents were now living permanently in these enhanced dwellings. The area was not well serviced, susceptible to numerous hazards including rising ocean levels and wildland fires. Existing emergency services are unable to meet the needs of residents and owners of undeveloped lots push for development variance permits.

How would you evaluate the application proposal for a large beautiful home to be built in this area?



Risk management iteration

Section 4: Decision Monitoring and Risk Reduction

Ensure the safe development decisions stay safe over the life of the development. Improve community land-use risk management by incorporating the lessons learnt from the on-going monitoring.

Monitoring is integral to effective risk management. People, structures and hazards change. Those changes can increase or decrease risk. Regular monitoring of assets and people at risk provides pro-active opportunities to maintain safety and sustainability.

Monitor the decision: use the guide to implement a protocol to sustain continuous improvement of land-use risk management. This includes systematic hazard risk monitoring. Some questions that could be asked include the following:

- How often are inspections conducted and should this timeframe become policy?
- What happens to the information gathered from the inspections?
- Should existing strategic plans be reviewed at the same time to include planning developments?
- Which elements of the hazard, the exposure and vulnerability of the assets and people who use those assets would be critical to monitor?
- Can the inspector's information about those elements be used to recalculate the hazard potential and risk?
- How would you manage the monitoring protocol?
- How would you manage any resulting re-evaluation to municipal land use planning protocols and policy for better evaluation of land-use risk? How would you recommend those changes be made?
- What advantage derives from implementation of a monitoring team?

Inspection: inspect the development a year after it was completed looking for site specific and neighbourhood variance from the plan of its exposure and vulnerability to probable hazards. Such inspections are meant to review the land-use decisions made to reduce hazard risk. Periodic inspections in 5 to 10 year intervals thereafter consider the following conditions that would require remedial action.

- Have any mitigation strategies become redundant?
- Evaluate if the risk control measures are effective or ineffective. How would you measure this and what action would need to happen?
- Did implemented mitigation transfer risk? Consider re-assessing the hazard in the areas where it may have been altered because of the mitigation.
- How would the findings be incorporated and implemented into recommendations to improve risk reduction and risk assessment methodology?

- Should intent statements and prescriptions in the development's risk mitigation strategy be redesigned?
- Can you determine any process and/or policy improvements based on your findings?

What to do and How to do it:

1. Monitor hazard risk
   1.1. Establish a hazard-risk monitoring process integrated with other inspection systems. These would include reviews of city operated infrastructure and mitigations.
      1.1.1. Set community hazard-risk monitoring principles such as:
         1.1.1.1. Transparency of monitoring schedule and outputs (public reporting).
         1.1.1.2. Systematic inspection schedule.
         1.1.1.3. Special inspections triggered by hazard events.
         1.1.1.4. Community engagement (with monitoring and awareness).
         1.1.1.5. Increases in observed risk are met with actions to achieve acceptable risk.
      1.1.2. Set implementation priorities.
      1.1.3. Align implementation plans to existing mitigation plans and implementation as recorded in strategic and operational documents.
      1.1.4. Consider if any timing elements for implementing monitoring schedules and controls are necessary.
      1.1.5. Establish and set dates for monitoring and inspections in as reliable a mechanism as possible.
      1.1.6. Identify any and all expert and professional requirements.
      1.1.7. Submit the plan for approval
      1.1.8. Create an inspection checklist for each development.
         1.1.8.1. Each item on the list would be one of the mitigation criteria set in the land-use approval
         1.1.8.2. Additional items include re-evaluation of the hazard, the exposure and the vulnerability findings from Step 2-5.
      1.1.9. Review and update the outline for the implementation plan.

2. Maintain acceptable risk
   2.1. Use the conclusions about the hazard-risk changes as discovered through monitoring inspections to inform actions to achieve acceptable risk.
      2.1.1. Share these publicly to provide neighbouring communities the opportunity to accelerate their risk reduction based on your lessons learnt. Their risk is interconnected with your risk.

2.2. Establish principles for the incorporation of hazard-risk inspection knowledge into strategic and operational plans for land-use safety.
    2.2.1. For instance, a schedule for achieving acceptable risk may involve many years of living with higher risk, depending on community priorities and risk tolerance.

