Federal Flood Mapping

Guidelines Series

Federal Land Use Guide for Flood Risk Areas

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Contributors to the development of this guideline include members of the Technical Working Group on Flood Mapping, a group of key stakeholders from federal, provincial, territorial and municipal jurisdictions, Indigenous representatives, the private sector, and academia. Valuable input from volunteer working groups with subject matter expertise and contract reports and studies were crucial in developing this guideline.

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NOTICE

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Additional Information

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CONTEXT

A community achieves an elevated level of resilience when its risks are proactively managed, it is adequately prepared for known and potential disaster events, and it demonstrates an ability to recover after such events have taken place. In order to become resilient, a community's mitigation planners must first understand risks and ensure their capacity to manage those risks.

Floods are commonly occurring natural hazards in Canada and account for the largest portion of disaster recovery costs on an annual basis. (Public Safety Canada, 2022) Mitigating flood risks is therefore key to increasing the resilience of affected communities. By proactively investing in flood risk mitigation activities, a community secures its future growth and prosperity, reducing the risk of significant disaster recovery costs, productivity losses, economic losses, destruction of non-monetary cultural assets, environmental damage, injuries, and deaths.

Flooding is the temporary inundation by water of normally dry land and can occur on marine and lake coasts, along rivers, and in low-lying areas. Flooding is caused by extreme rainfall, rapid snow/ice/glacier melt, strong winds (storm surge and waves), stream blockages from ice jams or debris, failure of engineering works including dams, poor drainage characteristics, high groundwater levels, and other sources. Flood mapping that accurately depicts flood hazards, including those impacted by future conditions due to anticipated development or projected changes in climate, serves as the precondition for mitigation activities and is therefore the first step to increasing community resilience regarding flooding. Establishing a national approach to flood mapping will facilitate a common national best practice and increase the sharing and use of flood hazard information, thereby improving the foundation from which further flood risk mitigation efforts can be initiated.

FLOOD MAPPING FRAMEWORK

The Flood Mapping Framework consists of all the components of the flood mitigation process, from flood hazard identification to the implementation of flood mitigation efforts. Figure 1 illustrates the relationship between these different components.

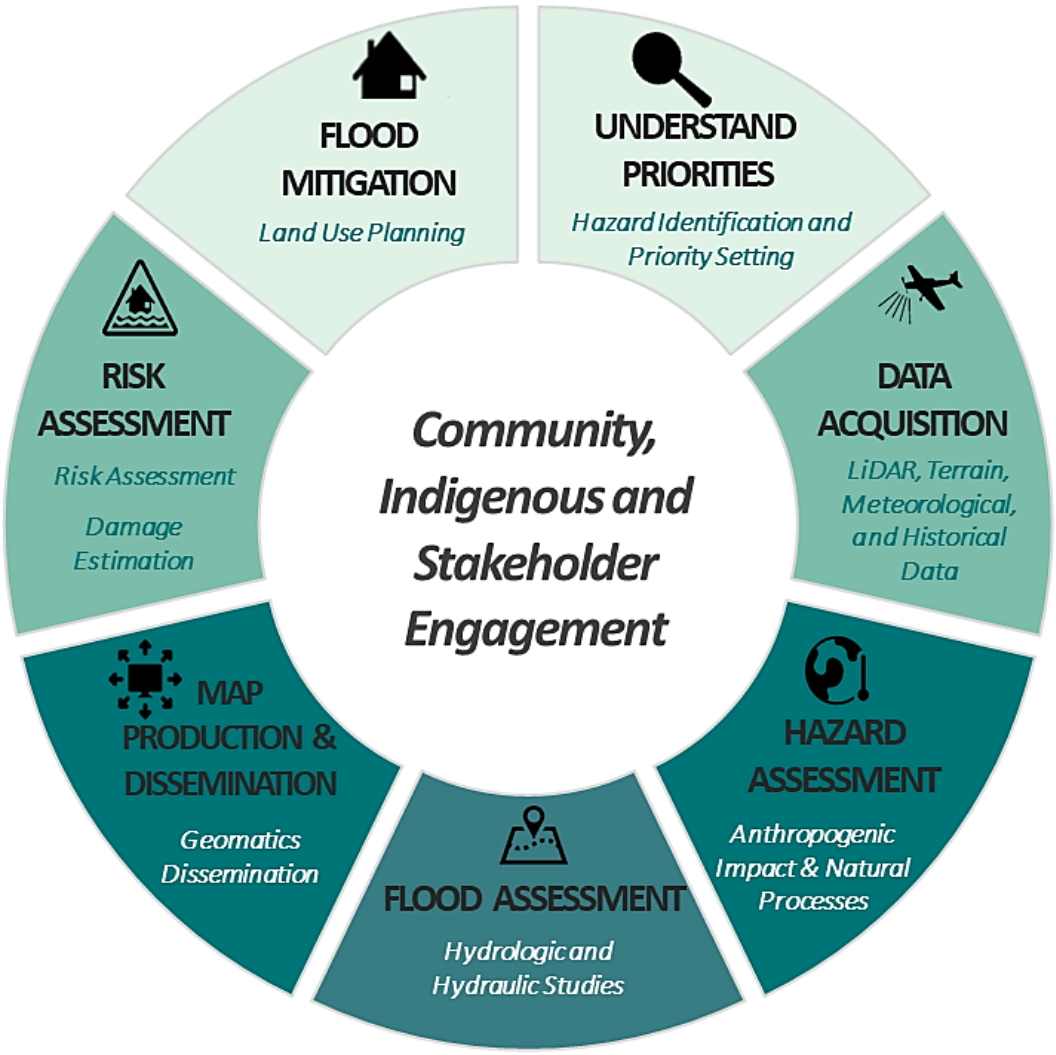

Figure 1: Flood Mapping Framework

FEDERAL FLOOD MAPPING GUIDELINES SERIES

The following documents are intended to inform any individual or organization involved with flood management in Canada:

1. Federal Flood Mapping Framework
2. Flood Hazard Identification and Priority Setting
3. Federal Airborne LiDAR Data Acquisition Guideline
4. Case Studies on Climate Change in Floodplain Mapping

5. Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation
6. Coastal Flood Hazard Assessment for Risk-Based Analysis on Canada's Marine Coasts
7. Federal Geomatics Guidelines for Flood Mapping
8. Flood Risk Assessment Procedures
9. Federal Flood Damage Estimation Guidelines for Buildings and Infrastructure
10. **Federal Land Use Guide for Flood Risk Areas**
11. Bibliography of Best Practices and References for Flood Mitigation

GUIDELINE SUMMARIES

The above list of the Federal Flood Mapping Guidelines Series is summarized as follows:

1. Federal Flood Mapping Framework

This document provides background and context on flood mapping in Canada, describes a vision and principles for flood guidance, and introduces the *Federal Flood Mapping Guidelines Series*. It provides a summary of each document in the Series and explains how each document fits into the overall framework, including roles in the flood mapping cycle.

2. Federal Flood Hazard Identification and Priority Setting

This document outlines methods for determining where to conduct flood mapping and how to prioritize flood mapping projects.

3. Federal Airborne LiDAR Data Acquisition Guideline

This document is a resource for the acquisition of base elevation data from airborne LiDAR data undertaken across Canada. This guideline provides technical specifications to federal, provincial and territorial departments, as well as individuals and organizations in Canada requiring information to understand and plan for airborne LiDAR data acquisition.

4. Case Studies on Climate Change in Floodplain Mapping

This collection of documents describes projects from across Canada where climate change was incorporated into the floodplain mapping process. It provides examples for practitioners to draw upon and learn from others' experiences and complements the climate change-related information and resources included in the "Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation" document.

5. Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation

This document provides guidance to municipal, provincial, and territorial agencies and Indigenous communities working to produce flood hazard maps. It provides technical information on the types of river and lake flooding, general practices, standard of care, procedures for hydrologic and hydraulic analyses, procedures for incorporating climate change, and reporting requirements.

6. Coastal Flood Hazard Assessment for Risk-Based Analysis on Canada's Marine Coasts

This document provides guidance on methodologies for coastal flood hazard assessments using risk-based approaches.

7. Federal Geomatics Guidelines for Flood Mapping

This document contains information on the different types of flood maps and outlines technical specifications to consider when acquiring, managing, and disseminating these maps and their associated geospatial data.

8. Federal Flood Risk Assessment Procedures

This document provides technical guidance on conducting flood risk assessments in Canada.

9. Federal Flood Damage Estimation Guidelines for Buildings and Infrastructure

This document provides guidance on how to evaluate potential economic losses, with a focus on buildings and infrastructure, incurred because of flooding.

10. Federal Land Use Guide for Flood Risk Areas

This document provides guidance to the professionals leading and supporting risk-based processes and methodologies for the purpose of land use planning with attention to flood-prone areas.

11. Bibliography of Best Practices and References for Flood Mitigation

This document contains lists of Canadian and international references and case studies pertaining to hydrology and hydraulics, climate change, risk assessment and flood mapping. The purpose of this document is to provide a consolidated list of reference materials intended as further resources for practitioners involved in flood mapping.

LIST OF ABBREVIATIONS AND ACRONYMS

AEP	Annual Exceedance Probability
BC	British Columbia
CSA	Canadian Standards Association
DFA	Disaster Financial Assistance
IPCC	Intergovernmental Panel on Climate Change
LID	Low Impact Development
LiDAR	Light Detection and Ranging
NDMP	National Disaster Mitigation Program
P/T	Province/Territory
UN	United Nations
WMO	World Meteorological Organization

1.0 INTRODUCTION

Flooding is increasingly significant in land use planning. Land use planning is one of the most effective land development junctures for managing flood risks and reducing loss of lives and property as land use planning is the precursor to all human development. More specifically, land use planning is the process of developing and implementing plans that provide information to communities and guide them in their growth and development.

This guide defines:

1) watersheds and governance;
2) the role of land use planning in flood risk reduction;
3) the types of floods and flood risk assessment; and
4) the role of the planning professional in mitigating and managing flood risks by way of land use planning tools in the context of the Flood Mapping Framework (FMF).

While flooding is a widespread challenge and an urgent priority in the context of climate change, there are a variety of planning approaches and jurisdictions in Canada to guide decision makers on planning and land use. For example, some provinces and territories have more directives and hierarchical structures that align well with planning systems and associated policies and strategies. In others, approaches to flood risk mitigation are less aligned with formal planning structures and rely more on independent municipal approaches and the knowledge and leadership of specific staff.

Regardless of the diverse types of legislative, management, and political structures that exist, this guide provides the foundation for a consistent, risk-based approach to land use planning as it relates to flood mitigation and management. This guide focuses on the “risk-based” approach in which practitioners look at the probability of occurrence of a range of flood scenarios (vs. “hazard-based” approach where there is a tendency to make decisions based on an individual flooding event). This approach has its foundations in other directives and guidance that encourage proactive best practices (see Appendix 1).

This guide puts the emphasis on a preventative approach focused on developing long-term strategies to reduce flood risk. In the case of emergency planning and post-disaster recovery, there is a broad range of questions for communities to consider. For example, whether or not to redevelop in the original location in the flood hazard zone. To that end, the Sendai Framework (Priority 4), along with Canada’s own Emergency Management Strategy (Priority 5), both recognize the benefits of building back better to “minimize the impacts of future disasters” and provide guidance as to approach. The Canada Standards Association[1] also provides guidance specific to municipal planning and imbedding the preventative approach within the local planning process.

