Securing Flood Resiliency: The Role of Insurance

Flood Insurance for Flood Risk Management
Lake Champlain-Richelieu River Watershed

International Lake Champlain - Richelieu River Study

A WHITE PAPER TO THE INTERNATIONAL JOINT COMMISSION

Submitted by

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EXECUTIVE SUMMARY

The Lake Champlain-Richelieu River (LCRR) basin is a geographically and culturally diverse region straddling the Canada-United States border. The vast drainage area is susceptible to springtime flooding that affects both lakeside and riverside residents of New York, Vermont, and Quebec. The International Joint Commission's Lake Champlain-Richelieu River Basin Study Board has undertaken an extensive evaluation of both structural and non-structural approaches to reduce the impacts of flooding in the LCRR basin.

STUDY FOCUS

As part of this effort, the Study Board adopted a flood mitigation framework centered on four mitigation themes:

1. Reduce extreme water levels on the Richelieu River and by extension, on Lake Champlain
2. Reduce inflows into Lake Champlain or the Richelieu River
3. Improve flood response (emergency preparedness); and
4. Modify floodplain management (adaptation to flooding).

To address Theme 4 (floodplain management), the Study Board convened a group of experts to identify non-structural tools for flood risk management in the LCRR basin. A 2020 expert workshop identified four key areas that the Study Board should focus on in providing floodplain management recommendations to the International Joint Commission:

1. Better flood risk maps are needed.
2. Flood risk should be better communicated and understood.
3. Management of floodplain occupancy should adapt and evolve.
4. Developments in Canadian and US flood insurance should be recognized.

The Study Board subsequently commissioned four White Papers to address these recommendations. This White Paper is the fourth in that series and focuses on flood insurance.

Government flood risk management programs include the following: spending on flood risk reduction, land use zoning and building code regulation, flood risk communication (often organized as flood risk maps), post-flood recovery aid, and participation in insuring flood peril. Flood risk management aims to secure flood resiliency, which involves not only reducing flood risk but also speeding recovery should flooding occur. Widespread coverage of flood insurance supports flood resiliency: Insurance payouts speed post-flood recovery when the payment of a claim is made. At the same time, a risk-reflective flood insurance premium communicates flood risk and can incentivize investments in risk reduction by governments and property owners when these actions result in premium savings.

This white paper explores the possibility of expanding flood insurance coverage in Canada and the United States generally but focuses especially on areas covered by the IJC Lake Champlain Richelieu River study. Since 1968, when it established the National Flood Insurance Program (NFIP), the United States federal government has aspired to have widespread flood insurance coverage. Flood insurance is offered at "affordable" premiums to residential and commercial property owners in any community that implements federally specified building code requirements within the 100-year floodplain, governing first-floor elevation and flood proofing for new or improved structures. Today 22,000 communities, representing 98 percent of the US population, are enrolled in the NFIP, and within those communities, 5,000,000 policies are in effect. Nonetheless, only about 25 percent of flood-prone properties purchase insurance, and most of those purchases are required because the property owner has a federally backed loan.

FINDINGS

According to NFIP data, no flood insurance policies are in effect along the Lake Champlain shoreline (within the study area). In the United States, post-flood disaster aid is limited, uncertain, and often delayed, meaning that flooded households and businesses without insurance often struggle to recover after floods. The cost of flood insurance can influence purchasing decisions, but multiple other influences have also resulted in limited insurance sign-up, and hence a flood insurance coverage gap. The US Federal Emergency Management Agency has established a "moon shot" goal of doubling flood coverage by the year 2023, either by expanding the purchase of national flood insurance policies or by encouraging the purchase of coverage from the newly emerging US private flood insurance marketplace.

In Canada, private companies began offering flood insurance for residential and commercial property in 2016, with each insurer making its own decision about whether to offer insurance, where to offer it, and at what premium. Currently, few companies offer flood insurance coverage in areas they deem to be high flood risks. Because the study area along the Richelieu River is at high risk of flooding; it is very unlikely that flood insurance is being offered or purchased at this time. Unlike in the Unites States, post-flood disaster aid in Canada, and in Quebec specifically, is generous, with more of the cost of rebuilding after a flood borne by Canadian taxpayers. The Federal Government of Canada and the governments of the provinces are investigating alternative strategies for expanding the reach of private flood insurance to reduce the future cost of post-flood disaster aid. Addressing the flood insurance coverage gap in Canada begins with expanding the availability of private flood insurance coverage into the higher risk areas; however, according to US as well as international experience, even if more flood insurance were offered, few property owners would opt to purchase it at the premiums they would likely be charged.

This paper proposes a conceptual design for sharing the responsibility for insuring flood risk between the public sector and private insurers. This risk-sharing system would increase the willingness of private insurers to expand coverage into high-risk areas. The framework builds upon insurance option ideas that have been promoted within both Canada (via recent reports from the Insurance Bureau of Canada and Public Safety Canada) and the United States. The *first layer* of coverage would be offered as a provincial government insurance or aid program offering coverage up to a low limit, such as $10,000 per event. This coverage would apply to all property owners within a community, although individual property owners could choose to opt out of coverage under certain conditions.

The *second layer* of coverage would be offered through the private sector, with the first layer providing a high deductible; the second layer would include a cap on the maximum payout. The combination of a high deductible and a cap on the maximum payout would bracket claim exposure, providing insurance actuaries more certainty when rating risk for areas currently deemed high-risk, and allowing insurers to charge a premium that most property owners would be willing and able to afford. This coverage could be included under homeowners' general coverage, in effect making it a default coverage, while allowing for individual homeowners to reduce their homeowner's insurance premium by opting out of coverage under certain conditions.

Under this plan, if a claim exceeded the maximum payout at the second layer, then damages above that limit would be paid by existing disaster aid programs (the *third layer*). This third layer could be means-tested so that higher-income property owners would be expected to self-insure instead of relying on post-flood aid.

The public sector role does not, however, end with risk-sharing. The proposed design envisions these additional roles for governmental entities:

- Investment in risk reduction,
- Model and data development that allows insurance actuaries and governments to better evaluate flood risk,
- Responsibility for insuring a share of flood risk, and
- Assurance that owners of flood-prone properties are willing and able to pay for the coverage.

The layered coverage strategy described in this paper is one possible design for a public-private risk-sharing partnership that could bring comprehensive flood insurance to places and properties currently defined as high risk, closing the flood insurance gap.

THE INTERNATIONAL JOINT COMMISSION

Under the Boundary Waters Treaty of 1909 (the Treaty), the governments of the United States and Canada established the basic principles for managing many water-related issues along their shared international boundary. The Treaty established the IJC as a permanent international organization to advise and assist the governments on a range of water management issues. The IJC has two main responsibilities: regulating shared water uses; and investigating transboundary issues and recommending solutions.

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1 BACKGROUND

This white paper explores the possibility of expanding flood insurance coverage in Canada and the United States generally but focuses especially on areas covered by the IJC Lake Champlain Richelieu River study.

The Lake Champlain-Richelieu River (LCRR) basin is a geographically and culturally diverse region straddling the Canada-US border. The vast drainage area is susceptible to springtime flooding that affects both lakeside and riverside residents of New York, Quebec, and Vermont. The International Joint Commission's Lake Champlain-Richelieu River Basin Study Board has undertaken an extensive evaluation of both structural and non-structural approaches to reduce the impacts of flooding in the LCRR basin. As part of this effort, the Study Board adopted a flood mitigation framework centered on four mitigation themes:

1 Reduce extreme water levels on the Richelieu River and by extension, on Lake Champlain

2 Reduce inflows into Lake Champlain or the Richelieu River

3 Improve flood response (emergency preparedness)

4 Modify floodplain management (adaptation to flooding)

A Floodplain Management Solutions in the Lake Champlain-Richelieu River (LCRR) Basin workshop was held February 6-7, 2020 in Montreal, Quebec. The findings from this workshop were synthesized in a report (Henstra and Shabman 2020), which was submitted to the International Lake Champlain- Richelieu River Study Board.

The workshop report identified four key areas that the Study Board should focus on in providing floodplain management recommendations to the International Joint Commission:

1 Better flood risk maps are needed.

2 Flood risk should be better communicated and understood.

3 Management of floodplain occupancy should adapt and evolve.

4 Developments in Canadian and US flood insurance should be recognized.

The Study Board agreed with the proposed framework to examine these four areas in more detail. Experts in floodplain management were subsequently contracted to explore best management practices and provide recommendations for each of these specific areas. The result was four White Papers, each of which focused on one of these topics. Better communication of flood risk helps assure that decisions about floodplain use are based on facts. The first and second white papers are closely connected because flood maps help communicate an accurate assessment of risks. Throughout the study area, floodplain management has already reduced the vulnerability to flooding since 1976. Quebec is in the process of revisiting its floodplain management techniques in its Normative Framework, and the United States will be instituting a new

approach called *Risk Rating 2.0*. The third white paper explores these developments, including new ideas that may or may not be part of any new policies. The fourth paper explores the potential of universal flood insurance to both reduce personal financial hazard and drive improvements in floodplain management. The fourth paper is closely connected to the third, in that it discusses a specific and novel floodplain management measure.

The unifying focus in developing these four White Papers is improving floodplain management. The goal is to ensure the wise use of floodplains. The principal characteristic of wise use is that it is sustainable; i.e., property owners understand flood risks but feel that benefits justify or outweigh these risks without the need for an external subsidy. Each of the white papers in this series focused on compiling best management practices based on interviews with experts and a literature review. The goal was to identify those practices that may apply to the basin, while also considering existing jurisdictional efforts. This report is White Paper No. 4: Securing Flood Resiliency: The Role for Insurance.

2 SETTING THE CONTEXT

Households, businesses, and governments make decisions about how they will use their flood-prone land. Government flood risk management programs seek to influence these decisions through the following actions: spending on flood risk reduction, regulating land-use zoning and building codes, communicating flood risk (often with flood hazard maps), spending on post-flood recovery aid, and participating in insuring for flood peril. (See Box 1 for a list of terms used in this paper.)

The goal of flood risk management is securing flood resiliency for households, businesses, and community assets located in flood-prone areas, and for any new assets located on undeveloped flood-prone land. The term *resiliency* has become commonplace in discussions of flood risk management. Papers on resilience have been published in fields as diverse as economics, engineering, biology, and psychology. Resiliency does not mean reducing flood damages always and everywhere in the floodplain by any means possible. Rather, resiliency is about realizing *wise use*, a term that can be traced to the writings of Gilbert White in the mid-20th century. The term *resiliency* is used in this paper because it explicitly recognizes the need to implement measures that reduce the hazard, exposure, and vulnerability, as well as the need to have policies in place *before* a flood that will speed post-flood recovery.