3. Improve land-use risk management
    3.1. Collaborate with other communities with similar developments for possible lessons learnt.
    3.2. Based on monitoring of past decisions, determine how existing municipal practices could be improved to achieve acceptable risk.
    3.3. Seek risk reduction principles in legislation and local and regional growth strategies, plans, regulations, etc.
    3.4. Identify and resolve any conflicts between municipal policy, and relevant regional, provincial as well as federal policy (.e.g. Regional Growth Strategy, Official Community Plan, Development Permit Areas).
    3.5. Identify land-use development practices that may adversely impact the municipal government's ability to recover following a large hazard event (e.g. earthquake and aftershocks).
    3.6. Incorporate the benefits of using a risk-based land-use management into the municipal government's mission, objectives and operation.
    3.7. Explain municipal or regional government's leadership role, including their accountability and liability within the risk-based process.
    3.8. Incorporate those improved practices into existing land-use management planning instruments, and create new ones if warranted. Examples:
        3.8.1. The Regional Growth Strategy (RGS)
        3.8.2. Comprehensive Plans (The Official Community Plan), associated Area or Town Centre Plans, Development Permit Areas, and Design Guidelines
        3.8.3. Zoning and Subdivision regulations

Checklist

- ☐ Identify and resolve any conflicts between municipal policy, and relevant regional, provincial as well as federal policy (.e.g. Regional Growth Strategy, Official Community Plan, Development Permit Areas)
- ☐ Review the existing land use patterns to ensure the proposed risk-based land-use management program adequately addresses any gaps or opportunities previously identified

- ☐ Identify land-use development practices that may adversely impact the municipal governments' ability to recover following a large scale hazard event (e.g. earthquake and aftershocks)
- ☐ State the benefits of risk-based land-use plan and relate them to the municipal governments mission, objectives and operation
- ☐ Explain municipal or regional governments leadership role, including their accountability and liability within the hazard risk reduction process
- ☐ Publicly shared lessons learnt to accelerate reduction of the cumulative risk.

Expected results

A comprehensive monitoring process that includes:

- Risk-based targeted monitoring plan submitted for approval
- Plan to engage community in monitoring
- Monitoring and reporting on findings of monitoring
- Additional knowledge, information and resources about field identification and documentation of risk changes are gathered
- Updates made to existing public resource library
- Detailed land-use risk management improvement plan is developed
- A mechanism and plan for distribution and implementation is put into place
- Training opportunities are identified
- An expanded exchange of information has taken place between sectors and communities[24]

Case study

Following a damaging tsunami the community made a decision to remove single-family homes along the ocean waterfront and put in a park and camping ground (there were expropriation costs and reparation of the area to put in camp ground facilities). Recently, in the summer, there was a tsunami warning. Campers ran to their large motor homes and campers to evacuate the area. The one road in and out of the campground was in grid lock. Fortunately, there was no tsunami; however, if there had been a tsunami casualties would have been considerable in

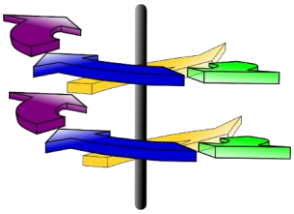
[24] The Corporation of the District of North Vancouver. (2012). *Schedule B: Development Permit Areas.* North Vancouver: DNV.

number as well as the losses due to the value of the vehicles and damage to camping facilities would have been high. The potential loss of lives with the campground in place would have been higher than if the single family homes had been left in place.

What could be learned about assessing the risk?

Checklist

- ☐ For the mitigation component, has an administrative mechanism been established to manage the resulting review data?
- ☐ Is there a mechanism developed for distribution and implementation of the plan?
- ☐ Is a monitoring protocol in place?
- ☐ Has the team agreed upon whether existing strategic plans should be reviewed during the periodic monitoring of approved land use?
- ☐ Has the communication plan been revised to support the implementation plan?
- ☐ Has the risk information library been updated?
- ☐ Is there a detailed improvement plan?
- ☐ Has an inspection timetable been decided and does it include the management of redundant mitigation strategies over time?
- ☐ Has the implementation plan been submitted for approval?



