

ANALYSIS

Building on river floodplains has proven costly and devastating to Canadians. A new Globe analysis reveals which cities are most at risk

Flooding has condemned some cities to painful cycles of loss and rebuilding. Although multiple levels of government seek to restrict further development on floodplains, some cities continue to allow it

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PUBLISHED 8 MINUTES AGO



Frank Van Nynatten, assistant manager of environmental services for the City of Chilliwack, stands on the bank of the Fraser River, metres from the dike protecting the city from flooding.

When rivers spill over their banks, the resulting damage is not simply the result of nature's caprice. It is also determined by how many homes, farms, roads and hospitals people built in a flood's path.

A new analysis by The Globe and Mail has discovered that of 150 Canadian communities with populations greater than 10,000, more than 30 have at least one-tenth of their buildings within river floodplains. This analysis was facilitated by new flood maps covering the entire country released by the University of Western Ontario.

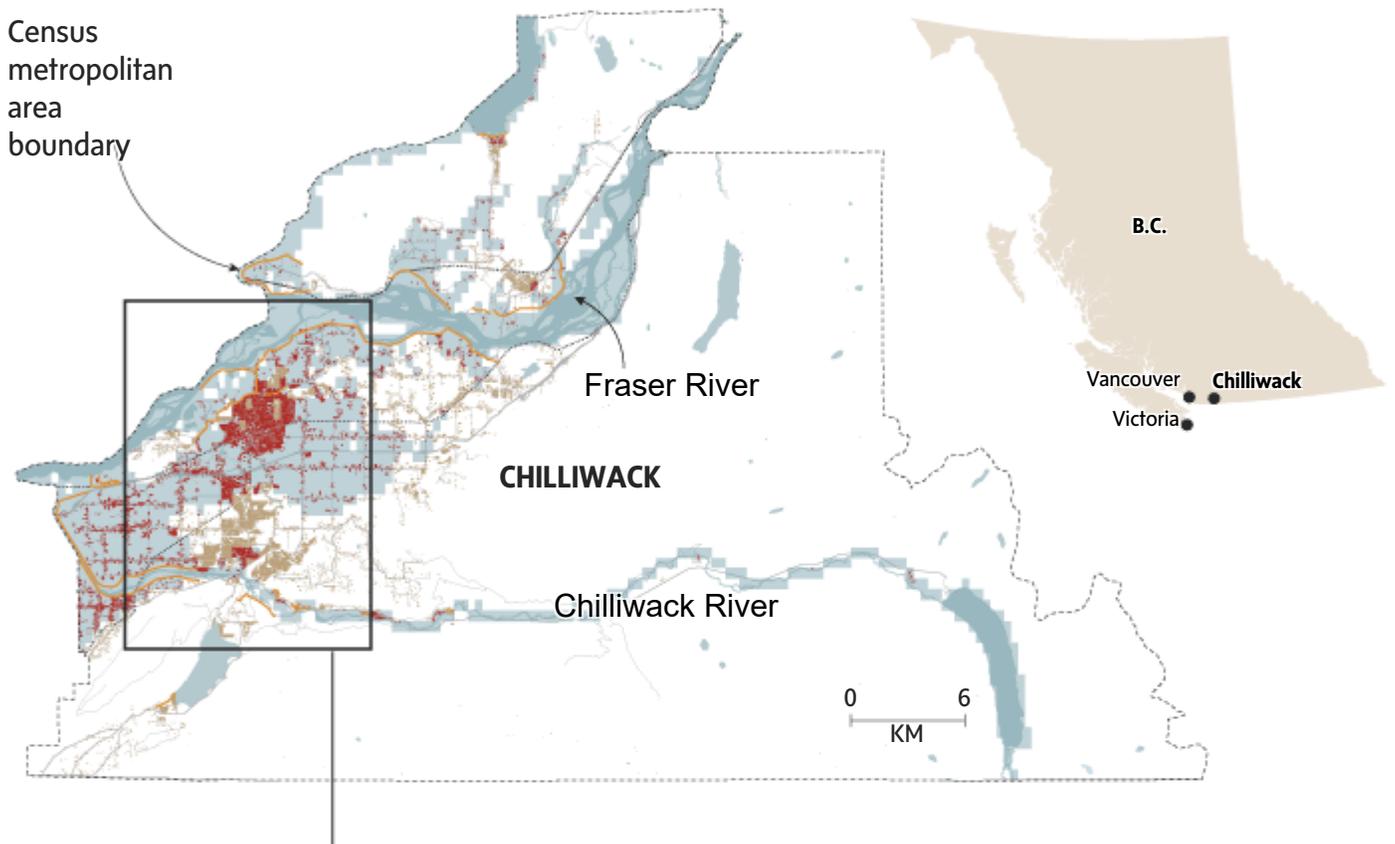
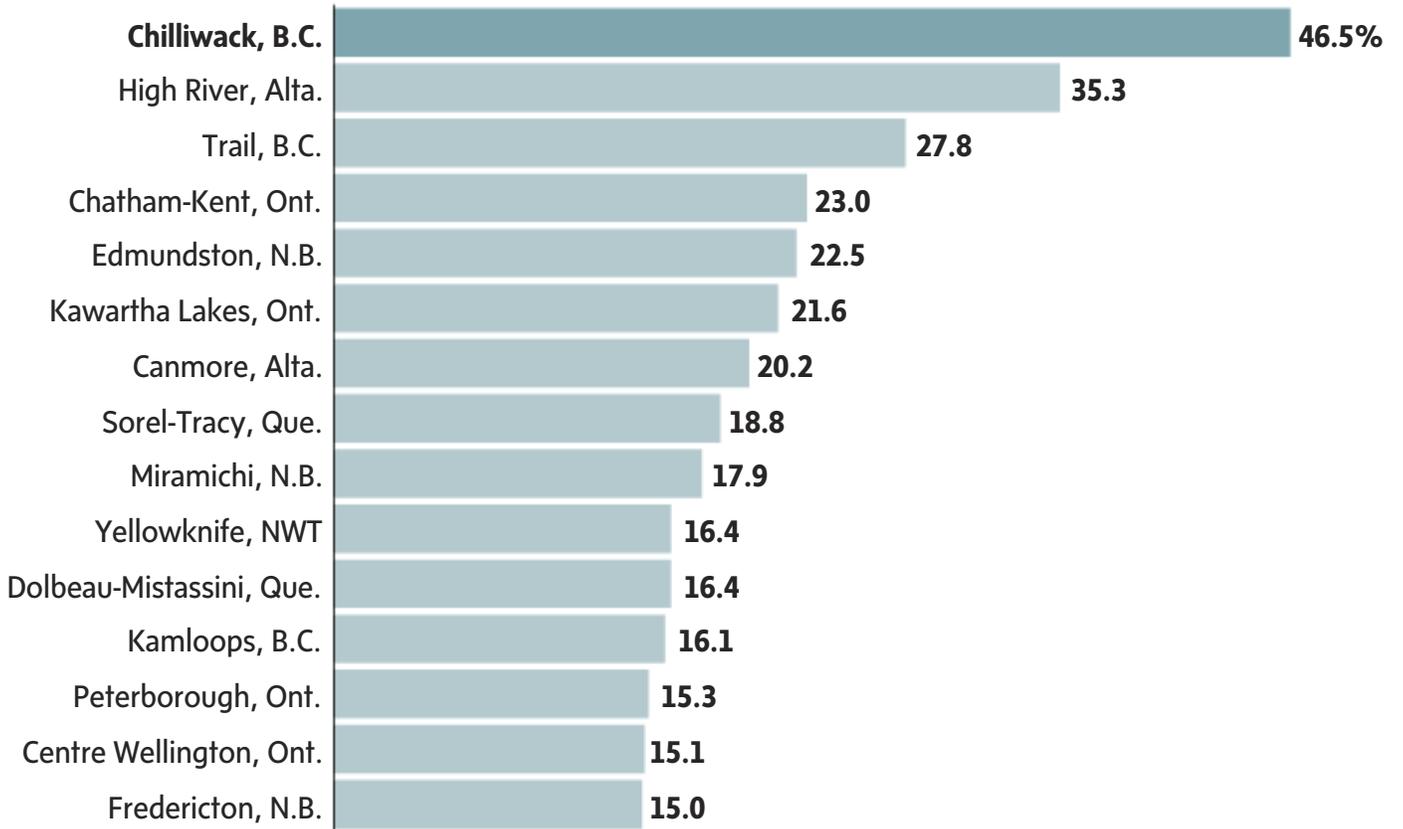
Chilliwack, B.C., stands out: More than 18,000 buildings in this metropolitan area lie within the floodplains of the Fraser and Vedder Rivers. That's nearly half of all buildings in the city – no other community we studied comes close. High River, Alta., which saw thousands of homes damaged in a 2013 flood, emerged as another community with extensive floodplain development.