Resiliency and post-flood aid to speed recovery are often treated as synonymous. While post-flood aid can be one measure for speeding post-flood recovery, post-flood aid does not in itself incentivize the implementation of pre-flood risk reduction measures. Insurance payouts, as with aid, can speed post-flood recovery but, relative to post-flood aid, insurance can also be an instrument for incentivizing the implementation of flood risk management measures to secure flood resiliency. For this reason, it is the premise of this paper that widespread coverage of flood insurance can be the foundation for choosing and then implementing pre-flood efforts to reduce the hazard, exposure, and vulnerability and that insurance payments are also preferred to post-flood aid for speeding post-flood recovery. In broad concept, expected flood damage is reflected in an insurance premium, efficiently providing flood risk information to floodplain landowners. In addition, paying insurance premiums makes those same landowners responsible for the costs of occupying the floodplain, while the prospect for premium savings supplies an incentive for investment in hazard, exposure, and vulnerability reduction at both the community and individual property level.

However, even when flood insurance is widely available, as in the US federal government's National Flood Insurance Program (NFIP), most households do not voluntarily purchase coverage. Less than 30 percent of all US households living in flood-prone areas have purchased flood insurance, and many of those are mandated to purchase coverage due to carrying a mortgage backed by the federal government. In Canada, overland flood insurance is not offered by governments. Private-sector insurers have only recently offered coverage, and even then, not in areas that the industry deems to be high-risk. If coverage were made available in these high-risk areas, it is not certain that it would be purchased. Whether in Canada or the United States, the cost of premiums may make it unaffordable for some. However, there are many reasons insurance is not purchased, even when doing so is affordable.

Today, governments in Canada and the United States have an opportunity to partner with the private insurance industry to secure widespread flood coverage. In the Unites States, this coverage has been the goal of the National Flood Insurance Program (NFIP) since its first policy was sold in 1969. Now the Federal Emergency Management Agency (FEMA) has set a "moonshot" goal of doubling coverage, whether by selling more NFIP policies or by increasing policies sold under the nascent but expanding private market. This moonshot has been justified to speed post-flood recovery, given that US post-flood aid is often delayed, inadequate and uncertain. Canada's interest in widespread coverage is most often justified to

limit the national and provincial financial exposure from the more generous (relative to the United States) post-flood aid programs that Canada now has in place.[1] The aspiration in Canada is for flood exposed property owners to be offered private flood insurance and to be willing and able to purchase it, thereby replacing post-flood disaster aid. This aspiration must be supported by a range of policies and programs that better promote flood resiliency (such as enhanced models and data for evaluating flood risk and communicating that risk, through flood mapping or GIS-based query services).

BOX 1: VOCABULARY

While a glossary is a list of terms with their definition listed in alphabetical order, a vocabulary orders the terms so that each definition follows from and logically builds up on the term that immediately precedes it.

Floodplain - Any area that is susceptible to a temporary partial or complete inundation of normally dry land, from inundation by large rivers, feeder tributaries, tidal surge flooding in coastal areas, and intense rainfall over a small catchment (sometimes called "storm water flooding"). The floodplain includes, but is not limited to, land subject to a one-percent or greater chance of flooding in any given year.

Flood Resilience - The capacity of a household, business, or community to withstand expected future floods, and if a flood occurs, the time it takes to recover, in part or in full, from the adverse consequences of flooding relative to the immediate post-flood situation.

Adverse Consequences - Typically adverse consequences are defined as flood damages or the financial cost of repairing or replacing damaged property (structures) as well as the market value of lost agricultural outputs. However, the categories of adverse consequences from a flood are numerous and varied. They can include adverse effects on 1) individuals' health, including changes in illness, injury, and mental distress (including pre-flood anxiety and post-flood trauma) as well as loss of life; 2) the market value of public and private assets as well as the change in the incomes of households and businesses; 3) community, regional, and national changes in employment and productivity of capital, land, and labor; 4) the ability of a community to maintain its desired cultural and economic attributes; 5) unbudgeted expenditures made by agencies of government; and 6) the natural and beneficial services provided by water and related land resources in the watershed.

Flood Resiliency Actions - Flood resiliency actions include those to 1) reduce flood hazard, 2) reduce flood exposure, 3) reduce flood vulnerability, and 4) increase the speed of recovery after flooding has occurred.

[1] See for example, https://nationalpost.com/news/politics/federal-government-cutting-back-on-disaster-assistance-as-floods-become-more-severe (accessed July 25, 2021)

BOX 1: VOCABULARY (continued)

Flood Hazard - The probability distribution of flood water surface elevations associated with all possible floods that can occur at a particular location within a floodplain. Other possible dimensions of flood hazard include the rate of floodwater rise, flow velocity, and duration of inundation associated with some water surface elevation.

Actions to Reduce Flood Hazard – Actions to reduce the flood hazard reduce the likelihood of floodwater inundating a location, for a given duration. Hazard reduction can be secured with actions that increase upstream floodwater storage (dams, wetland and floodplain restoration, runoff controls for pervious surfaces) and with flowage easements. Investments in channels, levee systems, walls, and culverts/pumps sized to keep floodwater away from an area of the floodplain can reduce the hazard. Hazard can be reduced by assuring the structural integrity and rehabilitation of previous flood hazard reduction investments as well as by temporary flood-fighting.

Flood Exposure - The potential for people and assets to come into direct contact with flood water as a consequence of their location in a floodplain. Exposure is a general term for more specific concepts such as "populations at risk" and "assets at risk."

Actions to Reduce Flood Exposure– Actions to reduce exposure to the flood hazard will reduce the potential for people and assets to come into direct contact with floodwaters. Information programs intended to affect floodplain location and use decisions and regulations that direct and limit floodplain land occupancy and use can reduce exposure. Ring levees can reduce exposure to the hazard for a subset of properties. Payments made to relocate assets and associated populations that are currently in the floodplain can reduce exposure.

Flood Vulnerability - The characteristics of people and assets that affect the likelihood that they will realize adverse consequences from exposure to the flood hazard.

Actions to Reduce Flood Vulnerability - Actions to reduce vulnerability reduce the adverse consequences when an asset is exposed to the flood hazard. Building codes that require floodproofing and elevation of structures reduce vulnerability. Local emergency warning systems, evacuation plans, information programs to encourage individual preparedness planning and strategies, and evacuation assistance can reduce vulnerability.

Floodplain Management - Policies and programs of federal and non-federal governments that are intended to limit the exposure and vulnerability of people and assets to the flood hazard.

Post-flood Recovery - The time for people and assets to return to some "normal functioning" in the aftermath of realizing flood damage.

Actions to Speed Post-Flood Recovery - Putting aside a financial reserve, purchasing insurance, and developing a standing capacity to assure rapid and effective execution of government post-disaster assistance programs will speed recovery.

This paper is organized into several sections. The next section is a conceptual overview of flood resiliency, making the case for insurance as the best means for securing that resiliency. This section is followed by a description of the current state of flood insurance in both the United States and Canada. The flood insurance "coverage gap" along the Lake Champlain shoreline as well as the Richelieu River is described. With the coverage gap explained, a "layered coverage" strategy for closing the coverage gap along the Richelieu River is offered. Key roles for provincial (Quebec) and federal government, in partnership with the private sector, needed for closing the flood insurance coverage gap are described in the following section. The flood risk along the Lake Champlain shoreline might be addressed through an innovative insurance strategy for only the most extreme flood event. The paper concludes with an evaluation of the layered coverage strategy.

3 FLOOD INSURANCE: SECURING FLOOD RESILIENCY

3.1 INSURANCE: IN BRIEF

Insurance is often understood simply as the payment made after an event to the owner of an insured asset. With this limited perspective, flood insurance becomes equivalent to post-flood disaster aid. However, a more appropriate understanding of insurance begins by recognizing that insurance is a risk transfer service; that is, insurance transfers the cost of the random possibility of flood damages (flood risk) at a location from an insured party to an insurer. The entity facing the risk (the insured) is buying a service from an insurer. The service the insurer provides is assuming some share of the risk, in return for payment – the premium.

The insurance premium can be a significant influence on flood resiliency decisions made by governments and the floodplain property owner. For the insured, the annual premium converts the uncertain cost (possible flood damages) from the floodplain location into a certain cost – the premium. This premium communicates the level of flood risk, as that risk is calculated by insurers' technical experts (actuaries). This payment can be used by the floodplain property owner (the insured) to compare the benefits of floodplain location against its costs, including flood risk costs as reflected in the premium. The insured can also use premium savings to evaluate the benefits from hazard (H), exposure (E), and vulnerability (V) reduction efforts (see *Vocabulary*) against the costs of their implementation.

For a private insurer to offer the risk transfer service at a premium level that asset owners are willing and able to pay, the insurer's revenue must exceed expected claims and administrative costs throughout the service contract, for the firm to make a profit. Private market insurance is subject to regulatory oversight to protect buyers of the service, with the most basic regulatory role assuring that the insurer has a capital reserve fund of sufficient size to honor policy holder claims. The insurer earns revenues from premium income, from investment returns on its capital reserve fund, and (possibly) taxpayer cash transfers. The term "actuarially sound" signifies that insurers maintain the financial resources to honor claims.

Among the criteria that make an insurer actuarially sound is the size of the risk pool, as well as the limited potential for *correlated loss*. Correlated loss potential can be limited by having a risk pool that is spatially dispersed, with a limited number of insured properties in a single location. However, flood risk is prone to correlated loss, because a single event can damage multiple insured assets in the same location. For the insurer to offer actuarially sound flood coverage, a large number of insured must be willing and able to pay the insurer's premium, creating a pool of insured properties that grows and diversifies. Storm and flood damage insurance offerings around the world have faced the actuarial challenge of achieving a larger pool of policies, without a high probability of correlated loss. Flood risk communication and mapping are meant to build awareness of the flood risk and increase floodplain occupants' interest in purchasing insurance. Governments can take on other roles that help make flood risk "insurable," including financial participation with insurers in risk-sharing and limiting claim exposure through spending and regulations for hazard, exposure, and vulnerability reduction.

3.2 THE CASE FOR INSURANCE

Figure 1 depicts flood resilience decision-making for a single entity (household, business, community) for the case of a single flood event. In Figure 1, resiliency is represented on the y-axis by a single variable – financial well-being.[2] The x-axis represents time. A flood event occurs[3], leading to a decline in financial well-being, equal to or exceeding the cost to repair and rebuild. After the flood, the period of post-flood recovery adds additional costs to the expense of flood damage repair (for example, the costs of borrowing to pay for the repairs, forgone income during recovery, and costs of temporary housing).