[1] Three Steps to Integrating CSA Standards into municipal planning and approval processes (July 2022): https://www.csagroup.org/article/municipal-how-to-guide-for-csa-community-water-standards/

2.0 NOTE ON TERMINOLOGY

All *Federal Flood Mapping Guidelines Series* documents will apply the following definitions, derived from both the Emergency Management Framework for Canada (EMFC 2017) and National Disaster Mitigation Program (NDMP 2022) literature:

Flooding: The temporary inundation by water of normally dry land.

Flood Mapping: The delineation of flood extents and elevations on a base map. This typically consists of delineations on a map indicating the area that will be covered by water, or the elevation that water would reach during a specific flood event. Additional details may be displayed on the map, including flow velocities, depth, and other risk parameters and vulnerabilities. See section 4.2 for descriptions of types of flood mapping.

Hazard: A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.

Risk: The combination of the likelihood and the consequence of a specified hazard being realized; refers to the vulnerability, proximity, or exposure to hazards, which affects the probability of adverse impacts.

3.0 WATERSHEDS AND GOVERNANCE

A watershed is a defined geographic area where all surface water drains to a common point. Watersheds exist at various scales but can generally be described as an area, basin or ridge of land that separates waters flowing to different rivers, basins, or seas. This is significant from a planning perspective because although it is the logical scale at which to consider flood management, a watershed may extend beyond one administrative/municipal boundary, requiring a degree of strategic planning and management beyond the responsibility of a single municipal jurisdiction - interjurisdictional flood risk mitigation and management.

Watershed management is performed by various governance structures (such as conservation authorities, integrated watershed districts, basin-wide authorities, etc.), though provincial governments (or regional governments in the relevant provinces) are ideally placed to help coordinate and establish organizations and/or entities that can champion a watershed perspective on land use planning and development.

Land use planners play a key role and therefore are encouraged to be aware of and consider the characteristics, land use, and governance of the wider watershed, i.e., both upstream and downstream, even though the authority may not have jurisdiction over the wider watershed area. Watershed planning and management, and the requirement for strategic collaboration and communication with other governments and authorities, cannot be overstated with the goal of mitigating and managing flood risks.

3.1. Managing the Watershed

In considering whether to adopt a flood strategy, a local and/or regional government should first consider whether any initiatives or organizations already exist for the catchment/watershed for which the strategy is intended. In this case, the local government is encouraged to conduct outreach with these relevant organizations to share knowledge and resources to optimize desired outcomes.

Some provinces require municipalities to undertake a flood risk strategy through regulation, thus mandating the creation of a watershed management plan[2]. However, as noted, watersheds exist in different sizes and scales and are unlikely to align with a municipal boundary. Furthermore, a municipality or planning district may have limited authority to regulate matters related to water quality, land drainage, land clearing, etc., and thereby limiting authority to make land use or strategic plans for the entire watershed. Instead, it is more common that a community or regional scale plan does not fully encompass a watershed and may also span interprovincial and international boundaries – hence the need for strategic cooperation and collaboration with other municipalities, regional, and provincial authorities.

A first step in creating a flood risk strategy could be establishing a planning advisory committee to bring together the necessary groups and individuals to effectively implement flood management strategies.[3] The committee should include groups and individuals who are involved in land use changes within the catchment, whether to the terrain, location of buildings and infrastructure, or in decisions that influence the natural flow of water. In some cases, grass-roots initiatives can also be useful for managing water resources.[4] A list of suggested collaborators is provided in Appendix 2. It is available to planners to use as reference and to build upon.

A planning advisory committee's purpose is to manage, share and update regional maps of areas prone to flood hazard, make high-level decisions about flood risk mitigation, and monitor progress and changes within the catchment area. Flood risk management may also coincide with other broad watershed management objectives, such as water quality and access.

Advisory committees can also take the form of independent non-profit organizations, such as the *Watershed Planning and Advisory Council* in Alberta, to more formal structures of government such as the *Conservation Authorities* in Ontario[5].

[2] The Manitoba Provincial Water Protection Act (2005) enabled a group of Water Planning Authorities to develop a series of Integrated Watershed Management Plans to "manage land, water, and related resources on a watershed basis" web2.gov.mb.ca/laws/statutes/ccsm/w065e.php

[3] A summary of flood management across Canada can be found in the *Flood Management Across Canada* (Kerr Wood Leidal Associates, 2017) and *The Adaptation Primers* documents: *Primer Four – Rising Waters* (Clarke and Clarke, 2018).

[4] Several researchers and publications document the lessons learned and ideas generated from these efforts, including the Handbook for Water Champions: Strengthening Decision-Making and Collaboration for Healthy Watersheds (POLIS Project on Ecological Governance, 2019).

[5] A summary of flood management across Canada can be found in the *Flood Management Across Canada* (Kerr Wood Leidal Associates, 2017) and *The Adaptation Primers* documents: *Primer Four – Rising Waters* (Clarke and Clarke, 2018).

Case Study: Integrated Watershed Management Framework

The Toronto and Regional Conservation Authority has prepared and adopted *The Living City Policies for Planning and Development in the Watersheds* (2014). This document provides an Integrated Watershed Management framework, which includes policy directions concerning flood risk management. Although unique to the circumstances of the Toronto region, *The Living City Policies* contains ideas and illustrations regarding a number of initiatives, including flood zones, stormwater management and green infrastructure, that could be of interest to other jurisdictions.[6]

Table 1: The Living City Policies for planning and Development in the Watersheds (2014)

4.0 LAND USE PLANNING

Land use planning concerns the use and development of land, so is intrinsically concerned with risk identification, analysis, mitigation, and management. Plan policies identify land uses that should (and should not) occur in flood risk areas. Zoning bylaws regulate land uses in flood risk areas, i.e., the types of uses, locations and other site and development standards for structurers.

However, land use planning (and community planning) has traditionally identified and enabled, by way of plans, land uses that should not occur in flood risk areas including residential and essential services such as schools and hospitals. There are several reasons for this, the exploration thereof is beyond the scope of this guide. This guide serves to describe why land use planning is the first defence for flood risk mitigation and management. The following section focuses on strategic land use planning and flood risk reduction.

4.1 Strategic Land Use Planning and Flood Risk Reduction

Managing a watershed can be a complicated exercise, as its scale will often extend beyond defined administrative boundaries. The land use planning process itself does not change and instead the incorporation of the flood risk “lens” is purposeful by way of the data and specific focus, as well as the climate change “lens” with the knowledge that the changing climate is and will continue to influence flood risks. For this reason, planners should consider how long-term land use objectives can complement flood risk mitigation within identified watersheds, and a management framework should be established in the absence of any formal watershed management structure (see also Appendix 7: Land Use and Flood Risk). Such considerations cannot be done in isolation and will need to involve cooperation with relevant professionals, groups and organizations who may not have been engaged before because of conventional planning practices.

Planning for flood risk mitigation is a strategic land use planning exercise involving multiple stakeholders, spatial scales, jurisdictions, capacities, and should be approached with these, and no doubt other, factors in mind.

[6] See Living City Policies for Planning and Development in the Watersheds

The Importance of Land Cover and Permeability

In determining flood risk areas, the type of terrain and gradient of land, in addition to other factors, will influence how much a catchment/watershed can flood. Land cover is one of the most significant factors when determining the level of flood risk. From meadows to forests to asphalt streets, each surface has a different level of permeability (the extent of water infiltration). In addition, the scale of changes to land surfaces such as the loss of wetlands, deforestation, and urban development can impact land permeability.

Therefore, risk models should show how existing (and potential future) surfaces in the watershed will influence flood risk (as illustrated in Figure 2). In doing so, communities are enabled to strategically mitigate that risk by demonstrating how a community within the watershed can shape its land use strategies, including deciding to not develop in high flood hazard areas. The model can also support and inform land use policies and zoning regulations to control levels of permeability on a site-by-site basis including cluster developments, bioswales, rain gardens, increasing permeability surfaces for linear infrastructure and other developments that have conventionally relied on “hard top” (asphalt) and other non or less permeable surfaces.

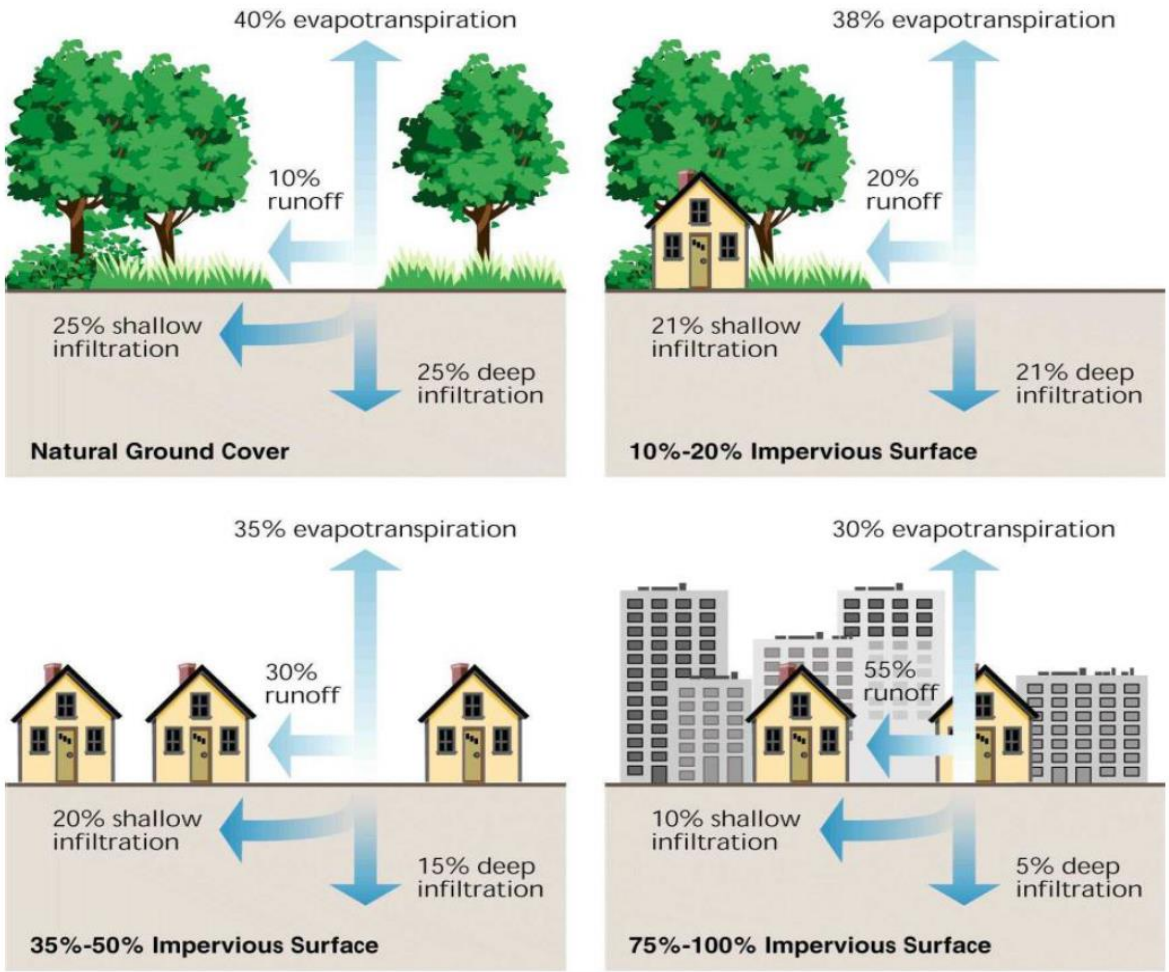

Figure 2: Impact of Imperviousness by the Federal Interagency Stream Restoration Working Group (FISRWG)

4.2 Importance of Flood Maps

Flood mapping provides a mechanism to convey a wide range of flood hazard and flood risk information, from flood extents of observed historical events to simulated flood extents for specified return periods (with the changing climate in mind). In other words, flood mapping tells the story of the watershed and the flood hazards and potential risks by utilizing both words and visuals to inform and communicate with the community.