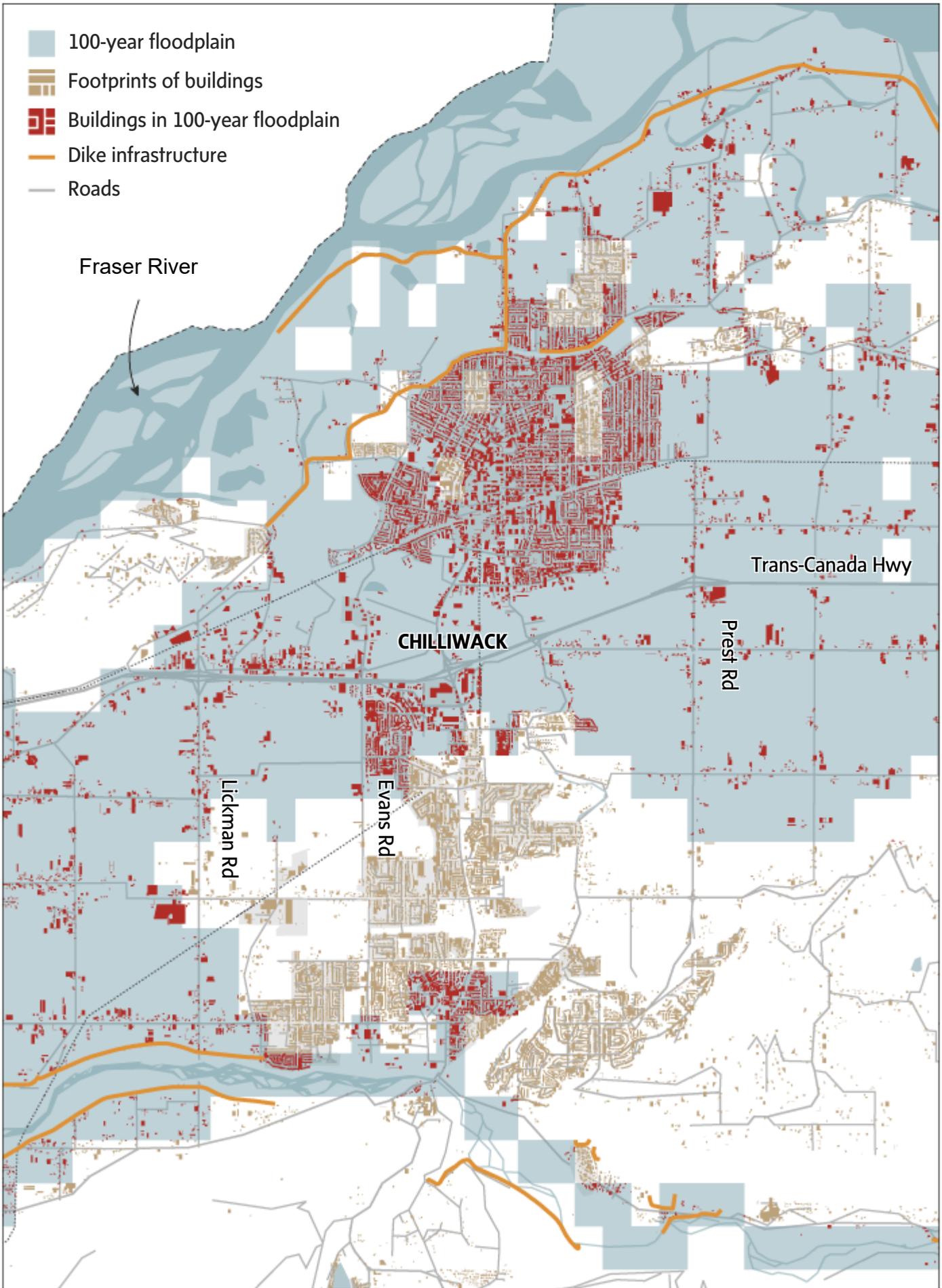
Time and again, construction on floodplains has been exposed as an expensive habit. It can condemn cities to painful cycles of devastation and rebuilding, at great financial and psychological cost to affected residents.