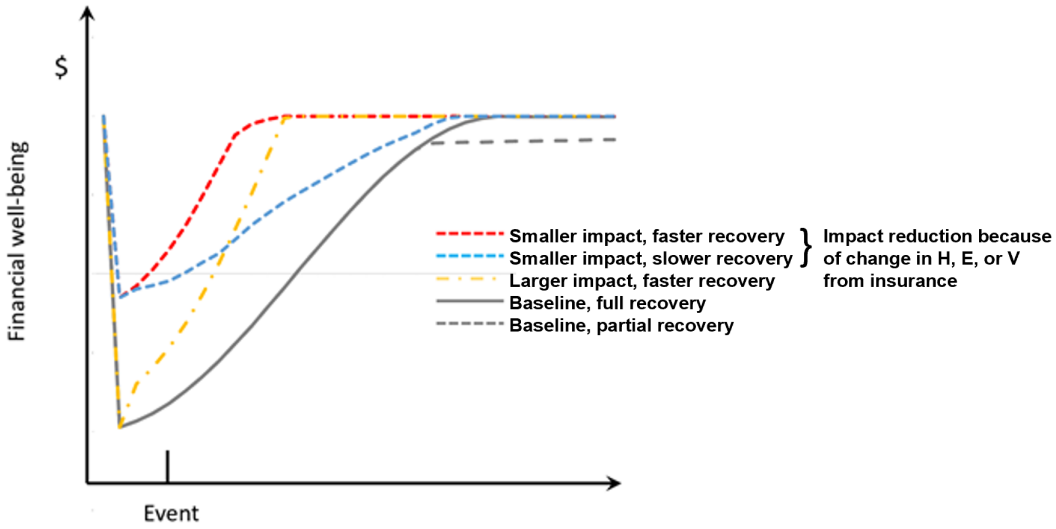

Figure 1. Flood Resilience.

In the baseline case, the flood-prone property owner took no action before the flood to reduce the expected flood losses, and after the flood had to rely on his or her financial resources (or perhaps delayed post-flood aid) to recover. The baseline case in Figure 1 shows a steep decline in financial status after the flood, followed by a long delay in recovery, as shown on the gray line, or possibly no recovery, as shown by the dotted gray line. All colored curves represent an improvement in resilience over the baseline case.[4]

[2] The resiliency literature has not identified common and well-established metrics to represent well-being. There are, of course, multiple dimensions to well-being, including psychological, community (social), environmental, and others. To facilitate discussion, the framework outlined here focuses on financial well-being following the assumption that financial well-being is a necessary, if not sufficient condition, for realizing the other dimensions of well-being.

[3] Figure 1 is a conceptual representation for a particular flood event. If these were empirically derived responses, a different graph would represent each of the different possible flood events. Each event would have its own likelihood of occurrence.

[4] Insurance speeds recovery for the individual household, but as more households and businesses have insurance, the community also recovers more quickly.

Flood resilience measures that are taken before the flood influence either the size of the initial shock or the time to recovery after the event. Landowners or governments can implement actions to reduce H, E, and V, reducing flood risk at the property level (Figure 2). The effects of these actions, relative to the base case, are represented in a less dramatic immediate decline in financial well-being (red and blue lines in Figure 1).[5] The other pre-flood action is to purchase insurance, or set aside funds, to reduce the time to recovery and/or increase the extent of recovery (yellow line in Figure 1).[6] All recovery paths represent an improvement in resilience over the baseline case, shown as the gray lines.

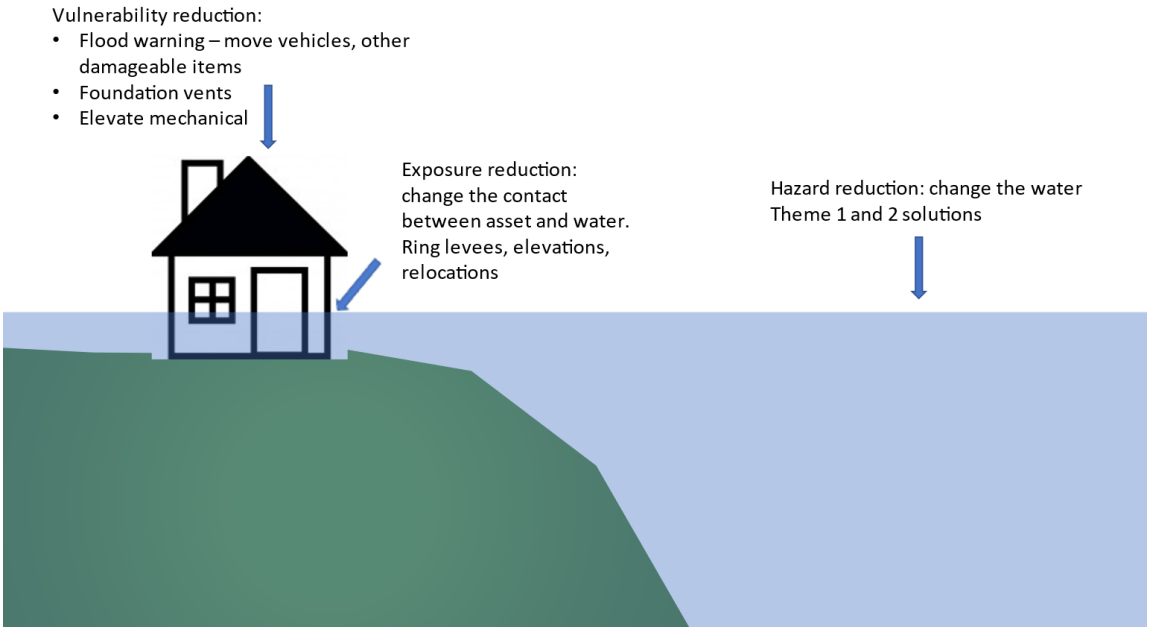

Figure 2. H, E, and V for Risk Reduction.

Programs to quickly provide liquidity in the form of post-flood aid could improve recovery times but would not encourage pre-flood risk reduction. An aid-only approach to resiliency is represented by the yellow line. Similarly, elevating a property could reduce damage initially but would not address recovery time; this risk reduction-only approach is represented by the blue line. There are cost-effective combinations of measures that reduce the initial shock and also speed post-flood recovery, shown as the red curve in Figure 1; in this illustration, there is pre-flood spending on some combination of H, E, and V, as long as savings in insurance premiums exceed the cost of H, E or V measures. Of course, this cost-effectiveness comparison assumes that insurance has been purchased (or funds to self-insure for recovery have been set aside). The red curve represents the result of having insurance coverage in place.

[5] If already in the floodplain, an entity may choose to leave the floodplain by selling, moving, or abandoning the asset.

[6] There may be factors that influence the initial loss or that speed recovery that are independent of resiliency actions taken at the parcel level. For example, community cohesion may be correlated with speed of recovery.

The insurance premium is the link for deciding the best level of pre-flood risk reduction and paying in advance to have the funds after a flood for post-flood recovery. However, this linking within a watershed can only be realized if most of the occupants of flood-prone properties carry insurance coverage. In both Canada and the United States, the current structure of flood insurance offerings, combined with limited willingness/incentives to voluntarily purchase flood insurance, has resulted in a flood insurance coverage gap. For the flood risk management value of insurance to be realized, no significant coverage gap can exist: all property owners must be offered insurance they are willing and able to pay for, and most must purchase the insurance.

4 FLOOD INSURANCE: CURRENT BASELINE

4.1 UNITED STATES

The US government-run National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA), was created in 1968 at a time when flood insurance was not offered by private insurers. The NFIP was expected to moderate the political demand for increasing federal disaster assistance by making insurance available at a reasonable (in today's terms, *affordable*) premium. US post-flood aid for the repair of residential and commercial properties in the United States has been and remains limited. (See Box 2). However, premiums were also expected to reflect flood risk as much as possible.[7]

BOX 2: POST-FLOOD AID IN THE UNITED STATES

In the United States, post-flood disaster aid for residential property owners is provided primarily, although not exclusively, through the FEMA Individual Assistance Program. Despite widespread perceptions to the contrary, this aid is uncertain, limited, and often delayed. Federal disaster aid to individuals becomes available only when the President issues a disaster declaration when the need for aid is determined to exceed state and local capability; hence, aid is not available for small-scale flooding, even when some individual properties in a local community are severally damaged. If a disaster declaration is made, residential property owners must apply for the aid and meet specific eligibility criteria. If the aid is approved, federal grants to repair and replace damaged property do not usually exceed a few thousand dollars and are capped at US$30,000. Finally, this limited federal disaster aid often takes months or years to reach aid recipients.

The NFIP makes flood insurance available, as a stand-alone product independent of private homeowners' insurance, to any property owner in a community that is a partner to the NFIP. An NFIP partner community agrees to require the first floor of any new or substantially improved structures located in the Special Flood Hazard Area (SFHA)[8] to be elevated above the stage of the one percent chance flood level (reduce exposure) or be dry flood-proofed (reduce vulnerability).

[7] Premium setting practices in an early program were primitive by contemporary insurance rating standards. The NFIP has announced it will be modernizing its rating practices when it implements *Risk Rating 2.0- Equity in Action*.

[8] The special flood hazard area (SFHA) is defined by that area inundated by the flood that has a one percent chance of occurring in any year, otherwise known as the 100-year flood.

These regulations, when combined with federal programs to reduce the hazard and to retrofit or remove existing buildings, would limit the growth in expected flood damages and limit future claim exposure.[9]

The initial expectation was that once insurance was available at reasonable rates, individual property owners would be ready and willing to purchase that coverage. Within five years of the program's operation, it became clear that the demand for insurance was limited. In 1973, Congress created the **mandatory purchase requirement** (MPR), meaning that any property owner with a federally backed mortgage within the special flood hazard area was required to buy flood insurance at least equal to the value of the loan. The mandatory purchase requirement remains in effect today, and effective enforcement of the purchase requirement has been achieved. While lenders do enforce the purchase requirement inside the SFHA, they do not require coverage beyond what the MPR requires. The NFIP today provides insurance for five million policy holders in 22,000 participating communities, representing 98% of the US population. A substantial number of policies currently in effect are the result of mandatory purchases.