Historically, hard copy flood maps have served as the primary source of flood information for land use planning and flood management. However, advances in data acquisition and geospatial and web technology have facilitated the production and dissemination of flood maps in a digital environment (Appendix 3). With an increase in relevant information, the planning practitioner can rely on the improved spatial data to convey flood hazard and risk information providing a complete story enabling a shared understanding. Regardless of their form and how they are generated and distributed, current flood maps play a significant role in communicating information regarding areas subject to flooding.[7]

Identifying and mapping flood hazard zones should be intrinsically linked with land use and community planning processes and activities. More specifically, mapping of flood hazards is based on the best available scientific and geoengineering analysis—telling the story about the land base under different land uses. For additional guidance on flood hazard delineation, consult the Federal Flood Mapping Guidelines Series document titled *Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation*.

The analysis includes identifying flood risks while considering existing and potential land uses in flood hazard areas to generate flood risk mapping to inform land use planning decisions. In doing so, the plan will be improved by:

- Increasing resiliency to flood risk via implementation of the guidance provided
- Improving disaster preparedness, thus enabling increased public safety
- Complementing climate change adaptation policies
- Encouraging continuity in reviewing adaptation/resiliency measures
- Including flood risk consideration in strategic planning processes
- Raising public awareness of flood risk and community support for mitigation and adaptation options
- Mitigating significant future flood impacts to the built environment and the costs associated with these impacts.

The process of risk assessment and flood risk mapping is described in a section below as well as in Appendix 3.

Flood maps show the extent to which a given area could be flooded based on the flood delineation exercise (below). This is typically illustrated by lines that define an area that will be covered with water or the height that water would reach in that area during a flood event. In

[7] See *Federal Geomatics Guidelines for Flood Mapping*

planning documents, the flood line is usually related to regulations and guidance, such as those concerning hazards and risk, and emergency planning and response. For consistency, four main types of flood maps are defined in the Federal Flood Mapping Framework as follows:

Inundation Maps: Maps that show the floodwater extent of real flood events, or that show potential floodwater coverage (e.g. annual exceedance probabilities). They are intended to aid in the management of emergency preparedness plans for communities situated within floodplains and flood hazard zones. *(Image source: Toronto and Region Conservation Authority)*

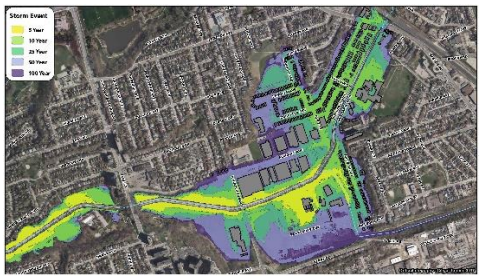

Figure 3: Example Flood Inundation Map

Flood Hazard Maps: Engineering maps that display the results of hydrologic and hydraulic investigations that show areas that could be flooded under different likelihoods. These maps are used for regulatory purposes related to land use planning and flood mitigation. *(Image source: Rideau Valley Conservation Authority)*

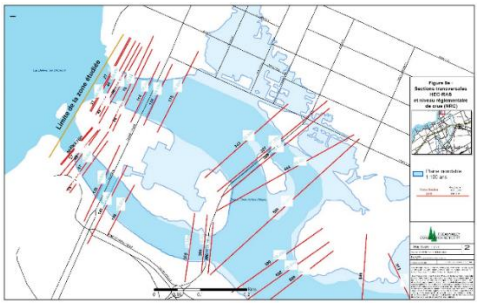

Figure 4: Example Flood Hazard Map

Flood Risk Maps: Maps that indicate the potential adverse consequences associated with floods, including but not limited to social, economic, environmental, and cultural consequences to communities during a specific potential flood event and the overall risks to the community from a range of potential flood scenarios. *(Image source: Toronto and Region Conservation Authority)*

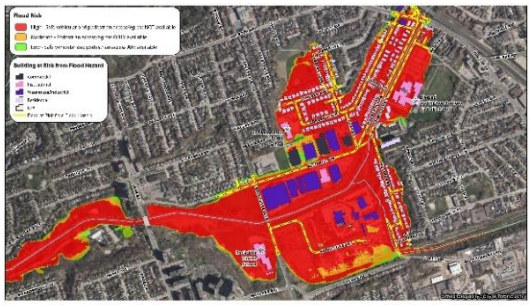

Figure 5: Example Flood Risk Map

Flood Awareness Maps: Communication maps that serve to inform members of the public regarding the history of flooding in their communities, as well as the potential for future flooding and the risks that such flooding would pose to residential properties, businesses, cultural assets, infrastructure, and human life. These interactive web maps or printed poster-style maps include a range of additional content types, such as photographs, descriptive text and graphics. *(Image source: Grand River Conservation Authority)*

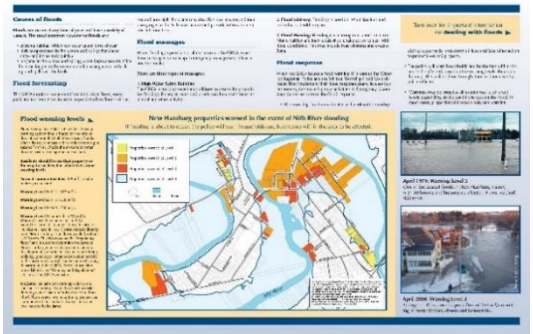

Figure 6: Example of Flood Awareness Map

5.0 FLOOD RISK ASSESSMENT

The risk-based approach to flood management establishes an understanding of the effect of a range of different flood hazard scenarios on people, buildings, and other infrastructure (both built and natural). The risk assessment may include environmental, economic, social, cultural, and other impacts that are assessed for areas both inside and outside the affected area. For additional guidance on flood risk assessment, consult the Federal Flood Mapping Guidelines Series document titled *Federal Flood Risk Assessment Procedures.*

These flood hazard scenarios tell stories with supporting visuals which enables an increased opportunity for the public to understand the risks in addition to the potential options to mitigate and manage those risks. In figure 7, the general process is detailed in steps (which are often iterative versus linear) in the risk-based approach to flood management.

This approach requires an understanding of what is at risk (exposure and consequence) under multiple hazard scenarios (e.g., differing severity of floods and types of floods). Scenarios should include climate change-enhanced risks (e.g., drought, extreme precipitation events, low stream flows, etc.). Also, to consider are other terms articulating flooding such as ‘return period/annual exceedance probability,’ etc. as detailed in Appendix 4. The information can be used to plan for a range of projected climate futures and support community resilience by strategically informing land use planning and development.

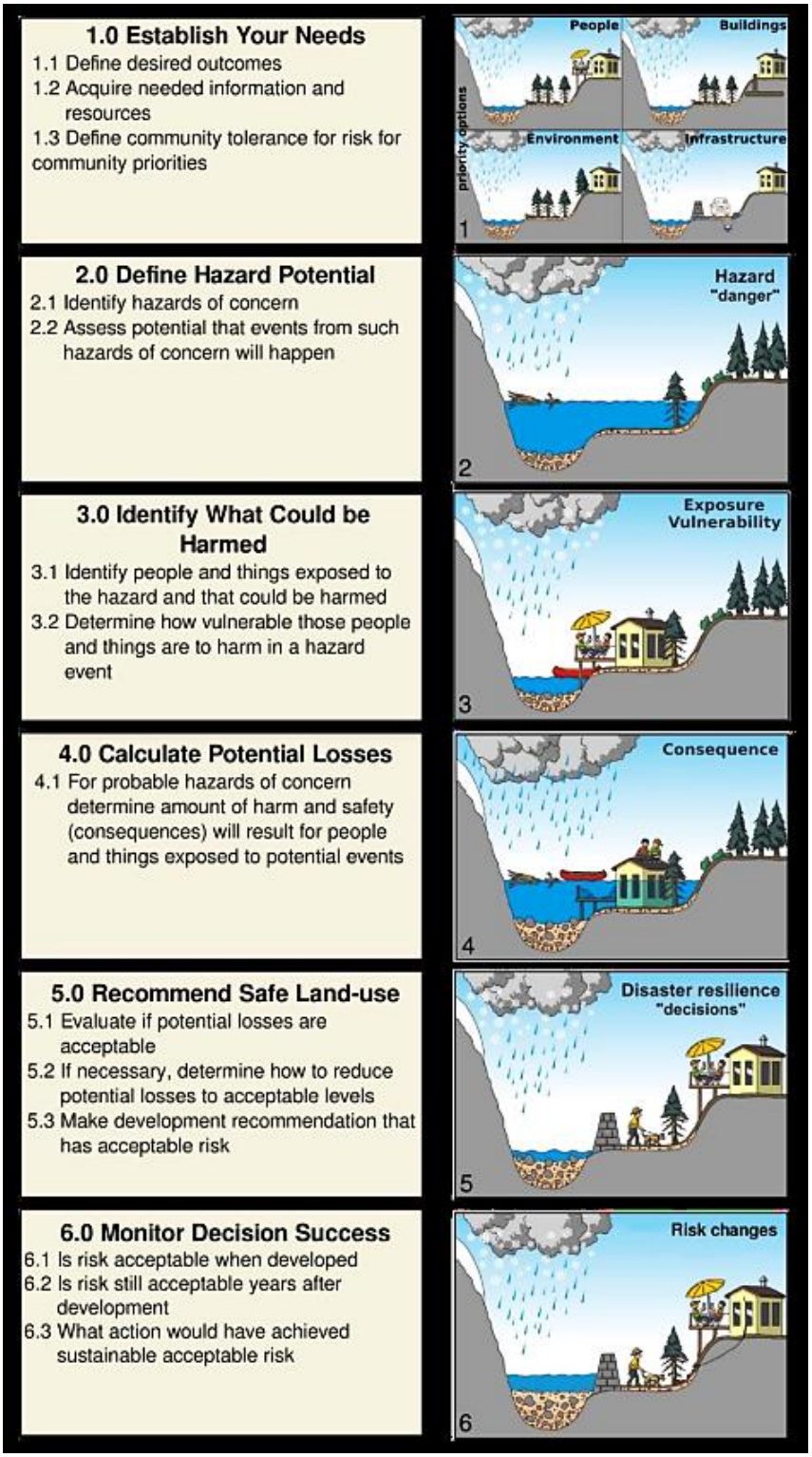

Figure 7: Land-use Risk Management Framework, where risk is the probability of a consequence (Geological Survey of Canada, 2015)

Understanding the Difference Between Exposure, Vulnerability, and Consequence
Exposure refers to the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. (UNDRR, 2009). For example, homes, schools, sewage treatment plants, municipal parks and where people are located are examples of exposure information.
Vulnerability, the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, community, valued assets, or systems to the impacts of hazards (UNDRR, 2009).
Consequence is the economic, social or environmental impact that may result from a flood event. For example, how many people would be displaced if a flood impacted their homes?