HIGH WATER, HIGH STAKES

A Globe and Mail analysis of flood models by the University of Western Ontario shows that more than 30 communities across Canada have at least one-tenth of their buildings within river floodplains. Chilliwack, B.C. had unusually high exposure. The community relies on networks of dikes for protection.

15 CITIES WITH THE HIGHEST PROPORTION OF BUILDINGS IN 100-YEAR FLOODPLAIN







MURAT YÜKSELİR / THE GLOBE AND MAIL, SOURCE: TILEZEN; OPENSTREETMAP CONTRIBUTORS; STATISTICS CANADA; MICROSOFT; UNIVERSITY OF WESTERN ONTARIO

This was demonstrated dramatically just west of Chilliwack, in the Sumas Prairie, a known floodplain inundated last November following a dike breach. The federal government and British Columbia expect to incur recovery costs of \$3.9-billion from the November floods, nearly all of which will ultimately be paid by federal taxpayers. That's the largest disaster recovery charge in Canadian history – and it's on top of what homeowners, farmers, businesses and municipalities must pay out of their own pockets.

Additional public funds are sometimes spent on massive flood protection works to protect vulnerable neighbourhoods after the fact. The federal government is also contemplating a program to facilitate relocating homes and businesses from at-risk areas, which might require yet more public spending.

Yet despite official policies at multiple layers of government that seek to restrict development on floodplains, some cities continue to allow it. Meanwhile, as Earth's climate warms, footprints of many floodplains are expected to expand.

How to defend or abandon such places could become an increasingly pressing dilemma for all levels of government – as will the question of who should pay when past permits lead to tragedy.

Gaps in the armour

The City of Chilliwack's flood maps largely corroborate the University of Western Ontario's. Indeed, a 2007 municipal map depicts a substantially larger floodplain, mainly because Chilliwack's maps depict a more severe flood than Western's. But there's a crucial difference: The municipal map classifies most of the sprawling floodplain as “protected.”

That's a reference to the 50 kilometres of dikes surrounding the city, defending tens of thousands of residents, businesses, water lines, railways, the Trans-Canada Highway and a hospital.



Chilliwack's official community plan only discourages development in the handful of areas deemed "unprotected." It's part of a pattern seen in cities across the country: Dikes attract more development, thus floodplain exposure increases.

DARRYL DYCK/THE GLOBE AND MAIL

Diking began as early as the 1860s, when settlers inundated the area. Impetus for more dike construction and upgrades was provided by major floods from the Fraser River in 1894 and 1948, and in 1975 from the Vedder River.

Those dikes provided reassurance that were crucial to Chilliwack's growth. Development originated on the north side of what is now the Trans-Canada Highway, but spread south to encompass the former communities of Sardis and Vedder, and up the surrounding hillsides.