Premium revenues allowed the program to be fiscally solvent through the year 2004. After Hurricane Katrina in 2005, the NFIP paid out more in claims than they paid over previous years of the program, honoring these claims by borrowing from the US Treasury. Subsequent storms also required the NFIP to use its borrowing authority. Congress has forgiven a share of this debt, but the program currently has a debt to the US Treasury of over US$20 billion. Multiple causes of the debt have been discussed in congressional reports, but the most significant contribution to the debt has been the adverse selection[10] problem that has long plagued the program. Specifically, most of the policies in the NFIP have been, and remain, concentrated in areas of high flood and coastal storm risk.

Since 2005, the tension between the goals of fiscal solvency based solely on premium revenues and charging affordable premiums has been resolved in favor of affordability, at the expense of fiscal solvency. In effect, the current debt is the price the nation is paying to have affordable premiums. Now the NFIP has begun implementing Risk Rating 2.0, with rating practices that will begin to align premiums with individual property risk, addressing the adverse selection problem. However, the existing debt remains and will persist, as the implementation of Risk Rating 2.0 rolls out over several more years.

Insurance provides more funding, more quickly than disaster relief in the United States. Insurance can also be preferable to self-insurance, particularly for low- and moderate-income families that lack sufficient reserves to cover substantial damage, and have limited borrowing opportunities. However, over this long history, despite decades of trying to keep premiums affordable, the NFIP has been characterized by relatively low take-up rates, even with the mandatory purchase requirement in place for some property owners. This means that millions of homeowners at risk of flood damages lack flood insurance. Five years ago, the NFIP announced a goal to double the number of policies in force by 2023. In announcing that goal, the NFIP called upon the private insurance industry to participate in reaching this goal by offering flood insurance to complement the NFIP offerings.

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[9] The United States has had two distinct flood insurance programs since 1968. The program began as a private/public risk sharing partnership, with a pool of 125 private companies. The aspiration was for flood insurance policies in force to grow, for risk to be controlled, and over time, for the partnership to transition to a wholly private insurance program. The partnership arrangement ran from 1968 to 1978, when the program transitioned to the government-run program that remains today. One carryover from the partnership is the use of the federal treasury borrowing authority to cover claims when the NFIP reserve fund is unable to do so. A second carryover is the zone-based rating system for setting premiums that will soon be replaced by **Risk Rating 2.0- Equity in Action**.

[10] Adverse selection refers to a situation in which the buyers and sellers of an insurance product do not have the same information available; for example, when an insurance company extends insurance coverage to an applicant whose actual risk is substantially higher than the risk known by the insurance company.

At this time, private flood insurance is not offered by most large property insurers, even as an optional endorsement in homeowners' policies. Private flood insurance offerings are written by small companies that offer only flood coverage, largely in areas of low to moderate risk. This market is developing, although the total amount of policies written is currently tiny in comparison to the more than five million policies currently written by the NFIP.

The Lake Champlain Shoreline

The land-use regulations the NFIP requires in its partner communities, and perhaps awareness of the flood hazard, came together after the 1976 flood to motivate property owner decisions that have reduced flood exposure and vulnerability along the New York/Vermont Lake Champlain shoreline. This is admittedly speculation based on a comparison of the number of homes damaged and monetary damages reported in the 1976 and 2011 floods. Over 2,000 homes were flooded in 1976, and fewer than 800 in 2011, despite higher water levels (the 1976 flood levels peaked at 30.8 m (101.1 ft.) NAVD88, while the 2011 flood peaked at 31.32m (102.77 ft) NAVD88).

Given this limited flood risk at present, it is not surprising that NFIP data show that no floodplain residents living along the Lake Champlain coastline purchase flood insurance, even though flood insurance is available at an affordable premium from both the NFIP and from some private insurers. Because the Lake Champlain shoreline has low take-up but also carries low risk, this area will not be a target area for the FEMA moon shot. This conclusion may not apply in the tributaries to the Lake, and if risk changes over time, increasing coverage along the lakeshore may become a higher priority for flood resiliency policy.

4.2 CANADA

Since 2016, *overland* flood (primarily fluvial and riverine) insurance has been available in Canada through private insurers, unlike the US government-run NFIP. Each insurer chooses whether to offer coverage, where it will offer that coverage, and at what premium. The coverage can be a standalone endorsement or might be offered as a bundle with sewer backup coverage, which is also a standalone endorsement. Individual insurance companies have different policy offering criteria and use different methods to assess flood risk at individual properties.[11]

With policy offerings only beginning in 2015, it is not surprising that insurers have been reluctant to offer coverage in higher risk areas, and that policies come with high deductibles combined with capped coverage limits. A statement from Insurance Bureau of Canada (IBC) CEO, Don Forgeron, after a 2019 flood in Quebec reflects the perspective of private insurers:

> *In all the jurisdictions we have looked at, where they fail is with the high-risk properties. That's where the vast majority of their losses come from, and the question becomes: how do you price that? If it's not full risk-based pricing, who pays it? And how is it paid? That's usually where these programs fall down and that's what the federal government has asked us to take a look at in terms of some sort of high-risk pool.*

[11] Canadians can access online tools that provide a risk assessment and premium quote from different insurers. Two examples, for illustrative purposes only, are:
https://www.belairdirect.com/en/home-insurance/quebec.html (accessed July 23. 2021)
https://www.getfloodinsurance.ca/(accessed July 23. 2021)

Numerous academic papers and reports (See Appendix A for a partial list) have explored the future of Canadian flood insurance, with reference often made to *high risk* and *pool*. *High risk* most often refers to any property that has a one percent chance of pluvial or fluvial flood damage in a given year. With *pool*, the reports refer to all existing residential or commercial property with more than a one percent chance of flooding. In some reports, any property that can be flooded during the one in twenty-year event is deemed uninsurable, and for these properties, flood risk needs to be reduced by H, E, or V actions, or the property needs to be removed from the floodplain.

The IBC reports that about 30 percent of properties in Canada carry flood insurance, but few policies are found in high-risk areas. Lacking insurance, property owners rely on their resources to recover after a flood, or on post-flood aid. Post-flood aid for repair and rebuilding is offered through the federal government and the provinces, in effect being a substitute for a post-flood insurance payout, although this aid may be delayed, and there is no assurance of its adequacy for rebuilding (See Box 3).

The Canadian federal disaster assistance program and all provincial programs specify that funds are available only for "uninsurable" losses, with no mention of the cost of the premium to secure the insurance. Governments can refuse to pay aid for flood damage now that the private sector has stepped into the flood insurance business. However, as noted, in many places, flood insurance is not available at all, and reliance on aid programs continues.

The current size of, and possible growth in, the post-flood aid budget means that the federal and provincial governments have a financial stake in expanding insurance coverage as a replacement for aid. Canadian governments want a private insurance market to step in to replace aid but recognize that private insurers face limits on whom they can profitably insure at premiums households would be willing and able to pay. Budget funds now being spent on aid could be redirected to partnering with the private sector in risk-sharing, and through these financial commitments, make flood coverage available for the high-risk pool.

BOX 3: POST-FLOOD AID PROGRAMS IN CANADA

The Federal Disaster Financial Assistance Arrangements (DFAA) is a federal program that reimburses provinces and territories for some post-flood aid payments that provinces make to residential property owners for the repair of flood damage. The program guidelines limit aid payments to uninsured losses to primary residences. However, flood insurance has not been widely available in Canada for very many years and is largely unavailable in what the insurance industry has called high-risk areas. The result is that in most instances, costs for flood damage are reimbursed through post-flood disaster aid, although provincial programs differ in caps and eligibility.

Provincial additions to DFAA in Quebec were reformed in 2019. In Quebec, receipt of aid requires the property owner in a high-risk area to contact their insurer and obtain a letter of refusal or acceptance when there is flood damage.

Q. I have flood insurance, but I think the insurance amount will not cover all the losses incurred. Can I request compensation to the ministère de la Sécurité publique (Public Safety Department)?

A. Yes, absolutely. We suggest you open a file with your private insurer and with the ministère de la Sécurité publique. The compensation amount you receive from your private insurer will pay for cleaning and repairs to the home, replacing furniture, and for additional living expenses for accommodation or food, up to the coverage amount. If this amount is not enough to cover all the damage suffered, you can file a claim with the ministère de la Sécurité publique. Note that you cannot be compensated by your insurer and by the government for the same items.[12]

The property owner would affirm the claim was refused by the insurer, presumably because the adjustor determined that water damage was caused by sewer backup or a roof leak, which may be covered, or by water entering through windows, doors, and cracks (i.e., overland flooding), which usually is not covered. If aid is approved, and it is the first claim, compensation of up to 90 percent of rebuilding costs incurred, up to CDN$200,000 or 100 percent of the replacement cost of the property, whichever is lower, may be awarded. If there are future requests for aid at the same property, the aid can again be for up to 90 percent of rebuilding costs incurred, but there is a cumulative lifetime limit. In comparison to the US aid programs, the Canadian programs are more generous, although these programs will still not cover all repair costs, and aid may be delayed.

[12] infoassurance - 9 questions about flood insurance

Along the Richelieu River

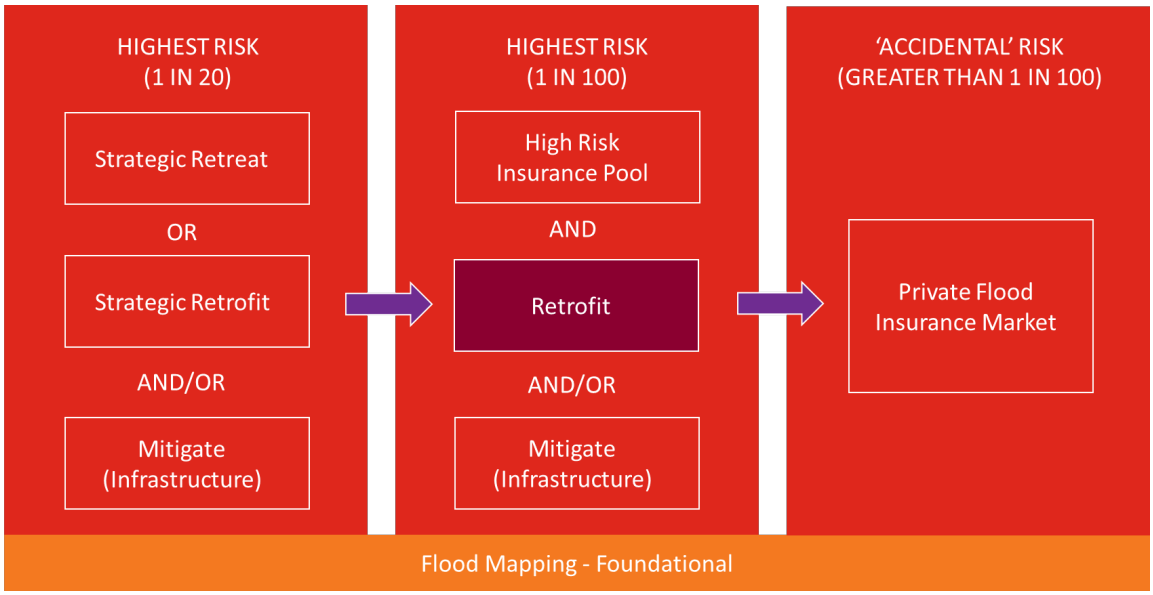
The IBC does not regularly track which homes are insured, but in 2017, it reported the take-up rate in Quebec for flood insurance was about 33 percent, and insured properties were likely properties at low or medium risk. In 2020, the IBC reported that about 222,000 properties (about 8 percent of all properties) were deemed *high-risk* across Quebec. Most properties along the Richelieu River in the study area are at high risk, and therefore unlikely to be insured.[13]

[13] Various Canadian private insurers offer flood coverage in Quebec (for example here, here, here and here) but some do not, as in this example.