Table 2: Exposure, Vulnerability, and Consequence

By adopting a flood risk assessment approach (see Appendix 7), flood-related risks can be evaluated and treated similarly to other risks that planners must consider (i.e., financial, political, reputational, demographic, engineering, etc.). In doing so, the approach is familiar as decision makers are aware of risk management and in utilizing practical and credible approaches to selecting the best course of action in uncertain situations to mitigate and manage the risks.

Flood risks are calculated based on the flood hazard (depth, flow, velocity, etc.) and the exposure and vulnerability of people, buildings, and infrastructure (both built and natural). When the flood hazard changes (e.g., due to a new subdivision and the increase in non-permeable surfaces such as paved roads, buildings, etc.), the flood hazard can increase. Similarly, in this same scenario with more buildings and roads constructed in a floodplain, the consequences from flooding increases. More people could be displaced, and buildings impacted during a flood event.

Establishing a baseline scenario (such as pre-development) is essential to understand specific changes over time, and as communities evolve, the risk studies need to be updated to reflect these changes. Creating and communicating dynamic flood models enables and supports individuals and industries to both understand the potential risks and proactively respond accordingly. In addition, illustrating progress in identifying and managing risk can build community support for risk-acceptable developments and projects with long-term monitoring and management.

Managing risk does not necessarily mean restricting all development in flood-prone areas. It may mean restricting certain types of development such as those that are vulnerable or where consequences are too great (e.g., not locating a hospital in a flood prone area vs. a golf course as the golf course is not an essential service and can serve as a flood catchment area for gradual filtration). Land use can vary depending on the likelihood and severity of a flood, and land use decisions should consider the overall benefits across multiple hazard scenarios. This dynamic concept allows for a range of actions that are robust across a wide range of futures.

A land use and/or community plan that effectively integrates flood risk considerations can guide land use policies to enable and support community resiliency throughout implementation and management throughout the life of community assets, thus enabling the community to feel and be safe from flood risks.

5.1 Flooding

Flooding is the temporary inundation by water of (normally) dry land, which can occur in coastal areas, lake areas, and river floodplains. It can be caused by stream blockages (including ice jams), engineering failures (e.g., dams), extreme precipitation events, rapid melting of snow and ice, and poor drainage characteristics. Planning policy in Canada concerns the distinct types of flooding (Table 3) and the regulation of land uses in floodplains.

Flood Type	Description
Fluvial (Riverine)	The temporary inundation by water of normally dry land adjacent to a river and caused by rainfall, snowmelt, stream blockages including ice jams, failure of engineering works including dams, or other factors. structures in the river or floodplain and water level at the river outlet (such as variable ocean levels) can influence fluvial flood depth and extent.
Pluvial	A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body. This is often the cause of urban flooding, resulting from the capacity of an urban drainage system being overwhelmed.
Coastal	The inundation of land along the coast by seawater. Factors that contribute to the coastal flooding include: mean sea level (including sea level rise and regional subsidence), tide, storm surge, and wave effects. Tsunami from earthquake or landslide sources is considered separately.
Lake Flooding	Rise of lake level due to increased inflow to the lake, restriction to outflow, wind effects (including setup and waves), or seiche associated with a storm event.
Tsunami	Series of waves caused by a sudden, large displacement of water, such as from an earthquake, volcanic eruption, or landslide in a marine, lake, or reservoir.

Table 3: Types of flooding

With changing climate, all forms of flooding events are becoming more exaggerated and abrupt, resulting in significant infrastructure damage and expense. Therefore, strategically incorporating flood science is an essential consideration in the land use planning process. More specifically, collaboration between professional planners and the scientific community is essential to strategic land use planning and flood hazard mitigation and management to enhance community resiliency.

The following provides further context as to the articulation of flood characterization as part of the flood hazard assessment.

> **Floodway** is the river channel and adjacent areas where water depths and velocities are greatest. In many jurisdictions in Canada, the Floodway is defined as the main river channel plus those areas having a water depth greater than 1 metre and water velocity greater than 1 metre per second.

Flood Fringe is areas of the floodplain where the water depth is shallow (e.g., less than 1 m), and water velocities are low (e.g., less than 1 m per second) during the design or regulatory flood event.

6.0 LAND USE TOOLS FOR FLOOD RISK REDUCTION

The flood risk reduction and mitigation approaches within a given strategy will depend significantly on current land use practices within the specific jurisdictions. A summary of the following land use tools can be found in Appendix 5.

The strategic model and aligned plans should consider all scales of mitigation and adaptation measures. It is important to understand the priorities and needs of a community so that a strategy is developed to respond to these unique flood risks as there is no single approach that is appropriate for all communities. Each community must consider its unique flooding circumstance, geography, climate, culture and values, and specific climate change priorities.

There are various decision-making frameworks that are used to support the evaluation and selection of appropriate flood mitigation and adaptation approaches. These frameworks include cost-benefit, multi-criteria, and real options analyses as well as structured and robust decision making. Several Canadian flood-risk management projects have used these approaches and planners will find those useful when establishing priorities among available options.[8]

Mitigation should focus on reducing flood risk (i.e., loss of life and/or damage to assets). However, as with most planning decisions, balance will need to be sought alongside other priorities (i.e., housing, infrastructure, employment needs, etc.). It should be noted that the concept of risk is specific to each party (i.e., the landowner/occupant, the planning authority, the relevant province, an insurance bureau, etc.) and will determine the amount of risk that is acceptable.

There are ten golden rules for approaching flood management (Sayers et al., 2014):

1. Accept that absolute protection is not possible and plan for exceedance.
2. Promote some flooding as desirable.
3. Base decisions on understanding risk and uncertainty.
4. Recognize that the future will be different from the past.
5. Do not rely on a single measure—implement a portfolio of responses.
6. Utilize limited resources efficiently and fairly to reduce risk.
7. Be clear on responsibilities for governance and action.
8. Communicate risk and uncertainty effectively and widely.
9. Promote stakeholder participation in the decision-making process.
10. Reflect local context and integrate with other planning processes.

Climate Change

Flood strategies have a heightened level of importance in the context of climate change. Within this context, it is important to recognize that risks are not just due to heavier rainfall, but also changes to landscapes that become more susceptible to rainfall due to higher temperatures and

[8] A recent study in Surrey, BC (*Surrey Lowlands Flood Management Strategy - Decision Tools and Next Steps*) includes a concise comparison of these decision-making frameworks (Ebbwater Consulting, 2015).

freshet changes. For example, changes could include more extreme and abrupt precipitation events in short periods of time than typically experienced which can, for example, exceed the design standards of the drainage infrastructure resulting in “flash flooding.”

Flood modelling and mapping studies should therefore be expanded to consider climate-related risks to better land use planning. By expanding the modelling study to consider a range of impacts[9], mitigation and adaptation measures can take on dual purposes. For example, these could include floodwater storage in an upstream catchment area, the incorporation of rain gardens on public and private property, and community green spaces serving as formally recognized (by way of signage and policy) secondary flood catchment areas.

6.1 Flooding, Planning Legislation and Policy Statements/Guidance.

Local governments have delegated powers from the provinces over land use through planning legislation and provincial or territorial policies. In addition to land use planning, in some circumstances local governments will issue supplementary guidance and data to complement local level information and guidance. These policies can come under *exposure avoidance, exposure reduction, vulnerability reduction, and hazard reduction* (see Appendix 6).

The following examples of provincial planning statements and guidelines serve to empower local governments, in specific jurisdictions, to isolate leverage points to enable and support flood risk mitigation and management. For examples of upper-tier government approaches from other countries, refer to Appendix 7.

Example of Provincial Planning Statement and Guidelines	
British Columbia	The Government of British Columbia has published *Flood Hazard Area Land Use Management Guidelines* to help local governments, land use managers, and approving officers to develop and implement land use management plans and make subdivision approval decisions for flood hazard areas. These guidelines must be considered by local governments when enacting land use bylaws. (Gouvernement de la Colombie-Britannique, 2018)
Manitoba	The Planning Act and The City of Winnipeg Charter, set the legislative framework for land use planning in Manitoba. This regulation guides local and provincial authorities in preparing land use plans and making sustainable land use and development decisions. (Government of Manitoba)
New Brunswick	The New Brunswick *Flood Risk Reduction Strategy* includes a local planning framework that incorporates flood risk, leading to better decisions about proposed structures, facilities, and land uses. (Government of New Brunswick)
Ontario	The Province of Ontario’s *Planning Act* requires that municipal land use bylaws are consistent with the *Provincial Policy Statement*, 2020, have regard to matters of provincial interest (as enumerated in the Planning Act), and conform to provincial plans (e.g., *Greater Golden Horseshoe Growth Plan*). In particular, the *Provincial Policy Statement* contains a section on Natural Hazards (such as flooding) and allowable development by municipal governments. (Government of Ontario, 2020)

[9] Climate Atlas of Canada: https://climateatlas.ca/

Quebec	The Government of Quebec's *Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains (Policy)* was adopted pursuant to the *Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains Environmental Quality Act* which includes management of floodplains, prohibiting construction in areas that are prone to flooding every 20 years and restricting construction in areas that are prone to flooding every 20 to 100 years (Government of Quebec, 2020).
Saskatchewan	The Province of Saskatchewan's *The Planning and Development Act* and *The Statements of Provincial Interest Regulations* (SPI) require new official community plans and zoning bylaws to contain policies to address the management of lands subject to natural hazards, including flooding. This includes the requirement that these planning bylaws prohibit the development of new buildings and additions to buildings in the floodway of the 1:500-year flood elevation of any watercourse or water body. They also require that new development in the flood fringe of a 1:500-year flood be floodproofed to an elevation of 0.5 metres above the 1:500-year flood elevation. All planning and land use decisions must be consistent with the SPI. As a result, municipalities cannot issue development permits on land located in a floodway. (Gouvernement de la Saskatchewan, 2020)

Table 4: Sample of Provincial Planning Statements and Guidelines

6.2 Local Plans to Address Flooding

There are general protocols that planners observe when drafting and updating plans of any format and focus. These include reviewing existing relevant plans such as watershed management plans, regional plans, etc., and the zoning bylaws (including development permits, secondary plans, e.g., neighbourhood, sector plans), and subdivision planning, following up with the relevant professionals to gain greater detail of these plans accordingly[10]. In doing so, every effort is made to build upon the efforts and management guidance already in place to enable and support community resiliency by way of flood risk mitigation.

For example, one such plan is the City of Calgary's *Municipal Development Plan* (2009), which has a section on Flood Hazard Areas, which includes policies to "[…] increase public safety, reduce private and public property damage and enhance the city's flood resiliency." Specific policy within the Municipal Development Plan is provided below:

Case Study of the City of Calgary Municipal Plan Statements on Flood Risk Reduction

i. Flood risk reduction work undertaken by, or on behalf of the City of Calgary within the floodway, consisting of repairing riverbanks, erosion control, and land stability where the primary purpose is to enhance public safety, protect public infrastructure and ensure proper function of river morphology, be allowed without requiring a development permit.

ii. All new development in the floodway should be refused by the Development Authority, with the exception of the following:

- uses related to agriculture, open space, outdoor recreation, parks, transportation infrastructure and utilities, and the redevelopment of low-density residential buildings on

[10] Please refer to the Canadian Standards Association. Community Water Standards, The Municipal How-To Guide for CSA Community Water Standards. July 2022. Canadian Standards Association Group. Available at: https://www.csagroup.org/article/municipal-how-to-guide-for-csa-community-water-standards/ for additional guidance as to the embedding of flood risk reduction and adaptive measures into local government plans.

the existing building footprint where sufficient risk reduction measures have been taken to satisfy the Development Authority.

iii. For redevelopment of existing buildings where the building footprint straddles both the floodway and flood fringe, the redeveloped building should be located exclusively in the flood fringe.

iv. All redevelopment of existing low-density residential buildings in the floodway must be done through a discretionary permit process.

v. All buildings located in the floodway, flood fringe or overland flow area must be designed to prevent:
- damage by floodwaters;
- damage by elevated groundwater; and
- incremental increase of upstream river water levels.

vi. The Development Authority, when reviewing applications that propose flood risk reduction measures, ensure that public safety and minimizing property damage take precedence in considering development relaxations that may alter the existing built form context and development pattern in a neighbourhood. Approved relaxations should be commensurate with the degree of proposed flood risk reduction measures.

vii. Align the City's flood policy and development regulations to at least meet the minimum standards set by the Government of Alberta.

viii. Recognize the importance of using up-to-date flood modelling information as the basis for informing policy and development regulations.

ix. In areas with Community Scale Flood mitigation measures in place, relaxation of redundant mitigation in individual buildings should be considered.