Risk management iteration

Conclusion

This risk-based land-use planning guide is designed to provide municipalities with a tool to help achieve acceptable levels of hazard risk. It provides principles and methods for assessing whether development proposals will help achieve acceptable municipal hazard risk. The guide's land-use focused modification of the national standard for risk management is integrated with locally derived best-practice. It is offered as a land-use risk management process for municipalities. The process shows that hazard risk is determined from knowledge about the hazard, exposure to the hazard and the vulnerability of structures and people exposed to the hazard. The process can be applied municipality-wide and to large and small projects.

The ultimate goal is to reduce costs and consequences for communities that face risk from hazards. This guide has been designed to be a working document and your comments for improvement are welcome.

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Supplement A: Glossary

The following glossary terms are provided in the context of hazard risk

Community inventory	Maps and databases of all community structures and people; everything of value to the community. Completing a community inventory is necessary to determine exposure and vulnerability to a hazard.
Consequence	The result of a hazard event. *Example*: The consequence of the hazard event was that 50 homes were destroyed, 150 homes were 30% damaged, 10 people died, 1000 people were injured, 10% of the business was disrupted and it will take 5 years to repair the damage and re-establish the business at a total cost of $1.5 billion.
Critical Infrastructure (CI)	Public Safety Canada defines critical infrastructure as "processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government."[25] The ten CI sectors are: Health Food Finance Water Information and Communication Technology Safety Energy and utilities Manufacturing Government Transportation
Delphi Method	Collaborative estimating or forecasting technique that combines independent analysis and feedback to build consensus among experts who interact anonymously. The topic under discussion is circulated (in a series of rounds) among participating experts who provide their best interpretation and modify the interpretation(s) reached up to that point ... and so on until some degree of mutual agreement is reached. Also called Delphi forecasting.

[25] Public Safety Canada. (2012). *Critical Infrastructure*. Public Safety Canada Website, Critical Infrastructure.

Deterministic	The probability of a hazard event based on analysis of the factors that create a hazard and trigger an event. *Example:* calculating the hazard potential of mixing two chemicals that when mixed can explode *Example*: calculating the earthquake potential of a known fault that could be moving, and for which an historical record of an earthquake may not exist
Development Permit Area	Legislative tool in British Columbia to designate areas for special development regulations
Development permit area for hazards	Legislative tool in British Columbia to designate an area affected by a specific hazard for special development regulations that mitigate the risk of the hazard
Disaster Resilience	Holistic strength built on low hazard risk and high potential for recovery from a disaster. Can be described as "the ability to anticipate and prepare …to survive and creatively adapt …and to transform to better meet future challenges …while accepting and integrating one's losses."[26]
Disaster Scenario	Description of the estimated or real losses or consequences of a hazard event. *Example:* The flooding in the southern part of the city could leave, or left, farms 3 metres under water.
Exposure	A measure of the amount of a structure or life that could be impacted by a potential hazard. *Example*: parts or all of houses, schools, and livestock on a flood plain are exposed to a potential flood
Hazard	Hazards are threats to humans and what they value: life, well-being, material goods, and environment.[27] Event whose results can cause damage or threaten lives. *Examples*: flood, landslide, explosion, drought
Hazard assessment:	Acquiring knowledge of the nature, extent and probability of a potential hazard.
Hazard identification	The process of identifying and characterizing a hazard

[26] Cox, R. and Pearce, L. (2011). *Disaster Resiliency: A Journey or A Destination?* Presentation at CRHNet, Ottawa.
[27] Harris, R., Hohenemser, C., and Kates. R. 1978. *Our Hazardous Environment.* Environment 20 (7): 6-15; 38-41.