5 CLOSING THE COVERAGE GAP: A CONCEPT OF LAYERED COVERAGE

The current structure of the flood insurance offerings in both Canada and the United States, combined with a reluctance to voluntarily purchase flood insurance, has resulted in a flood insurance coverage gap. In the United States, this gap is entirely attributable to limited demand for the stand-alone flood coverage offered by the government-run NFIP. In Canada, the gap results from private insurers' reluctance to offer stand-alone flood coverage in what they deem to be *high-risk* areas, and a low take-up in other locations where private insurers offer stand-alone coverage. In Canada, the policy focus is on extending private flood insurance to properties with high flood risk; however, the same factors that limit demand in the United States, as well as in other international settings, would also be present in Canada, even if insurers were able to offer coverage at "affordable" premiums within the higher risk areas.

The challenge to closing the flood insurance gap in Canada is described in a 2020 IBC report that proposes a three-part national action plan organized according to three categories for differentiating flood risk[14] (Figure 3). The highest risk properties (with a one in 20 chance of flooding in any year) will not be insured, unless retrofitted to be less prone to flooding (left side box in Figure 3). The private sector would offer insurance to all properties with a less than one in 100 chance of flooding in any year (right box in Figure 3). The insurable high-risk pool is the center box in Figure 3. Properties in the middle box might realize lower premiums as governments and property owners implement risk-reducing H, E, and V measures.



Source: Insurance Bureau of Canada

Figure 3. National Action Plan on Flooding (after The Geneva Association 2020 report).[15]

[14] Insurance actuaries do not define high risk by return frequency, even though this is how the IBC reports describe it for communicating to the general public. How insurance actuaries would define high risk when rating is discussed in more detail below.

[15] Golnaraghi, M., Thistlethwaite, J., Henstra, D. and Stewart, C. 2020. **Flood Risk Management in Canada Building flood resilience in a changing climate.** The Geneva Association. International Association for the Study of Insurance Economics, Zurich.

These H, E, and V measures can move any particular property from the left to right in Figure 3; failure to implement such measures, if the risk is increasing over time, may cause a property to move from right to left. The responsibilities of governments who seek to bring about widespread coverage of insurance include being proactive in promoting, and indeed funding, implementation of H, E, and V measures. This responsibility is discussed in more detail below.

An unstated premise of this figure is that insurers can position a property within Figure 3 based on an accurate risk assessment for premium setting purposes. This premise suggests a responsibility of governments to improve and make publicly available data and tools that insurers can use to accurately calculate flood risk within communities across the nation. This government responsibility is discussed further below.

Leading up to the 2020 IBC report, a multi-stakeholder task force led by IBC and Public Safety Canada prepared a highly conceptual list of options for closing the flood insurance coverage gap and scored each based on six agreed-upon criteria. (Table 1).

Table 1. IBC Options Table.

Table 1: Reviewing Options against Principles

● STRONG ● NEUTRAL ● WEAK	RISK BORNE BY		
PRINCIPLES	**HOMEOWNER (OPTION 1)**	**GOVERNMENT (OPTION 2)**	**HIGH-RISK POOL (OPTION 3)**
Affordability	●	●	●
Inclusivity	●	●	●
Efficiency	●	●	●
Optimal Compensation	●	●	●
Shield the Taxpayer	●	●	●
Financially Sustainable	●	●	●

In Option 1, flooding of private residences is no longer covered by aid programs, and homeowners either voluntarily purchase an overland flood endorsement from a private insurer, paying the premiums required for actuarial soundness, or choose to go without insurance. The stakeholders assessed that Option 1 would not lead to flood resiliency for the high-risk pool, scoring low on affordability and inclusivity. Of course, ending post-flood aid was the assumption that gave this option a high score on "shield the taxpayer," but the political likelihood of that design feature was questioned.

In Option 2, the private sector continues to offer coverage and expands into areas it is not currently insuring, as its risk tolerance allows. Property owners who are not offered flood insurance, or who find the premium unaffordable, would continue to rely on post-flood disaster aid for recovery after flooding. Public investments and improved data to support insurance rating practices, combined with investments in H, E, and V, might make insurers willing and able to offer flood insurance in areas where it is not now offered. This option scores high on affordability only because it assumes that few high-risk property owners would be purchasing the policies, and would continue to rely instead on post-flood disaster aid. For this reason, Option 2 scores low on efficiency, optimal compensation, and shielding the taxpayer.

In Option 3, properties that are at high risk of flooding would be assigned by their existing insurer to a pool, and then would be offered flood insurance at an affordable premium. The property owner could then choose whether to purchase the insurance or rely on post-flood aid to speed recovery. The pool would be run as a risk-sharing private partnership administered as a cooperative agreement among private insurers. The pool would set premiums, with collected premiums deposited to the pool's capital reserve fund for honoring claims. The pool's reserve would need to be built with contributions from governments, especially in the early years of the program. Option 3 scored the highest in extending the offering of flood insurance at affordable rates to all property owners in Canada, including those in high-risk areas.

Common to all the options is that property owners would voluntarily choose to purchase standalone overland insurance coverage, and overland flood damage would not be one of the perils included in the basic homeowner's policy. As a result, none of the options address the problem of limited voluntary purchase that has confronted the United States and other nations over the years, so none of these options can be expected to create the widespread coverage needed for flood resiliency.

Since the publication of the 2020 IBC report, these options have been further evaluated and refined. In 2021, two reports were submitted to Public Safety Canada, giving even more definition to the designs described above and providing an evaluation of more detailed options. A March 2021 report from Daniel Henstra, "Flood Insurance in Canada: Policy Context and Lessons from the International Community," describes the experience with flood insurance in Australia, France, the United Kingdom, and the United States, and includes an evaluation of those programs with lessons for the design of a Canadian strategy for insuring high flood risk properties. Building on that report, Jason Thistlethwaite prepared an April 2021 report titled "Flood Insurance Design: Assessing Suitability and Recommendations for Sustainable Insurance," which describes different models for expanding flood insurance for high-risk properties. Table 2 is taken from the April 2021 Thistlethwaite report.

Table 2. Flood insurance options (Thistlethwaite 2021).

Table 1 : Summary of flood insurance scenarios and models

Scenario	Description	Model 1	Model 2
1. Risk Pool	High-risk policies are redistributed and pooled together	Insurers are responsible for pool administration and funding. Limited risk-adjusted premiums via subsidy funded by levy	Insurers administrate but government responsible for funding. Premiums fully risk-adjusted.
2. State Insurance	Risk is removed and redistributed by the government	Crown corporation administers and sells coverage in primary market. Premiums are subsidized	Crown corporation administers and sells reinsurance in econdary marker. Premium fully risk-adjusted
3. Parametric-based community insurance (PBC)	Community redistributes risk for frequent flood events in high-risk areas	Community facilitates the purchase of parametric insurance by property owners in high-risk areas	Crown corporation brokers and facilitates parametric insurance for municipalities who purchase for high-risk areas

In Table 2, the risk pool under Scenario 1 aligns with Option 3 in the IBC report. Model 1 is patterned after the UK approach. Model 2 further adapts the IBC's 2019 risk pool proposal along the line of an Industry Task Team (ITT). The state insurance model (Scenario 2) aligns with the US NFIP. The third scenario introduces two concepts for offering coverage that had not appeared in previous reports. The first concept envisions a government body securing, or even providing, insurance for high-risk properties. The second new concept involves offering insurance as a parametric product, as opposed to an indemnity-based product. (Community offering of parametric insurance is discussed in more detail below in the explanation of Layer 1 coverage.)

The April 2021 Thistlethwaite report uses several criteria from the National Task Force on Flood Insurance and Relocation to evaluate the different models (Table 3). In general, Thistlethwaite concludes that although additional assessments are needed, some combination of the ideas from the risk pool scenario and state programs models offer the best path forward. The report did not score the community parametric scenario highly against the report's evaluation criteria. However, the community parametric option was offered as a complete substitute for the risk pool or state insurance, as opposed to a supplement to, or support for, those programs.

Table 3. Insurance Program Evaluation Criteria.

Table 2: Evaluation objectives and criteria	
Objective	**Description**
Adequate compensation	Providing adequate and predictable financial compensation for residents in high-risk areas
Risk reduction	Incorporating risk-informed price signals and other levers that incentivize risk-appropriate land use, mitigation, and improved flood resilience
Affordability	Ensuring affordability to residents of high-risk areas with specific consideration for the needs of marginaized, vulnerable and/or diverse populations
Availability	Providing coverage that is available for those at high-risk across all regions
Market penetration	Maximizing the take-up of flood insurance by residents of high-risk areas
Value for money	Providing value for money for governments and consumers

5.1 LAYERED COVERAGE: A CANADIAN APPLICATION

A layered coverage design envisions a public-private partnership to close the flood insurance coverage gap for existing residential (and some commercial) buildings in areas currently deemed high-risk.[16] The conceptual design builds upon insurance concepts that have been described and evaluated within the United States and in recent reports from the Insurance Bureau of Canada and Public Safety Canada.[17]

Layer 1

Layer 1 coverage would be offered through a provincial government agency, allowing for the pooling of flood risk across many individual communities.[18] All *developed* properties[19] within a *designated high-risk flood area*[20] in a jurisdiction would be automatically covered up to a low limit, in effect covering the higher frequency, lower consequence floods.[21] For example, the payout might be for up to CDN$10,000, above a CDN$1,000 deductible. The cap would vary by jurisdiction (or other areas) depending on the flood risk profile.