Table 5: Case Study of the City of Calgary Municipal Plan Statements on Flood Risk Reduction

Indigenous Land Use Planning

Indigenous communities develop land use and community plans that reflect their priorities and desired current and future goals. However, Indigenous communities who are confined to the reservation tenure face a unique challenge. Many of the ideas presented in this guideline assume room to move or change land use practices in flood risk areas. This is often not possible or is especially difficult for Indigenous communities in circumstances where they were settled onto finite lands in floodplains or flood-prone lands. As a result, Indigenous governments may find this guide useful at a higher level compared with local governments.

In addition to the guidance provided by the plans and strategies ratified by Indigenous communities, registered professional planners are encouraged to refer to the *CIP Policy on Planning Practice and Reconciliation*[11] to inform professional practice as reconciliation in planning will look different in every context, as it is shaped by the unique needs, experiences, and priorities of each Indigenous community. Thoughtfulness and care cannot be overstated

[11] For more information about planning practice with reconciliation as a formative baseline see CIP's *Policy on Planning Practice and Reconciliation*, 2019, for guidance cip-icu.ca/getattachment/Topics-in-Planning/Indigenous-Planning/policy-indigenous-en-interactive.pdf.aspx

especially when working to address significant concerns such as flood risk to Indigenous communities.

6.3 Integrating Flood Considerations into Other Plans, Guides, and Strategies

In addition to a municipal plan, municipalities can integrate flood risk considerations into other plans and policy guides to address specific issues at different spatial scales. Such plans can provide more comprehensive analysis and strategies for unique sets of circumstances and issues. These plans are intended to complement the official municipal plan or equivalent. Some guidance will be specific to one type of issue, e.g., natural hazards, flood risk, and climate change. Other plans that would impact flood risk include waterfront revitalization plans, major infrastructure projects and capital plans, asset management plans, and open space/recreation plans.

A well-integrated local area plan, community plan, land use plan, or watershed management strategy should set the standards for appropriate flood risk mitigation and adaptation. Those standards should be strategically integrated into local policies and legislation. For the purposes of this guidance, different approaches can be allocated to four categories: *exposure avoidance, exposure reduction, vulnerability reduction, and hazard reduction*. Overall, communities can prepare plans that address flooding in the context of unique local issues and development patterns.

Examples of Supplementary Plans, Guides and Strategies Related to Flood Risk Reduction

- In November 2019, the City of Surrey, British Columbia completed its *Coastal Flood Adaptation Strategy,* which is touted as the first of its kind by a Canadian municipality. This strategy was designed to help prepare Surrey for a changing climate and help coastal communities become more resilient. It was a multi-year undertaking that identified the current and potential impacts of climate change on Surrey's large coastal floodplain area and developed a long-term strategy to reduce climate change-driven coastal flooding risks now and into the future.

- The City of Baltimore combined all-hazards mitigation and climate adaptation plan is a highly comprehensive plan, which captures measures to address current and future coastal flood risks (Baltimore City Department of Planning and Office of Sustainability, 2013). The plan is focused on altering floodplain regulations and building codes to improve the resilience of buildings, public infrastructure and critical facilities that provide emergency response services (hospitals, fire stations, police stations, etc.). One goal of the plan is also to "strengthen City zoning, floodplain and construction codes to integrate anticipated changes in climate." Specific actions include, for example:
    - Review zoning code and strengthen language (where necessary) to better protect citizens and increase resiliency in buildings…
    - Review and amend existing building and floodplain regulations to require new and existing structures to be more flood-resistant when located in the floodplain…" (p. 192).
    - Notably, this action applies to both new developments and redevelopment projects.
    - The plan also captures an action to review and adopt, in full or in part, design requirements captured in the ASCE 24-05 *Flood Resistant Design and Construction Standard*. These include both wet and dry floodproofing techniques, such as: "Mechanical, heating, ventilation, and air conditioning elements shall be located on the landward side of structures."

- In 2019, the City of Toronto published its *First Resilience Strategy*. This Strategy sets out a vision, goals, and actions to help Toronto survive, adapt, and thrive in the face of any challenge,

particularly climate change and growing inequities. Issues regarding flooding and flood resilience figures prominently in this document as one of its action plans is to make Toronto "more resilient to climate change, including the hazards of flooding and heat."

- A growing number of Canadian municipalities are preparing Climate Change Action Plans that directly and indirectly address flood hazards and flood risk.

Table 6: Sample of Supplementary Plans, Guides and Strategies Related to Flood Risk Reduction

6.4 Zoning

Zoning bylaws regulate the use and development of land. Examples include restricting land uses in flood hazard areas to those that are less vulnerable/more resilient, restricting development in flood hazard areas (e.g., changes in use, intensity of use, changes to existing structures, etc.), setting development standards such as minimum building elevations, "flood proofing," development setbacks, and so forth. Zoning is a tool for both exposure avoidance and exposure reduction by restricting development within flood-prone areas and encouraging adaptive measures where flood risk is being managed[12].

Zoning regulations can also be adopted to reduce the Impervious Surface Ratio (ISR)[13] of a lot/site (see figure 1), which can decrease the volume of storm water runoff into watercourses, primarily by retaining stormwater on sites and allowing it to infiltrate (by way of permeable surfaces). Reducing impervious surfaces and/or replacing them with pervious alternatives (green roofs, porous paving, rain gardens and bioswales, etc.) can support mitigating flooding throughout the watershed. Some municipalities set targets for particular zones to achieve a better ISR in that area (known as performance zoning).[14]

Example of Municipal Regulations Regarding Flood Zones
• The Town of St. Mary's, Ontario, defines the floodway as the inner portion of the floodplain, representing an area required for the safe passing of flood flow and/or an area where flood depths and/or velocities are considered to pose a potential threat to life and/or property damage. The outer portion of the floodplain is called the flood fringe, where depths and velocities of flooding are generally less severe than those experienced in the floodway. The flood fringe is the area where development and site alteration may be permitted, subject to appropriate floodproofing to the flooding hazard elevation or other flooding hazard standards approved by the Ministry of Natural Resources.
• Other examples of municipalities that use a two-zone approach to floodways include the Rural Municipality of Ritchot's Zoning By-law and the City of Moose Jaw, Saskatchewan.

[12] Please refer to the Canadian Standards Association. Community Water Standards, The Municipal How-To Guide for CSA Community Water Standards. July 2022. Canadian Standards Association Group. Available at: https://www.csagroup.org/article/municipal-how-to-guide-for-csa-community-water-standards/ for additional guidance as to the imbedding of flood risk reduction and adaptive measures into local government zoning bylaws.
[13] The portion of a lot that is covered by impenetrable materials, such as concrete, asphalt, roofs, etc.
[14] Pappalardo and La Rosa, 2020.

- The County of Colchester, Town of Truro, and Nova Scotia Department of Housing and Municipal Affairs established a Management Plan for future development in the flood fringe of the Salmon River. The Management Plan was the culmination of modelling alternative approaches to identify appropriate zones where property owners could apply performance-based approaches to continue development while maintaining static storage in the floodplain (i.e. “cut and fill” balance). The Management Plan was adopted and has served the community since 1997. The town and county’s development technicians track the balance of storage in the floodplain as projects are developed.

Table 7: Sample of Municipal Regulations Regarding Flood Zones

Sample of Flood Hazard Overlay Zoning
• The zoning bylaw for the City of Orillia, Ontario, includes several overlay zones, in particular one specifically for flood hazards.
• The Land Use Bylaw for the Town of High River, Alberta, includes a flood hazard overlay, the purpose of which is to: (a) Identify lands within the town that are liable to flooding during high water events; and (b) Provide regulations for lands liable to flooding to ensure development can be undertaken safely.

Table 8: Sample of Flood Hazard Overlay Zoning

Certain projects require development permits to regulate the design and location of a building. They may also regulate the sequencing and timing of construction. In 2012, the District of North Vancouver in British Columbia adopted legislation identifying Hazard Development Permit Areas (DPA), with a specific DPA for creek (i.e., flood) hazards. A development permit is required to build a new structure or substantially renovate existing structures within these areas. Additional flood protection measures may also be required, based on the recommendations of a qualified professional engineer.[15] An added benefit of this mechanism (as with setting ISR performance targets) is that it can feedback into the FMF cycle, as the permits are recorded.

International Examples of Municipal Land Use Strategies for Flood Risk Assessment	
Ireland	*The Planning System and Flood Risk Management – Guidelines for Planning Authorities (Nov 2020).* https://www.gov.ie/en/publication/7db50-the-planning-system-and-flood-risk-management-guidelines-for-planning-authorities-nov-09/#
Scotland	*Flood Risk and Land Use Vulnerability Guidance.* Scottish Environment Protection Agency, Version 4.0, July 2018. https://www.gov.scot/publications/scottish-environment-protection-agency-core-documents/

15 (District of North Vancouver, 2018

United States	*Municipal Land Use Strategies for Improving Flood Resilience Guidance for Protecting Health, Safety, and Welfare.* Janet Thigpen, CFM Southern Tier Central Regional Planning & Development Board, March 2017. https://planning.westchestergov.com/environment/flooding *Flooding and Land Use Planning: A Guidance Document for Municipal Officials and Planners.* Westchester County Department of Planning, Edward Buroughs, AICP, Acting Commissioner, June 2010. http://nescaum-dataservices-assets.s3.amazonaws.com/resources/production/stc-muni-landusestrategiesforflooding-booklet.pdf

Table 9: International Examples of Municipal Land Use Strategies for Flood Risk Assessment

6.5 Subdivision Control

As with zoning regulations, subdivision controls are useful to control development within flood-prone areas. For example, flood impact mitigation can be by way of preserving riparian corridors, wetlands, greenspace, and other environmentally sensitive areas; protecting open space, agricultural lands, woodlands, and other open landscapes; avoiding development on steep slope areas, while also providing the added benefit of increased recreational opportunities. In addition, there could be the requirement for all lots containing watercourses/hazard lands to be placed into public ownership through the subdivision process to ensure protection in perpetuity.

Municipal regulation of the division of land manages how parcels of land are divided into smaller lots. The municipality regulates the layout of lots and their development. The subdivision of land will have a permanent impact on the road layout, development pattern, and the extent of development. Subdivision control can ensure that the lots designed minimize hazards, are accessible, and can be maintained over the long term. Managing where and how land is divided into smaller lots is an important way to promote development patterns that are resilient to flood hazard risks[16].