Hazard inventory	An inventory of the location, nature and extent of influence of any potential hazards in an area of concern. Now generally done as a GIS database
Hazard Scenario	A description of a potential hazardous event. *Example:* The low-lying lands along the river could experience up to 4 m depth of flood water
Historic record	A written record of events
Pre-historical record	The geological record of events that occurred before human recorded events
HRVA	Hazard Risk and Vulnerability Analysis tool kit available from Emergency Management British Columbia and based on community stakeholders and expert opinion ratings of the likelihood of a consequence of a hazard scenario.
Loss	An injury or damage to health, property, the environment, or something else of intrinsic value to an individual or community
Mitigation	A structure, device or behaviour that decreases risk over a long term. *Example:* The Red River spill way that diverts the Red River around Winnipeg during a flood and thereby protects Winnipeg from being flooded (up to 500 year flood level) is a mitigation. *Example*: Decreasing access to land exposed to flooding is a mitigation strategy. Hazard Mitigation specifically controls the hazard: e.g. dikes, deflection berms. Risk mitigation controls any aspect of risk; more commonly it is a means to decrease the exposure and vulnerability to the hazard.
Official Community Plan (OCP)	The Local Government Act authorizes the development of Official Community Plans (OCPs) in BC (Sections 875-879 Part 26). An official community plan is a local government bylaw that provides objectives and policies to guide decisions on planning and land use management within the area covered by the plan. OCPs are significant because, after their adoption, all bylaws and works undertaken by a Council or Board must be consistent with the plan. Every OCP will be slightly different but each will address core aspects of a community: Proposed land use and density; Transportation, water and wastewater infrastructure;

	Environmentally sensitive areas, parks and open space; Housing needs and policies; Public facilities, including schools, health care, etc. Neighbourhood character; Social policies; Economic development; Targets, policies and actions for the reduction of GHG emissions. The regulation of development Building and landscape design guidelines.
Probability	The statistical chance that something could happen. *Example:* The flood level of 1m above the bank of the river statistically occurs once every 100 years, or in other terms has a 1 in 100 chance of occurring this year.
Recurrence interval	Also defined as a return period – the expected time that a hazardous event could reoccur. *Example*: the river has flooded every ten years for the past century.
Residual risk	Residual risk – the risk remaining after all risk control strategies have been applied
Risk	Risk = Probability x Consequence The probability of a consequence of a hazard event. *Example:* The risk of a chemical spill at that rail yard killing 10 people, disabling 50 people, injuring 200 people, breaking 20 rails cars and a locomotive, causing evacuation of 20 businesses and apartment buildings, and disrupting the rail and local community business is 1 in 10,000 working days. *Example:* The risk of being killed in an automobile accident is 1 in 10,000.
Risk analysis	Calculation of the risk. *Example*: Calculating the probability of certain consequences and frequency from a hazard event.

Risk assessment	Combined effort to identify and calculate the risk and determine if it is tolerable. Example: Calculating the risk of increasing the population density within a neighbourhood with a particular mix of housing and business types and determining if that risk exceeds community tolerance In some definitions this includes evaluating the risk mitigation options to achieve tolerable risk.
Risk control measures	Some examples of risk control measures include: inspection, monitoring, research, planning, relocation, changed guidelines or standards, mapping, updating emergency plans, developing capacity
Risk identification	The process of finding, recognizing and recording risks.[28]
Risk Information Library	A collection of all information gathered and developed through the risk management process. This includes information on the risks, decisions, stakeholder views, meetings and other information that became a part of the land-use planning strategy
Risk management	A resourced system of policy, risk assessment, and mitigation to ensure risk is tolerable and remains as tolerable. Example: Ensuring an on-going risk assessment includes monitoring changes to the hazard and the exposed structures and people
Risk perception	The significance assigned to risks by stakeholders. This perception is derived from the stakeholders' expressed needs, issues, and concerns. One person may perceive that sky diving is a very risky sport, while another may think the risk is negligible.
Risk tolerance	The amount of risk an individual or community is willing to tolerate. Example: The chances of dying in a car accident in Canada are 1:10,000. Thus those who drive a car accept a risk tolerance of 1:10,000. Example: The chances of dying in a commercial airplane crash in Canada are 1:100,000; thus, those who fly with a commercial airline accept a risk tolerance of 1:100,000.

[28] [ISO 31000:2009, 2.15]

Risk transfer	The process of formally or informally shifting the financial consequences of particular risks from one party to another. For example, insurance is a well-known form of risk transfer, where a resident may pay an insurance premium in order to reduce the financial impact of potential future losses.
Vulnerability	The damage that can occur if a structure or a life is impacted by a hazard event. Example: All the wood, drywall, clothes in the house touched by 3 feet of flood waters needed replacing. So the wood, drywall and clothes were vulnerable to a flood. Example: The persons living in the house that was hit by a landslide were partially buried and had major injuries. The persons were vulnerable to the landslide.