Layer 1 could be described either as a program of *parametric insurance* or as post- flood aid. Whether Layer 1 is described as insurance or aid, the payout would be a set amount based on a measure of an event, called a "parametric trigger," such as water height at a set of gauges. A well-designed trigger depends on instrumentation and any related data analysis that allows for rapid reporting and independent third-party verification. Cost-effective sensor technology and deployment is advancing rapidly and is already used to offer parametric flood coverage in the United Kingdom). There could also be more than one trigger that must be met for payment; for example, the payout might also require some minimal proof of loss.

Most consumers are familiar with *indemnity insurance*, which compensates the insured for the exact amount of a loss (subject to deductibles and coverage limits). However, indemnity-based insurance has administrative and transaction costs for rating risk to set the premium, selling the policies, assessing damages, and then paying claims. All these costs are reduced with parametric coverage. For example, costs for rating and setting premiums are lower for parametric products since this step only requires modeling the hazard and not considering property-level specific features that could influence claims. This means that parametric policies have two important benefits for the first layer of coverage: First, payouts can be made rapidly, avoiding typical delays in securing post-flood aid and settling insurance claims. Rapid payout of funds to the property owner allows for immediate remedial actions that can minimize damage (mold control for example), and for

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[16] There are multiple international examples of how the public and private sectors cooperate to expand the offering of flood insurance. Several of these alternative models have been described in IBC reports, and most recently in the report from Daniel Henstra to Public Safety Canada. In the United States, the NFIP operates as a wholly governmental entity, with an emerging private market operating in parallel with the public offering. The layered coverage strategy begins with the premise that Canada and the provinces are seeking a way to expand private sector coverage, as opposed to offering flood insurance as a wholly public program.

[17] The layered design, if brought to the United States (for example, by a state), could supplement and in some places replace the NFIP or expand the willingness of US private insurers to offer coverage to higher risk properties. However, the layered design would not be applicable to the Lake Champlain shoreline, although it may apply in the tributaries to the Lake in Vermont and New York.

[18] For a high level review of community delivery alternatives see: **https://riskcenter.wharton.upenn.edu/wp-content/uploads/2021/02/Community-Based-Catastrophe-Insurance-February-2021.pdf** (accessed July 25, 2021) . For an example of a detailed design see: **https://www.rff.org/publications/reports/a-proposed-design-for-community-flood-insurance/** (accessed July 25, 2021)

[19] The coverage would be for all residential and some commercial property.

[20] New development would need to comply with floodplain management regulations, would not be eligible for Layer 1 or 3 coverage (i.e., would not be eligible for disaster aid), but would be able to purchase insurance at the premium charged by private insurance companies.

[21] Layer 1 only is available to existing properties. New properties, or "substantially improved" properties, would be expected to pay the private sector premium, and eligibility for disaster aid payments (Layer 3) would not be available.

smaller damages, the payment might prove sufficient for a full recovery. Second, the parametric payout gives the insured flexibility to act on the most pressing recovery need, as determined for each case in the immediate aftermath of the flood.[22]

The insured would pay a fee to a provincial agency for the parametric coverage, with the proceeds deposited in a parametric coverage reserve fund managed by the provincial agency. The provincial agency can act as an "insurer" (collect premiums and provide post-flood payouts), act as a buyer to secure private sector Layer 1 coverage for the communities, or take on a combination of these roles. The responsibility for honoring claims that cannot be covered by the reserve fund would be met by the responsible agency. That agency could choose to purchase re-insurance or rely on funds from the provincial budget, as is done now for post-flood aid.

Owners of a property, confronted with a required payment, would be allowed to opt out, subject to specific conditions. For example, opting out might require participation in community education programs to gain an understanding of flood risk and the limits on post-flood aid in Layer 3. Behavioral economics literature suggests that assigning coverage and then allowing an opt-out provision will increase the number of property owners who accept and pay for Layer 1 coverage, relative to the voluntary purchase (opt-in).[23] (See further discussion below and in Appendix B).

Layer 2

The second coverage layer would be offered in high-risk areas by the private sector as a traditional indemnity-based policy. Consumers could use Layer 1 coverage as a deductible when purchasing Layer 2 and may choose an even higher deductible. Also, Layer 2 insurance would have an upper limit on payout, for any flood, and perhaps a lifetime limit for the property.[24] Losses at a property beyond the cap might be eligible for payment under the revised disaster aid program of Layer 3 (below). The combination of a high deductible and a cap on the maximum payout would bracket the claim exposure, allowing insurance actuaries more certainty when rating the risks for what are now deemed high-risk areas, thereby making insurance companies more likely to charge a premium that most property owners would be willing and able to afford.

Layer 2 coverage would be offered by a pool of private insurers as a standard indemnity-based policy in any area designated as a high flood risk area.[25] The high deductible and government backstop in the form of a cap would lessen the reserve fund requirements for the insurer pool, but a reserve fund would still need to be established and maintained. The government might initially capitalize the pool, buy reinsurance, or stand ready to honor claims in the early years, should the reserve fund not reach adequate levels. The reserve fund would be maintained on an ongoing basis with premium revenues and earnings on investments of the reserve fund balance.[26]

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[22] The potential difference between the actual loss and the payout is referred to as basis risk and is one downside of parametric insurance. However, the Layer 2 cover, in the layered design, addresses the basis risk problem.

[23] **One recent paper**, based on research in Germany, reports that voluntary purchase of the coverage described here would be limited.

[24] Layer 3 (discussed below) acts as a government backstop for losses that exceed the Layer 2 limit. In effect, Layers 1 and 3 are government risk-sharing roles, for partnering with the private sector.

[25] "Pool — (1) A group of insurers or reinsurers through which particular types of risks (often of a substandard nature) are underwritten, with premiums, losses, and expenses shared in agreed ratios. (2) A group of organizations that form a shared risk pool." **https://www.irmi.com/term/insurance-definitions/pool**

[26] The insurers pool is consistent with Thistlethwaite's ITT model.

Layer 2 coverage would include overland flood as default coverage among the other perils covered by basic homeowner's insurance.[27] The amount added to the homeowner's premium for including flood coverage (to meet the actuarial soundness criteria required by regulators) would be isolated and reported to governments and to the insured. The property owner could choose to opt out of Layer 2 and pay a lower premium.[28] An insured might maintain Layer 1 coverage but opt out of Layer 2 coverage; conversely, a property owner who opted out of Layer 1 could still purchase Layer 2.

Layer 3

Layer 3 is a revised version of current aid programs. If a claim exceeded the maximum payout at the second layer, then damages above that limit might be paid by existing disaster aid programs. The primary change from current policy is that eligibility for aid payments begins when damages exceed the Layer 2 level.[29]

If the property owner opted out of Layer 1 or 2 coverage, they would only receive aid for damages exceeding the Layer 2 cap and would be responsible for damages that would otherwise have been covered by Layer 1 or 2. Governments might choose to limit Level 3 aid, leaving owners of the most expensive properties responsible for costs greater than the limits of the post-flood aid.

5.2 LAYERED COVERAGE: IN SUMMARY

The layered coverage strategy, summarized in Table 4, is one possible design for a public-private risk-sharing partnership that could bring comprehensive flood insurance to places and properties currently defined as high risk by the insurance actuaries and underwriters. The government risk-sharing roles in Layers 1 and 3 should make it possible for private companies to profitably provide affordable flood coverage in Layer 2.[30]

The layered coverage strategy does not constitute a government directive to private companies to insure high-risk properties. Rather the design creates an incentive structure organized around risk sharing that will allow private insurers to enter areas that they now consider high risk and offer insurance that is both profitable for the seller and affordable to the buyer. However, in addition to risk sharing, other governmental roles are of critical importance.

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[27] Canadian insurers will be reluctant to include overland flood coverage in the general homeowner's policy because knowledge of flood risk is still highly uncertain for rating purposes. The layering strategy helps reduced some of the rating uncertainty. Also, new **modeling platforms, computing power and data bases can reduce rating uncertainty, as can the claims experience from the US NFIP**, recognizing differences that may exist in housing across the two nations. As noted below, the willingness of insurers to include overland flood coverage in homeowner policies will depend on government investment in upgrading data bases needed for rating purposes.

[28] A 2010 Swiss Re report (Sandink et al. 2010)) argued for including flood in homeowners' policies for all but the highest-risk properties. At that time, there was no overland flood coverage offered by insurers anywhere in Canada. After publication of the Swiss Re report, a series of floods created both public sector interest and "reputational risk" pressure that led insurance companies in Canada to offer overland flood coverage outside high risk areas and as a standalone endorsement that property owners could choose to purchase (opt-in).

[29] Governments might deny aid to any property owner who opted out of Layer 1 or Layer 2 coverage, providing an incentive to participate in the insurance programs, thereby expanding the pool.

[30] While the layered coverage strategy may work for the larger provinces, the federal government may need to take a role for places such as Prince Edward Island or Newfoundland, where the communities are small and government capacities are limited.

The many background papers on Canadian flood insurance acknowledge that expecting private insurers to extend coverage to high-risk properties will require actions and spending by governments. One report notes:

> *For any of these plans to be successful, all levels of government must commit to long-term investment in complementary measures such as mitigation, better flood mapping, and consumer awareness initiatives. It is also necessary to create a system where mitigation investments are reflected in the models' insurers use to price risk, which should then lead to improvements in the availability and affordability of insurance (IBC).*

Table 4. Layered Coverage Summary.

Layer 1	Layer 2	Layer 3
Provincial government leads in creating and offering limited payout coverage Parametric triggered payout All property in community covered A fee might be paid to a "community flood disaster relief fund" All property owners can opt out of coverage, subject to certain conditions	Private insurers offer capped payout indemnity-based coverage to insurable properties in areas now deemed high risk Coverage offered from a pool of private insurers Means-tested premium discounts with revenue equalization payments Included in homeowner all peril policy, with an opt out	Eligibility for post-flood aid begins when damages exceed the Layer 2 cap. Post-flood aid is available to those who opt out of Layers 1 and 2 Post-flood aid can be means-tested based on market value of property, income, non-real property assets

6 BEYOND RISK SHARING: CRITICAL GOVERNMENT ROLES

6.1 H, E AND V RISK REDUCTION

Government support for insurance offerings, and in turn, flood resiliency, entails investing in risk reduction programs and implementing land use and regulatory requirements that limit flood risk.[31] The National Disaster Mitigation Program of Public Safety Canada focuses investments on significant, recurring flood risk and costs, and in so doing, seeks to facilitate private residential insurance for overland flooding. Most importantly, for layered coverage in Canada, federal and provincial governments could help local communities identify the highest risk, difficult-to-insure properties and pay toward reducing the risk at those properties (if the cost of risk reduction is paid for by premium savings) or relocate the properties, when justified by premium savings.[32]

6.2 UNCERTAINTY, PREMIUMS AND BASELINE DATA

Actuaries operate in a world of both risk and uncertainty. A complete risk assessment means that the probability of a particular set of outcomes and the consequences of those outcomes is completely understood. Randomness is expected but can be predicted as a distribution. Uncertainty in the extreme means that probabilities of a particular set of outcomes and/or consequences of those outcomes are not known. An actuary rates risk as the basis for the charged premium, based on the best possible understanding of risk at the individual level and for the pool of insured.[33]

An insurable peril needs to occur randomly, and actuaries need to be able to model the likelihood of the peril (perhaps for different intensities, such as flood stage) and the payout if it occurs, with limited uncertainty. On that basis, insurance companies can sell policies to multiple insured entities with different and independent risk profiles.