The *Municipal Land Use Strategies for Improving Flood Resilience* (2017) prepared for New York State defines Conservation Subdivisions as a type of cluster subdivision that is designed to permanently protect a large portion of a site with important environmental areas or cultural features while clustering compact building lots on the remainder of the land. Conservation subdivisions are specifically designed around each site's most significant natural and cultural resource.

6.6 Provincially Regulated Zones

Provincial governments can act directly to regulate land uses, but such action needs to be assessed and tailored to the challenges facing specific areas of a province. Examples of provincial land use plans include British Columbia's Agricultural Land Reserve and Ontario's provincial plans, namely the *Greater Golden Horseshoe Growth Plan*, and *Greenbelt Plan*. Similarly, provincial governments can also apply land-use controls to flood-prone areas, as was recently done by the Province of Quebec:

[16] Please refer to the Canadian Standards Association. Community Water Standards, The Municipal How-To Guide for CSA Community Water Standards. July 2022. Canadian Standards Association Group. Available at: https://www.csagroup.org/article/municipal-how-to-guide-for-csa-community-water-standards/ for additional guidance as to the imbedding of flood risk reduction and adaptive measures into local government subdivision bylaws.

Quebec Regulatory Control of Flood-Prone Areas
On June 17, the Ministère des Affaires municipales et de l'Habitation (MAMH) adopted a draft order to declare special planning zones (SPZ) to promote better management of flood zones. The SPZ covers the 0-20-year flood zones and flooded areas in 2017 and 2019. The order placed a moratorium on the construction and reconstruction of buildings within the SPZ. The restrictions are in effect until the government creates a new regulatory framework to be implemented by all municipalities (Government of Quebec, 2019).

Table 10: Quebec Regulatory Control of Flood-Prone Areas

6.7 Easements

An easement is a non-possessory interest in real property that provides the holder with the right to use another party's real property for a specific purpose. The landowner continues to "own" the property affected by the easement but gives up or grants specified rights of use (e.g., giving up the right to build a permanent structure). The upper boundary of the easement functions like a development setback line.

An example of exposure avoidance in coastal floodplains, easements are employed to incrementally move or remove structures as the high tide line moves inland. Such mechanisms could form part of an integrated planning and watershed management strategy to aid risk avoidance and retreat from flood risks.[17]

International and National Examples of Rolling Easements
• In Canada, the Atlantic Climate Adaptation Solutions (ACASA) Project, a partnership between the provincial governments of Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and New Brunswick, and regional stakeholders including non-profits, tribal governments and industry, provides policy summaries on the use of Conservation Easements and Rolling Easements (2015). • Additional information on the application of rolling easements is found in the U.S. Environmental Protection Agency document Rolling Easements Primer (2011). This document further outlines the legal instruments available to manage rolling easements. These include zoning tools and the use of covenants on title, which can compel owners to sell to a land trust when the sea-level rise trigger has been met. In the U.S., where the National Flood Insurance Program (NFIP) exists as a tool to manage floods, there are instruments and tools within this program to incentivize buyouts. • Within the Shire of Byron Bay, Eastern Australia, Coastal Hazard Planning Provisions are in place to manage ongoing coastal erosion. The provisions permit certain development in each of three coastal hazard precincts. These are defined based on the level of shoreline erosion predicted to occur due to a 1% AEP design storm in the immediate future, in 50 years and in 100 years. New developments (any new building) within these zones are subject to various requirements, such as being modular and relocatable by a 4-wheel-drive vehicle. New developments can also be "triggered" for relocation or development when a predefined distance between the development and erosion escarpment is reached. As part of this, the Council undertakes surveys of properties and the coastal erosion escarpment (Knight, 2016).

Table 11: International and National Examples of Rolling Easements

[17] These practices are commonly used in the USA, but the principles are considered workable in a Canadian context (Atlantic Climate Adaptation Solutions [2020a and 2020b], Clarke and Clarke, 2018).

6.8 Density Redistribution

Example of *exposure reduction*: the City of Brampton, working with the Toronto Regional Conservation Authority, has recently proposed a plan to redistribute density in their current regulatory floodplain, which runs through the downtown core (*Downtown Brampton Flood Protection Environmental Assessment Project*, City of Brampton and the Toronto and Region Conservation Authority, 2019). Using computational flood models, they are exploring several alternatives that aim to revitalize the downtown core. The downtown core is currently controlled using a Special Policy Area (SPA), a tool within the Province of Ontario regulatory framework. The proposed alternatives allow more floodplain storage outside of the downtown core, thereby allowing increased densification and revitalization in the downtown area. This approach relies on a graduated use of flood hazard areas, where the least vulnerable land uses are closest to the river or flood hazard, and critical services are placed outside of harm's way. This is a simple conceptual approach to land use and flood hazard. However, this approach can be difficult to achieve in areas that are already developed.

6.9 Low Impact Development (LIDs)

While not often considered in flood hazard and risk modelling, low-impact development (LID) can be particularly useful in alleviating pressure on overwhelmed storm water systems. LIDs work by mimicking natural processes to reduce flooding loads and impacts, protecting water quality and aquatic habitats. Some examples of LID designs include rain gardens, retention ponds, bioswales, infiltration trenches, permeable pavement, green spaces, and rainwater harvesting[18]. Cumulatively, they can strategically mitigate the flood peak and loads, and therefore reduce the overall flood risk.

Examples of Stormwater Management and Flood Control
• The City of Vancouver's Rain City Strategy is an example of controls for stormwater and flood risk management (https://vancouver.ca/home-property-development/green-infrastructure-documents-and-policies.aspx).
• The Toronto and Region Conservation (TRCA) has developed criteria to guide the planning and design of stormwater management infrastructure for developers, consultants, municipalities, and landowners. https://trca.ca/conservation/stormwater-management/understand/
• Most major municipalities in Canada have Stormwater Management Design Guidelines that incorporate principles of low-impact development.
• Municipalities have programs to disconnect combined sewer and stormwater systems.

Table 12: Examples of Stormwater Management and Flood Control

Green infrastructure is a strategic network of natural and semi-natural areas with other environmental features designed and managed to deliver a range of ecosystem services and protect biodiversity in rural and urban settings[19]. Green infrastructure can contribute to the

[18] Please refer to the Canadian Standards Association. Community Water Standards, The Municipal How-To Guide for CSA Community Water Standards. July 2022. Canadian Standards Association Group. Available at: https://www.csagroup.org/article/municipal-how-to-guide-for-csa-community-water-standards/ for additional guidance as to incorporating low-impact development at the local government level.
[19] Municipal Natural Asset Initiative (https://mnai.ca/what-is-green-infrastructure/)

management of both localized and riverine floods by reducing storm water loads and intensity. In areas impacted by pluvial flooding, green infrastructure absorbs rainfall, preventing water from overwhelming pipe networks and pooling in streets or basements by way of strategic design and employ. Green infrastructure can also reduce the volume of storm water that flows into streams and rivers, reducing the flood damage to downstream infrastructure and property.[20],[21]

6.10 Natural Infrastructure/Assets

Natural infrastructure (also referred to as natural assets[22]) can be a robust complement to traditional infrastructure solutions. Natural assets are just that: ecosystem services that can be employed to mitigate flood risk. Every community incorporates green spaces, parks, playing fields, etc. into neighbourhood area developments (i.e. subdivisions). By way of thoughtfully planning these green spaces through strategic siting and design, these areas can provide flood mitigation (flooding backup) for a municipality. More specifically, these green spaces are planned primarily for human use and enjoyment, but also serve as temporary water retention areas during extreme precipitation events. In addition, ecosystem restoration and selective vegetation planting can enhance the capacity of natural assets to provide flood mitigation.

The 2018 Insurance Bureau of Canada (IBC) *Natural Infrastructure Report* provides a quantifiable demonstration of the value of natural infrastructure investment and includes case studies.

6.11 Building Codes

While planning regulations and policies are separate from construction standards, decisions over development will be impacted where the two intersect. Building codes are usually adopted at the provincial level and can be valuable mechanisms to compliment flood risk mitigation and adaptation goals outlined in planning legislation/policy by, for example, requiring a higher level of floodproofing on a building-by-building basis.[23] As well, plans can require new buildings/structures within a defined flood hazard area to meet specified floodproofing requirements.

The above eleven options, albeit not an exhaustive list, provides professional planner tools for the express purpose of strategically addressing flood risk mitigation and management when land use planning. In doing so, planners can strategically address flood risk and enable and support enhanced community resiliency in a changing climate.

[20] See https://www.epa.gov/green-infrastructure/manage-flood-risk
[21] (http://nwrm.eu/)
[22] Municipal Natural Asset Initiative (https://mnai.ca/)
[23] For more information, the City of New York released a *Retrofitting Buildings for Flood Risk Design Manual*. The manual analyzes and illustrates retrofit design options to enhance building resiliency. It presents a methodology to identify the building flood risks, review the relevant regulations and design a retrofitting strategy (The City of New York, 2014). At the time of writing this document, the National Research Council is leading a project to update the National Building Code to ensure that climate change is considered in the design of buildings at risk from flooding. This is a long-term, resource-intensive project, which will ultimately be the basis of updates to provincial Building Codes.

7.0 GLOSSARY

All Hazards: Refers to the entire spectrum of hazards or threats, whether they are natural or human-induced, malicious or non-malicious. Note: For example, hazards can stem from geological events, industrial accidents, national security events, or cyber events.

All-Hazards Approach: An emergency management approach that recognizes that the actions required to mitigate the effects of emergencies are the same, irrespective of the nature of the incident, thereby permitting a collective optimization of planning, response, and support resources.

Annual Exceedance Probability (AEP): The probability, expressed as a percentage, of a given flood magnitude or water level occurring or being exceeded in any given year. (See Appendix 4)

Asset-At-Risk: Refers to things that may be harmed/damaged by a hazard (e.g., people, houses, buildings, infrastructure, or the environment).

Asset Inventory or Database: An inventory of assets-at-risk, including the location and vulnerability of an asset or system.

(Asset) Encounter Probability: The probability that an asset will be affected by a hazard of a given magnitude in a given time period.

Critical Infrastructure (CI): 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.

Frequency: The number of occurrences of an event in a defined period of time.

Hazard Assessment: Acquiring knowledge of the nature, extent, intensity, frequency, and probability of a hazard occurring.

Hazard Inventory or Database: An inventory of the location, nature, and extent of influence of any potential hazards in an area of concern, generally compiled as a GIS database.

(Natural) Hazard: Natural process or phenomenon that may cause loss of life, injury, other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

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APPENDIX 1: KEY GUIDANCE DOCUMENTS.

Associated Programme on Flood Management

The programme is a joint initiative of the UN World Meteorological Organization and the Global Water Partnership and provides technical and policy guidance on issues of flood management. Programme publications related to land use and flood risk have been considered in the development of this guide.

Canadian Standards Association (CSA) Community Water Standards, The Municipal How-to Guide for CSA Community Water Standards

The Guide supports municipalities to develop strong, flood-resilient communities and reduce costs related to property and infrastructure damage. Despite the strong technical merits of CSA Standards, understanding how they fit into the existing governance structure of a municipality can be challenging.

To assist communities in this regard, the comprehensive step-by-step Municipal How-to Guide provides planners, managers, and municipal officials context-relevant standards, the integration of these standards, and examples to refer to.

Global Facility for Disaster Risk Reduction and Recovery (GFDRR)

The GFDRR is a global partnership, managed by the World Bank, which aims to better understand and reduce vulnerability to natural hazards and climate change. The initiatives developed by the partnership are directed at developing nations, but many concepts and ideas, such as those presented in *The Making of a Riskier Future* (GFDRR, 2016), are relevant in Canada.