A pure premium for an individual property (the insured) is based on a risk assessment and includes administrative costs for providing the risk transfer service. To the extent actuaries are concerned about uncertainty, they add a *load* (an additional cost) to the charged premium. Depending on the insurer's risk appetite, they may find the uncertainty so great that they do not offer the insurance at all. Another possible outcome is that the load for uncertainty becomes so large that premiums become unaffordable for most of the insured.

[31] Quebec has begun a process of limiting damage from future flood events. A comprehensive discussion of floodplain regulation is provided in other white papers in the series.

[32] In the United Kingdom, government has committed to investment in risk reduction as a contribution to the partnership with the private insurance sector. For example, https://www.reinsurancene.ws/flood-re-calls-for-industry-wide-action-to-ensure-a-more-resilient-uk-by-2039/?web=1&wdLOR=c1137CF0F-697A-42BB-8DB1-56A048D139B8 (accessed July 25. 2021) The United States has failed to maintain investments in its hazard reduction programs over the years and has only recently increased spending on exposure and vulnerability reduction. The regulation of new construction and rebuilding after a flood in the SFHA required to enroll in the NFIP has limited flood risk in some communities, but inaccuracies in mapping the SFHA, exemptions to the requirement to build back differently, and (most importantly) the lack of attention to flood risk beyond the SFHA has led to increase in flood risk, without a concomitant increase in coverage of insurance for that increased risk. And, as noted, the take-up rate for flood insurance in the United States is low.

[33] Possible other loads can include charges to build and then maintain a reserve fund, that might include consideration of the size of the insured pool. Of course, private insurers also require a load for profit.

If the flood insurance market is going to be organized around private insurers, as individual companies or as risk-sharing pools, then different companies (risk-sharing pools) will use their own preferred and proprietary modeling and data sources for rating and setting the charged premium, as they each decide whom to insure and at what premium level. In general, private insurers employ a catastrophe modeling firm (there are many) to simulate rainfall, runoff, and flood stages. All models require area-specific data inputs on topography, property locations, and characteristics, similar to the content of flood maps. Different catastrophe models can give different answers largely because of the absence of the fine-scale data necessary to make the ratings more accurate. This rating challenge confronts the NFIP and private insurers within the new US private flood insurance market, and the property insurance industry generally, as the underwriting process sets charged premiums.

In the near term, private sector actuaries in Canada will face significant analytical challenges, given the dearth of good data for populating various models. This leads to uncertainty when setting premiums, which can, in turn, result in higher premiums. To a limited extent, the layering strategy does help reduce the costs of uncertainty. Governments can further reduce this uncertainty for actuaries by investing in modern tools for risk assessment, and developing LIDAR-based topographic data and building inventory data. These data can be used by insurance actuaries in rating. At the same time, they can be used to build modern flood risk maps as risk communication tools that can increase willingness to pay for insurance, while supporting regulation of floodplain land use. Public Safety Canada has made this development of improved data a priority.

6.3 BUILDING AN INSURABLE POOL

The *insurability* of a peril benefits from both widespread take-up and an absence of adverse selection. The problem of *adverse selection* is addressed by full risk pricing, with means-tested discounts, default coverage in Layers 1 and 2, and making the layered coverage system only available to properties already constructed within the high-risk floodplain. However, without widespread purchase by property owners, insurers will face the problem of correlated risk (geographic concentration of claims in a limited area), which can only be addressed by spreading, or distributing, risk. A single firm might spread this risk by having a larger take-up, i.e., across many business lines and for multiple perils.

In Canada, the current challenge is to bring coverage to a single peril. One way to do this, at least in the near term, would be for that peril to be covered by multiple insurers, across space, as members of an insurers pool. Insurance regulators at the federal and provincial levels may need to make rulings that allow for the creation of a private insurers pool, both in allowing a pool to be formed and in setting the policy terms offered by the pool – especially affirming that private insurers can cap payouts for any flood.

Even with the formation of a pool, the challenge remains of increasing the take-up to spread risk across a large population of insured entities with different and independent risk profiles. Widespread coverage is needed, but flood insurance take-up is always low wherever it is offered as a voluntary purchase option. Insurance regulation may play two roles in increasing coverage: First, regulators could mandate coverage of overland flooding by default in basic homeowners' coverage. Second, in Layer 2, governments may need to partner with insurance regulators to direct the pool to offer means-tested premium discounts for affordability. The pool would be compensated for any forgone premium revenue with a payment from the government to the private insurers' pool reserve fund.

Motivating Purchase of Flood Insurance

Floodplain property owners accept flood risk costs to secure location-specific benefits. A floodplain property owner will easily consider the immediate and readily understood location-specific benefits, but the uncertain prospects of incurring the unfamiliar adverse consequences of flooding (property replacement and repair, inconvenience, post-flood trauma) may be less tangible. The flood insurance premium converts the uncertain and unfamiliar flooding impacts to a certain cost. Insurance demand depends on how the floodplain asset owner values the risk transfer service offered by the insurer, relative to the premium charged.

Price is a factor in insurance demand, and the layering design helps make premiums "affordable". Nonetheless, paying for flood insurance premiums competes with other uses for a household's budget, and as household income falls, paying the flood insurance premium comes at the cost of forgoing other necessities. For that reason alone, securing widespread coverage of flood insurance in the high-risk areas may require offering means-tested discounts for premiums in both Layer 1 and Layer 2, and targeting post-recovery aid to those least able to bear the cost of flood damages when implementing Layer 3.

Governments responsible for Layer 1 will have to make decisions on how much, if anything, to charge floodplain property owners for the coverage being offered under that layer. Meanwhile, for premiums offered under Layer 2 to be discounted for some property owners from the full risk rate, some entity would need to make equalization payments to the private insurers to make up for this lost revenue. These equalization payments could come from surcharges on other policies in effect (a cross-subsidy), as is the case in the United Kingdom, or could be provided from general taxpayer funds at the provincial or federal level.

Default Coverage in Basic Homeowners Policy

Widespread coverage will not be secured simply by lowering prices for certain property owners, or by improving communication about flood risk. The published literature describes multiple factors other than the premium that limit the demand for flood insurance, even among property owners at high risk who can afford to pay the premium and have been provided with clear and effective flood risk communication programming (see Appendix B). This literature will not be reviewed here, except to note that voluntary purchase of flood insurance cannot be expected to result in widespread purchasing. For this reason, the proposed design envisions covering all properties and charging a fee for coverage in Layer 1, and regulations mandating the inclusion of flood coverage in basic homeowners' coverage for Layer 2. However, mandatory coverage that results in a new government fee or that raises premiums is likely to be resisted by homeowners and by insurance regulators. Having an opt-out provision can make mandatory coverage or mandatory offers more acceptable, and elections to opt out will be less likely if risk communication programs make the extent of the flood risk known to the property owner and if the benefits of flood insurance for speeding recovery are explained carefully, including limits on eligibility for disaster aid in the future.

7 CONCLUSIONS

This paper has proposed a layered coverage strategy for closing the flood insurance gap. Risk sharing is the logic behind a government entity being responsible for securing Layer 1 coverage, focused on high frequency, low consequence events, and a high deductible. Risk sharing is also the rationale for capping Layer 2 coverage and making payments, as disaster aid, above the cap (Layer 3). Financial risk-sharing with a private insurers' pool limits claims exposure, reducing reserve requirements, lowering premiums, and expanding the willingness to offer insurance. Financial participation with private insurers in risk-sharing should satisfy federal and provincial governments' interest in transferring post-flood aid payments to insurance, and at the same time capture the incentives for risk reduction that come with insurance. However, some of the federal and provincial budget savings from reduced aid payments will need to be directed to supporting the design and offering of Layer 1 coverage to support the provincial agency as the source of Layer 1 coverage.

This strategy could be applied throughout Quebec and across Canada, but the focus of this paper is the specific flood risk along the Richelieu River. Given the nature of the flood risk along the Lake Champlain shoreline, widespread take-up of flood insurance should not be expected. However, in the case of an extreme event, the states of Vermont and New York might consider an innovative approach to insuring against catastrophic flooding.

Jason Thistlethwaite, in an April 2021 report to Public Safety Canada, used six criteria to guide a conceptual evaluation of a range of flood insurance options for Canada. These criteria are listed in Table 5 as they appear in the Thistlethwaite report.

Table 5. Evaluation Criteria.

Objective	Description
Adequate compensation	Providing adequate and predictable financial compensation for residents in high-risk areas
Risk reduction	Incorporating risk-informed price signals and other levers that incentivize risk-appropriate land use, mitigation, and improved flood resilience
Affordability	Ensuring affordability to residents of high-risk areas with specific consideration for the needs of marginaized, vulnerable and/or diverse populations
Availability	Providing coverage that is available for those at high-risk across all regions
Market penetration	Maximizing the take-up of flood insurance by residents of high-risk areas
Value for money	Providing value for money for governments and consumers

The layered coverage strategy scores well against the six evaluation criteria:

Adequate compensation: The layered coverage design provides timely and adequate funding for speeding recovery for property owners who do not opt out of Layer 1 or 2 coverage. Those who do opt out may be able to self-insure up to the limit of Layer 2 coverage.

Risk reduction: The partnership concept that is fundamental to the design of the layered program requires public agencies to invest some disaster relief savings to create policies requiring the relocation or floodproofing of uninsurable or recurring risk properties to make premiums more affordable. Both Layers 1 and 2 coverage will provide premium savings as an incentive for a wide variety of hazard, exposure, and vulnerability risk reduction implementation measures.

Affordability: Government responsibility for Layers 1 and 3 make Layer 2 private flood insurance affordable within high-risk areas. Layer 2 coverage could be made more affordable for lower-income populations with premium discounts, coupled with equalization payments to the private sector pool offering Layer 2 coverage.

Availability: The availability of flood insurance in high-risk areas will depend on the financial commitment of governments to use savings in future disaster aid as support for Layer 1 coverage. The availability of affordable Layer 2 coverage will depend upon insurance regulator facilitation of private industry pooling.

Market penetration: The layered coverage system is designed to make flood insurance available to all properties within the high-risk areas. The opt-out provision that is central to Layer 1, along with requirements that overland flooding be included by default in basic homeowner policies for Layer 2, will increase take-up rates relative to voluntary purchase.

Value for money: Under current programs, significant future disaster aid payments are likely. If this expected future spending is viewed as a government liability, that liability can be reduced by spending to establish the layered coverage design that will reduce future disaster aid payments. On balance, the government cost of implementing the layered insurance coverage should be paid for by savings on future disaster aid payments, while the value to society will be increased flood resilience.

The next step in the IJC work will be the modeling and evaluation of alternative layered insurance designs to enhance flood resiliency for the approximately 3,000 properties at high risk of flooding along the Richelieu River. This empirical work will illustrate how an integrated program for flood risk management can be implemented with insurance as the platform for integration, or H, E, and V, and insurance purchase to secure flood resiliency. The same analysis will describe the role of governments and budget expenditures, as compared to the baseline of growing post-flood aid (in Quebec).

APPENDIX A - Selected Papers on Canadian Flood Insurance

Boudreault, Mathieu, Boudreault, Grenier, Patrick, Pigeon, Mathieu, Potvin, Jean-Mathieu, Turcotte , Richard, 2020. Pricing Flood Insurance with a Hierarchical Physics-Based Model. North American Actuarial Journal, 24:2, 251-274. 2020.

Calamai, Lapo and Andrea Minano, 2017. Emerging Trends and Future Pathways: A Commentary on the Present State and Future of Residential Flood Insurance in Canada. Canadian Water Resources Journal 42 (4): 307–14.

Canadian Council of Insurance Regulators, 2016. Natural Catastrophes and Personal Property Insurance. July 2016.:

Canadian Council of Insurance Regulators, 2017. Natural Catastrophes and Personal Property Insurance. Summer 2017.

Davies, James B., 2020. Reforming Canada's Disaster Assistance Programs. . UTP Journals. Volume 46 Issue 2, June 2020, pp. 187-197.

Davis, George, Stacey Gotham, Alan Frith, Jim Christie, and Stanley Caravaggio, 2018. Incorporation of Flood and Other Catastrophe Model Results into Pricing and Underwriting. Ottawa: Canadian Institute of Actuaries.

Henstra, Daniel and Jason Thistlethwaite, 2017. Flood Risk and Shared Responsibility in Canada: Operating on Flawed Assumptions? Centre for International Governance Innovation, Brief No. 116 — September 2017.

Henstra, Daniel, 2021. Flood Insurance in Canada: Policy Context and Lessons from the International Community. Report submitted to Public Safety Canada. March 2021.

Insurance Bureau of Canada, 2020. Financial Management of Residential High-Risk Flood Properties through a Flood Insurance Pool: An IBC White Paper. Toronto, ON. 2020.

Oulahen, Greg, 2015. Flood Insurance in Canada: Implications for Flood Management and Residential Vulnerability to Flood Hazards. Environmental Management 55 (3): 603–15.

Sandink, Dan, Paul Kovacs, Greg Oulahen, and Dan Shrubsole, 2016. Public Relief and Insurance for Residential Flood Losses in Canada: Current Status and Commentary. Canadian Water Resources Journal 41 (1–2): 220–37.

Sandink, Dan, Paul Kovacs, Greg Oulahen, and Glenn McGillivray, 2010. Making Flood Insurable for Canadian Homeowners: A Discussion Paper. Toronto, ON: Institute for Catastrophic Loss Reduction & Swiss Reinsurance Company Ltd.

Thistlethwaite, Jason, 2013. The Emergence of Flood Insurance in Canada: Navigating Institutional Uncertainty. Risk Analysis, August 2013.

Thistlethwaite, Jason, 2021. Flood Insurance Design: Assessing Suitability and Recommendations for Sustainable Insurance. Report submitted to Public Safety Canada. April 2021

Thistlethwaite, Jason, Daniel Henstra, Craig Brown, and Daniel Scott, 2020. Barriers to Insurance as a Flood Risk Management Tool: Evidence from a Survey of Property Owners. International Journal of Disaster Risk Science 11 (3): 263–73.

APPENDIX B – Behavioral Economics and the Demand for Flood Insurance

Research in the behavioral sciences, beginning in the 1970s but accelerating recently, describes two mental systems that people use to form judgments, in this case about expected flood risk costs and the value of insurance to them.[34] System 1 describes intuitive decision processes that employ heuristics, or mental shortcuts. One example of a heuristic is that individuals will think a flood hazard is more likely when example experiences come readily to mind, referred to as the availability heuristic. Therefore, soon after a flood, an individual may judge that future floods are more likely, and perhaps be more willing to purchase flood insurance if offered. On the other hand, the gambler's fallacy suggests that after an event occurs, individuals often believe the likelihood of another similar event occurring has declined; to illustrate, some people may believe that two 100-year flood events cannot occur in the same area within a few years. This would suggest that immediately after a flood, individuals will be less likely to buy flood insurance, and if they had insurance, will be less likely to renew it. Note that in the immediate aftermath of a flood, the availability heuristic and the gambler's fallacy heuristic will lead to different decisions about whether to purchase insurance.

System 2 thinking is more deliberative, employing either an informal or formal process of evaluating information; it is often considered the domain of experts who employ tools of statistical inference.[35] However, the formality of the analysis is *not* what describes System 2. Rather, System 2 can be defined as any process of forming judgments that is *not* based on heuristics. Government risk communication programs most often rest on an analytical foundation of System 2 thinking. These programs explore ways to communicate System 2 information to inform the judgments of households, businesses, and local governments. In effect, these risk communication programs, perhaps without explicitly realizing it, seek to replace System 1 thinking with System 2 thinking.[36] [37]

System 1 thinking dominates the assessment of flood risk: With limited time and attention, and myriad other day-to-day decisions to be made, floodplain property owners may not take the time to think analytically about flood risk and insurance. Flooding is remote in time, infrequently experienced, and "not worth thinking about." Even in the face of programs attempting to promote System 2 thinking, heuristics will exert an influence on decision-making. Recognizing this possibility suggests two implications for a risk communication program designed to increase the purchase of flood insurance.

First, risk communication can be designed to harness decision heuristics in various ways, depending on the ultimate objectives of the program. The operative term here is ***boosts***. For example, the availability heuristic could be used to develop flood risk communication efforts that consistently remind people of past flood events as a way to encourage them to assess risk as higher and therefore increase willingness to purchase insurance. As another example, a well-recognized problem in flood risk communication is the public's misunderstanding of the term "100-year flood" (it leads them to fall prone to the gambler's fallacy). To avoid that misunderstanding, the "boost" will emphasize the concept of the one percent annual chance flood, and in turn (to avoid the truncation heuristic of assigning a small likelihood as zero) the flood probability will be described as having a 26 percent

[34] The literature is vast, rapidly expanding and has its own language. While this paper presents a brief summary of some of this literature, with commentary relating the particular heuristic to flood risk understanding, a more comprehensive survey that is accessible to the general reader, can be found here: **https://us.macmillan.com/books/9780374533557/thinking-fast-and-slow** (accessed December 8, 2021)

[35] For this report, an expert is anyone who uses data and established analytical methods to make judgments about the likelihood of possible flood events and the consequences of those events. Often these experts are frustrated by floodplain property owner's inability to use System 2 thinking. **https://pjmedia.com/lifestyle/2017/09/02/can-two-500-year-floods-ten-years/** (accessed July 25,2021)

[36] There is no prior assumption that System 1 judgments relative to System 2 will always be "wrong." **https://www.psychologytoday.com/blog/seeing-what-others-dont/201704/positive-heuristics**

[37] Decision makers may adopt System 2 thinking if they are engaged in a learning environment, as opposed to having to make judgments on their own in isolation from others and from experts. Securing that result may require engaging individuals in an extended stakeholder process with give-and-take among stakeholders (especially community leaders) and experts with sufficient time to foster System 2 thinking. However, people may be unwilling to commit to such a learning process.

chance of occurring during the life of a 30-year mortgage. When flood risk is presented as a 30-year risk as opposed to an annual risk, individuals may perceive a higher risk and be more willing to purchase insurance. New programs of risk communication, especially tied to more advanced databases and modernized floodplain mapping, could communicate the potential for damage. Describing the flood risk using both likelihood and elevation (stage) as *high*, *medium*, or *low* might minimize the truncation heuristic; however, this description, if it consists only of a line on a map, may miscommunicate by suggesting that merely moving across this line radically changes the risk.[38]

However, although effectively communicated information about flood risk may affect some insurance purchase decisions, this might not result in the widespread coverage needed for pooling risk for insurers and for flood resiliency. This leads to the second implication of the heuristic literature; specifically, the design of the insurance itself should direct individuals toward its purchase. Directing individuals to make a particular choice that experts believe is in the best interest of the individuals is termed a *nudge*. Nudges are justified as a form of "libertarian paternalism," in which individuals retain the freedom to make choices, but the way a choice is presented is more likely to secure a particular outcome – in this case, paying for flood insurance.

Thaler and Sunstein[39] refer *to choice architects*, who design choice contexts in such a way that people make decisions that improve their lives.[40] In simplest terms, a choice architecture for flood insurance would mandate coverage in some fashion, but allow the insured to opt out, subject to certain conditions. The Layer 2 design is based on this insight from the behavioral economics literature. Including flood coverage in basic homeowners insurance is the same as mandating the purchase, but reporting the resulting increase in premium and allowing the insured to opt out is an application of nudging. Conditions imposed for opting out could include participation in educational programs that boost understanding of (1) flood risk, (2) the limits of disaster aid, and (3) the benefits of insurance.

[38] Quebec plans to revamp its flood mapping, dropping the recurrence maps (0-20 year, 20-year) to adopt a risk mapping approach (low, moderate, high). https://ici.radio-canada.ca/nouvelle/1780162/levee-zone-intervention-speciale-transition-inondations-quebec?fbclid=IwAR1S3KiUk7GJGsK2nD0_CuwSzdvLP6VxgNyL6Cz61aIsyi9x0G_vMAqPUxY (French).

[39] Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving Decisions about Health, Wealth, and Happiness. Yale University Press.

[40] This contrarian view on nudges may not apply for insurance against a future and uncertain risk such as flooding. https://behavioralscientist.org/neoliberalism-after-behavioral-economics/


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