Risk-based Land Use Guide

This document was the basis for the creation of the current guide. The Risk-based Land Use Guide is intended for land use planners in the Lower Mainland region of British Columbia and provides actions for municipal staff to determine whether land use proposals will be safe for their intended use. A copy of the Risk-based Land Use Guide can be downloaded from http://publications.gc.ca/collections/collection_2017/rncan-nrcan/M183-2/M183-2-7772-1-eng.pdf (Struik et al., 2015).

Sendai Framework on Disaster Risk Reduction (2015-2030)

The Sendai Framework for Disaster Risk Reduction is an international document that sets out four priorities for action. 1) Understanding disaster risk; 2) Strengthening disaster risk governance to manage disaster risk; 3) Investing in disaster risk reduction for resilience; and 4) Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation, and reconstruction. (UNDRR, 2015)

The United Nations Office for Disaster Risk Reduction (UNDRR; https://www.undrr.org/) initiative was endorsed in 2015 by the United Nations (UN) General Assembly. Canada is a signatory. The objective of this voluntary, non-binding agreement is to achieve a “significant reduction of disaster risk and losses in lives, livelihoods and health in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.”

APPENDIX 2: PLANNING ADVISORY COMMITTEE

A planning advisory committee may include the following organizations, for example:

- First Nations, Inuit, and Métis communities (e.g., integration of traditional and cultural knowledge, land cover, hydrological impacts, environmental, cultural, and historical impacts).
- Regional and local governments (e.g., land use and building regulations, environmental protection).
- Provincial/territorial water authorities and federal agencies that are responsible for water regulation or infrastructure in the impact zone or nearby regions.
- Conservation Authority or Ministry of Environment (e.g., watercourse alterations, flow protection, environmental protection).
- Transport authorities (e.g. culvert and ditch maintenance, highways where built-up roads act as dams on existing floodplains, at-risk infrastructure, port authorities, other hydrological impacts).
- Forestry companies and resource management entities (e.g., land cover maintenance, hydrological impacts).
- (Sub)urban development interests (e.g., land cover change, low-impact development measures).
- Non-profit groups, environmental groups (e.g., stewardship-focused, community preparedness- and response-focused, supporting data generation-focused, public policy-focused, etc.).
- Agriculture associations (e.g., memberships that are involved in practices that influence land use, runoff, infiltration, and sedimentation rates in watercourses).
- Dam operators (e.g., who may influence flow control).
- Industrial owners (e.g., who may have the potential to contaminate floodwaters, use and withdraw from water sources).
- Railway companies (e.g., that would impact hydrological processes).
- Insurance companies (e.g., data sharing, insurance coverage decision making).
- Sewer and water infrastructure providers (e.g., that would have an impact on pluvial flooding).
- Electricity and communication providers (e.g., that would impact hydrological processes, and control critical at-risk infrastructure)).
- Commerce associations, or local businesses in areas of impact (e.g., local business improvement area associations, chambers of commerce, etc.).
- Other land-based ministries (e.g., lands and natural resources, parks, mining, etc.).

APPENDIX 3: EXAMPLES OF INTERACTIVE FLOOD MAPS.

The following list are representative examples of flood maps that incorporate interactive and collaborative development, thereby enabling and supporting shared learning and understanding. This approach enables all participating parties to better understand the flood risks, the mitigation options, and the role each party plays to execute meaningful action by way of land use planning and implementation.

For further examples, please see *Policy Brief No. 141*: *Flood Risk Mapping in Canada: Moving Forward on a National Priority* (Henstra and Thistlethwaite, Centre for International Governance Innovation, 2018).

Examples of Jurisdictions with Interactive Flood Maps	
Jurisdiction	**Reference**
BC Water Resources Atlas portal – Province of British Columbia	http://maps.gov.bc.ca/ess/hm/wrbc/
Flood Awareness Map Application – Province of Alberta.	https://floods.alberta.ca
Flooding in New Brunswick	https://flooding-inondations-geonb.hub.arcgis.com/
Toronto and Regional Conservation Authority – Regulatory Flood Online Mapping Tool	https://trca.ca/conservation/flood-risk-management/flood-plain-map-viewer/#map
Maritime Coastal Flood Risk Map	https://agrgims.cogs.nscc.ca/CoastalFlooding/Map
Okanagan Basin – Online Mapping Tool	https://okanagan-basin-flood-portal-rdco.hub.arcgis.com/
USGS Flood inundation mapping – Interactive floodplain mapping tool	https://www.usgs.gov/media/images/flood-inundation-mapping-interactive-floodplain-mapping-tool

Table 13: Examples of Jurisdictions with Interactive Flood Maps

APPENDIX 4: RETURN PERIOD/ANNUAL EXCEEDANCE PROBABILITY/REGULATORY FLOOD

The following defines the specific terms relevant when assessing flood risk and informing flood mitigation and management options.

Return Period is also known as the *recurrence interval,* is the average time between significant events. It is the inverse of AEP and expressed in number of years. For rivers, this calculation is based on predicted stream discharge flows drawn from historical data. Return periods are depicted in planning documents as different flood lines, showing, for example, 1: 20, 1:100 or 1:500 year return periods. While these different periods may seem straightforward, they can sometimes be misinterpreted as the maximum frequency in a given number of years that a flood event will occur. However, a flood event may occur multiple times or not at all in that period. For clarification, a table of equivalent return periods and annual exceedance probabilities is shown at the end of this document.

Annual Exceedance Probability (AEP) is the probability, expressed as a percentage, of a given flood magnitude or water level occurring or being exceeded in any given year. Flood events are usually expressed in terms of a return period or an Annual Exceedance Probability (AEP). For example, a 1% AEP flood event, and a 1:100-year flood event, are equivalent. However, the concept of return periods is sometimes misinterpreted by non-technical audiences as a period of time between events (e.g. 100 years until the next 1:100-year flood) rather than an annual probability. Therefore, the annual exceedance probability is depicted in what is known as the **Regulatory Flood** map, commonly referenced in planning documents.

Annual Exceedance Probability (AEP)	Indicative Return Period	Encounter Probability of Occurrence in 25 Years	Encounter Probability of Occurrence in 50 Years	Encounter Probability of Occurrence in 75 Years	Encounter Probability of Occurrence in 100 Years
100%	Annual	100%	100%	100%	100%
30%	Once every 3 years	100%	100%	100%	100%
10%	Once every 10 years	93%	99%	100%	100%
3%	Once every 33 years	53%	78%	90%	95%
1%	Once every 100 years	22%	39%	53%	63%
0.1%	Once every 1,000 years	2%	5%	7%	10%

Table 14: Equivalent return period and annual exceedance probabilities

APPENDIX 5: SUMMARY OF LAND USE PLANNING TOOLS

The following provides several examples of land use planning tools. It should be noted that there are other regulatory controls that other agencies/organizations are authorized to administer (e.g., Conservation Authorities in Ontario, Meewasin Valley Authority in Saskatchewan) in addition to municipalities.

Land Use Planning Tools for Flood Risk Reduction		
Land Use Planning Tool	**Description**	**Examples**
Development Permits	A development permit is a permit that specifies how development is to occur on a given parcel of land. Development permits may also impose conditions respecting the sequencing and timing of construction.	• Hazard Development Permit Areas
Easements	Property easements to manage development within floodplains.	Rolling Easements
Infrastructure Works	Municipal infrastructure works are impacted by flooding and can also be used to manage floods.	• Transportation Networks • Stormwater Management Plans • Sewerage and Water Works Capital Plans. • Green Infrastructure Plans • Natural Water Retention Measures
Municipal plans	Most municipal governments have developed comprehensive plans to guide the land use planning of their communities. These plans set out rules to regulate land use and development—including the requirement to obtain permission to develop land. Also note Section 6.0 above.	• Official Plans (Ontario) • Official Community Plans (BC) • Municipal Development Plan (AB)

Municipal Subdivision Controls	Subdivision of land into smaller lots provides an opportunity to review flood resiliency.	• Subdivision Controls/Bylaws • Conservation Subdivisions
Municipal Regulatory Controls: Zoning	Most municipal governments have the regulatory power to control the types of land uses that occur in different areas.	• Overlay Zoning • Hazard Area Policies and Land Use Controls • Watershed-based Zoning • Impervious Surface Controls
Other Plans and Strategies	Municipal governments may have developed other plans which directly or indirectly address development in flood-prone areas.	• Environmental Plans • Climate Change Declarations • Natural Hazards
Provincial government tools (indirect and direct)	Some provincial governments have enacted indirect and direct regulatory controls over flood-prone areas	• Provincial policy statement. • Provincial land use regulations • Provincial guidelines
Provincial building codes	Building codes and regulations	• Provincial building codes • Hazard area building codes

Table 15. Land Use Planning Tools for Flood Risk Reduction

APPENDIX 6: INTERNATIONAL EXAMPLES OF FLOOD POLICIES AND GUIDELINES SET BY GOVERNMENTS

International examples of policy guides can provide examples for the various levels of governments and their planners, on innovative trends to integrate land use planning and flood risk management. Below are a few examples:

International Examples of Flood Policies and Guidelines Set by Governments	
Australia	*Natural hazards, risks and resilience: Flood*. The State of Queensland Department of Infrastructure, Local Government and Planning, Australia, July 2017.
United States	*Integrated Flood Management Tools Series: The Role of Land-Use Planning in Flood Management*. Associated Programme on Flood Management (APFM), 2016.
Scotland	*Flood Risk and Land Use Vulnerability Guidance.* Scottish Environment Protection Agency, July 2018.
Europe	European Union Floods Directive, applies to different flood types (river, lakes, flash floods, urban floods, coastal floods, including storm surges and tsunamis). The approach requires Member States to use a three-stage process: 1) preliminary flood risk assessment, 2) preparation of flood hazard maps and flood risk maps and 3) flood risk management plans.

Table 16: International Examples of Flood Policies and Guidelines Set by Senior Levels of Government

APPENDIX 7: LAND USE AND FLOOD RISK

Land use planning tools can be used according to their primary role in addressing flood risk: 1) exposure avoidance, 2) exposure reduction, 3) vulnerability reduction, and 4) hazard reduction (APFM, 2016). The "PARA" framework is a similar framework, using the terms 1) protect 2) accommodate, 2) retreat, and 3) avoid.

The following are brief descriptions for how these categories are defined and some of the land-use tools frequently associated with each approach:

Exposure Avoidance:
The increase in flood risk and flood damage in Canada and around the world can be primarily attributed to increased exposure in flood hazard areas[24]. Avoiding increases in exposure is the most effective means of risk reduction (such as not continuing to build high-risk flood hazard areas). More specifically if there is no exposure then there is no risk. Common land use tools associated with this approach include zoning, transferring of development rights and land acquisition such as with strategic/managed retreat.

Exposure Reduction:
Exposure reduction seeks to reduce or limit the amount of exposure over time in the floodplain. This category includes a managed retreat (planned migration; Annex A: Planning for Retreat: where structures and infrastructure are moved out of flood hazard areas over time. Land use tools associated with this approach include easements, land acquisition, density bonuses, and natural feature restoration. Depending on the extent of the planned retreat/migration, municipal plans might identify potential sites for relocation and resettlement of areas that are experiencing current and future flood inundation.

Vulnerability Reduction:
Vulnerability is the susceptibility of exposed people, assets (including natural assets) and livelihoods to the damaging effect of floods. Where exposure avoidance and reduction are difficult to achieve, vulnerability reduction can significantly reduce flood risk. There are significant opportunities in this category for innovative planning solutions. For example, bylaws have the potential to support the development and retrofitting of flood-resilient structures. Identifying vulnerable social groups according to their ability to relocate, density of population, demographics, household make-up, access to critical and government services, etc. (GFDRR, 2016) can help focus investment decisions. In addition, other planning decisions, such as the location of infrastructure and government services can affect the community's vulnerability.

Land use and general planning tools used to implement a reduction to physical, social, cultural, and environmental vulnerabilities may include:

- Regulating subdivision and building permit approvals in floodplains to avoid increasing infrastructure vulnerability.
- Raising the physical height of certain municipal services (e.g., roads, water services buildings, etc.) over time, taking advantage of regular planned infrastructure renewal cycles and encouraging adjacent private owners to follow suit.
- Incorporating flood-resilient design into building codes, such as locating electrical rooms and other critical infrastructure on the second floor.

[24] (WMO, 2017; GFDRR, 2016

- Developing incentives to help residents and businesses retrofit their buildings to increase property-level flood resilience.
- Reducing population in high-risk flood areas, especially vulnerable populations.
- Moving transportation routes and government services away from floodplains.
- Cleaning industrial sites to limit environmental degradation in flood-prone areas; and
- Identifying safe evacuation/muster areas (with clean water and services) for high-risk flooding areas.

Hazard Reduction:
Hazard describes the flood extents, depths, velocity and debris from a flood event and is based on information such as tides, rainfall, river flows, or storm surges. The flood hazard severity and the damages that occur are a function of the overall volume of water and how the water moves through the landscape. Faster-moving water has greater energy and power to inflict damage. Hazard reduction in Canada is accomplished primarily by the construction of engineered works, including sea walls, dikes, and dams, but also through green infrastructure or nature-based infrastructure, including dune building, swales, ecosystem restoration to increase natural asset capacity.

ANNEX A: PLANNING FOR RETREAT

Managed retreat is the purposeful relocation of people and property out of areas vulnerable to flooding (Thistlethwaite, 2020). Land use tools associated with this approach include easements, land acquisition, density bonuses, and natural feature / ecosystem restoration. Depending upon the extent of the planned retreat / migration, municipal plans might identify potential sites for relocating and resettlement that are experiencing current and anticipated increased future flood inundation (e.g., flood risk scenarios and mapping).

Managed retreat presents numerous complex challenges—legal, logistical, ethical, political, financial, environmental, and architectural. Communities, and community cultures, are not easily transported and preserved as they are unique to each specific community. However, with the changing climate and the projected increases in extreme precipitation events, there is a growing recognition that we need to incorporate strategic flood retreat / migration with increasing frequency as flood risk mitigation option.

From a planning perspective, the actual planning process does not change from the usual land use planning process. As detailed in Figure 8, there are ‘good practices for planner retreat’ that are familiar to the professional planner. For example, the requirement for communication to be early and often, while also providing appropriate duration in the communications and engagement to allow for the information to be received and understood, while also using care in how information is provided is a cornerstone to all forms of land use and community planning. The strategic approach to communication for retreat planning is especially important in light of the impact of retreat / migration for those who live in these areas, as detailed further below.

The requirement for good governance and process is essential when engaging about planned retreat. The potential impacts of retreat / migration for those who live in these areas require knowledgeable local champions who have a proven track record of enabling and supporting community-focused and based decision making, who understand the requirement for a thoughtful and timely community-centric process.

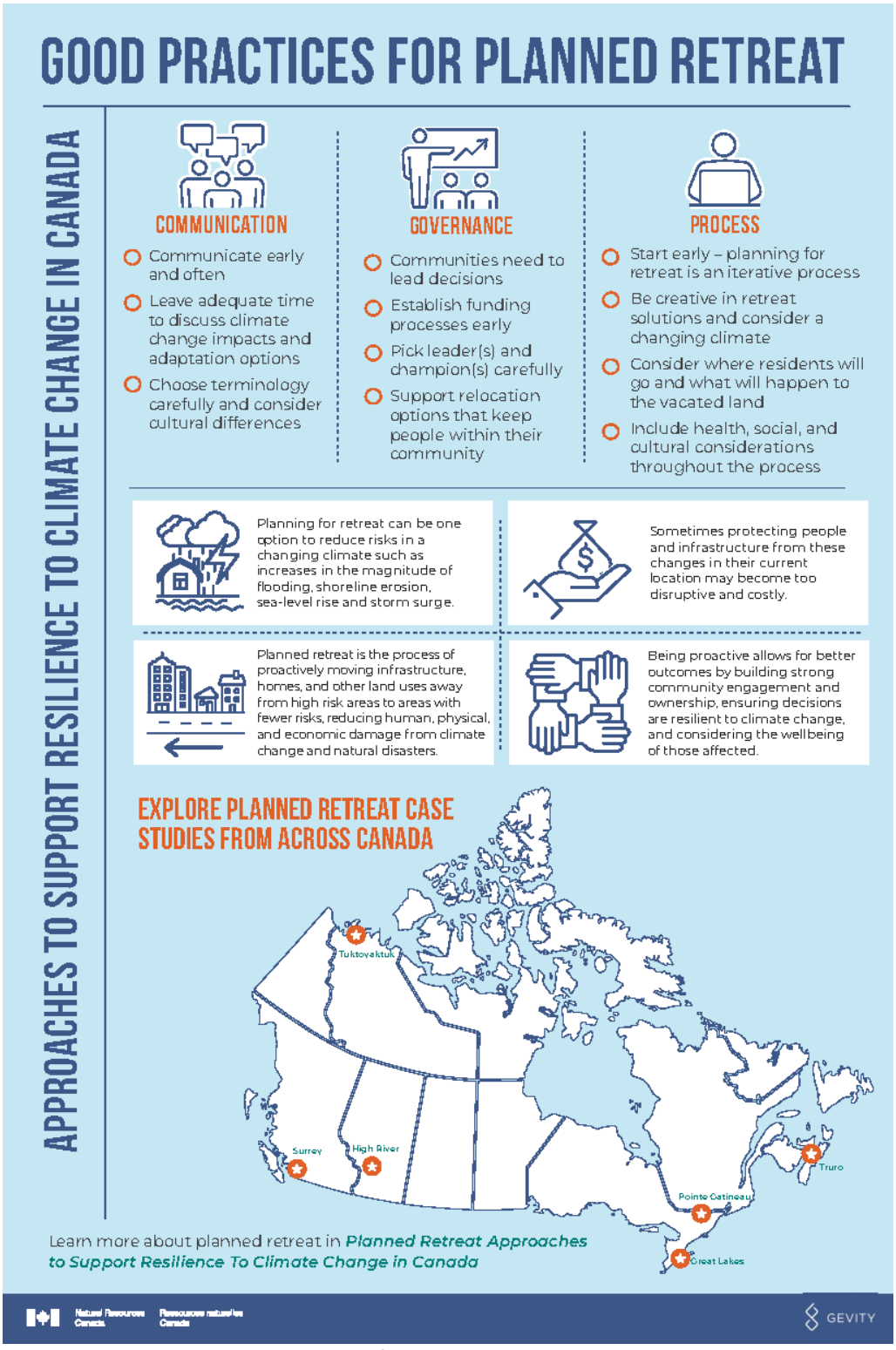

Figure 8: Good Practices for Planned Retreat[25]

[25] Planned retreat approaches to support resilience to climate change in Canada at: https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=328323

It should also be noted that as planning practitioners, there is the recognition that the use of specific terminology in the planning process can 'trigger' participants, which can result in a challenging planning process. Language is powerful. An example of the use of language is illustrated in the following question from a participant of a retreat-focused workshop[26]:

> "Did you folks consider the use of the term migration rather than retreat? Retreat has battle implications and implies a defeat. Migration carries less of these connotations of loss or defeat, but still carries with it the idea of purposeful movement."
>
> Primary response to the above question: "Yes, we considered migration, retreat, relocation, resettlement and other terms. … the advisory team wanted to hold onto the concept of 'retreat', feeling that it was honest and needed to be confronted."
>
> Secondary response to the above questions (from a municipal representative): "… we reworded 'retreat' options to 'pullback' to be more sensitive…"

In addition to the strategic use of terminology, there is the requirement to also be aware of the impact of retreat / migration for those who live in these areas. For example,

> 'Rather than rebuild or protect the neighbourhood from future flooding, Grand Forks chose a path that's likely to become more common as sea levels rise and weather gets more extreme due to climate change.
>
> It's called "managed retreat[27]," and it means the people, their neighbourhood and all the dreams they had for the land have to go — returning the area to a natural floodplain.
>
> "It was kind of a shock to the whole neighbourhood to find that we were to be eliminated," O'Brien said, sitting on the porch of his former home.
>
> "I'd been here 30 years, but there were some who had been here their whole lifetime." (da Silva, 2022)

The above illustrates the mourning for loss of home and community. As planning practitioners, we have a responsibility to be thoughtful in our planning processes and incorporate a 'lens of empathy.' And if you do not believe you have this specific capacity, you have a responsibility to augment your 'capacity toolbox' and incorporate the required tool to thoughtfully navigate the process accordingly.

There is significant focus upon the topic of retreat as a viable flood risk mitigation option including the following examples of where strategic / managed retreat has been explored:

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[26] Adaptation Platform Webinar (July 21, 2020), 'Supporting Long-term Climate Resilience in Canada through Planned Retreat'. Available at: https://climateriskinstitute.ca/2020/07/06/webinar-supporting-long-term-climate-resilience-in-canada-through-planned-retreat/

[27] Grand Forks, BC received $49 million from the Disaster Mitigation and Adaptation Fund (DMAF) to do a managed retreat from the river and restore adjacent wetlands rather than constructing berms and dams. Avalable at : https://www.calgary.ca/content/dam/www/cs/documents/resilientcalgary/Natural-Infrastructure-in-Alberta-Sept2019-Workshop-Report-public.pd

City of Surrey, BC, hosts a web site that details the City's *Coastal Flooding Adaptation Strategy* (CFAS) project (initiated in 2016) providing numerous resources have been produced and sourced to support the process of strategy development, community consultation and information sharing: https://www.surrey.ca/services-payments/water-drainage-sewer/flood-control/coastal-flood-adaptation-strategy/cfas-background-and-resources

> The City of Surrey led an extensive flood risk planning process that, ultimately, resulted in recommendations that included strategic retreat. The broader Surrey community supported retreat but the residents specific to the areas of study opposed the option. Instead, the high flood risk areas have a hazard development permit requirement with homes being built to flood construction levels (FCL).

Melissa Le Geyt (2022). Expanding the adaptation toolbox: exploring managed retreat in Grand Forks, BC. UWSpace. http://hdl.handle.net/10012/18261

> Thesis details the policy and planning of managed retreat for risk reduction in Canada, in particular the flood-related property buyout program in Grand Forks, BC, including the mechanisms and vehicles for buyout program.

Thistlethwaite, J., Henstra, D., and Ziolecki, A. (2020) Managed Retreat from High-risk Flood Areas: Design Considerations for Effective Property Buyout Programs, Policy Brief, Centre for International Governance Innovation No. 158, April 2020. Available at: https://www.cigionline.org/static/documents/documents/PB%20no%20158.pdf

> Brief focuses upon managed retreat as one of the policy options for addressing disaster risk reduction. The brief describes managed retreat as the purposeful relocation of people and property out of areas vulnerable to flooding.