Recently Chilliwack has been among Canada's fastest-growing cities, its population up 12 per cent in the 2021 census compared with 2016. The total now exceeds 113,000, and municipal officials expect continued growth in the coming decades.

Daryl Moniz, a realtor and president of the Chilliwack and District Real Estate Board, said affordability is pushing home buyers to Chilliwack. “They want the detached home with the white picket fence dream for their family, as opposed to the condo living that’s the reality for a lot of first-time home buyers in the Vancouver area,” he said.

Finding room for that growth, though, is a challenge. Chilliwack is hemmed in by provincially protected agricultural lands and neighbouring First Nations. Demand for many thousands of new homes led to intensification of existing neighbourhoods on the valley floor, as well as some development on nearby hillsides.

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DARRYL DYCK/THE GLOBE AND MAIL



Above, new two-storey houses are seen under construction in Chilliwack this month. Below, a home in the Yarrow neighbourhood of Chilliwack is submerged in floodwaters in November 2021.

JESSE WINTER/REUTERS

In Chilliwack, Mr. Moniz said, the floodplain is a “minor to irrelevant” consideration in real estate transactions. “It’s just a way of life, more or less, in western B.C.”

The problem is that flood defences can fail, and their maintenance is often neglected.

Chilliwack’s history proves the point. As serious flood conditions developed in 1948, locals just east of the city belatedly realized their dikes needed to be raised. According to one contemporary account, they “pressed their own trucks into service, turned a 10-acre pasture into a gravel pit and formed the nucleus of an army of 3,500 men.”

Those last-minute efforts spared Chilliwack and its surroundings from complete inundation. Dikes nonetheless failed and several neighbourhoods flooded, most notably in the Mennonite community of Greendale on the Sumas Prairie just west of Chilliwack, which became a lake 34 feet deep.

“Following the Greendale break,” the account notes, “Chilliwack took stock of its own defences and found them wanting.”

And not for the last time. A 2015 assessment published by B.C.’s Ministry of Forests, Lands and Natural Resources noted many dikes around Chilliwack were “presently too low,” or else had other deficiencies.



People run and walk along the dike on the north arm of the Fraser River, in Vancouver, on Friday, April 22, 2022. Darryl Dyck/The Globe and Mail

DARRYL DYCK/THE GLOBE AND MAIL

The last decade has seen continuing work to upgrade the dikes, beginning in eastern Chilliwack and moving downstream along the Fraser River. Officials told The Globe the work might take another decade or more to complete, and depends in part on federal and provincial funding becoming available.

Officials fully realize what's at stake. A 2009 study by engineering firm BGC Engineering estimated potential damages from a major flood of around \$1-billion. "The consequences of a breach in the City flood protection system would be extensive," a 2016 municipal report noted. Once nearly half a city is in a floodplain, though, backing away can be prohibitively difficult and expensive.

"We are not starting with a blank page, and have to work with the City as it was developed in years past," Mayor Ken Popove said in a written response to questions.

In addition to diking, the city dredges sediment from the rivers every two years. Several decades ago, it prohibited living spaces on the main floors of residences within the floodplain, so that space is occupied in newer structures by garages, storage and rec rooms.

Gradually, such rules are changing the city's appearance and reducing risks: In established neighbourhoods, 1960s bungalows sit alongside newer, much taller two-storey homes.

How close is too close?



A multi-family development is seen under construction next to an existing single-family home, in Chilliwack, B.C.

DARRYL DYCK/THE GLOBE AND MAIL

Each floodplain community has its own unique story, but they often have similar plot twists.

Ryan Ness, director of adaptation research at the Canadian Climate Institute, said many Canadian cities were established along rivers because they offered transportation routes for goods, drinking water and a source of mechanical power for mills. “Development started next to the water and branched out from there,” he said. “So, we had a lot of development in place before the notion of not building in a floodplain as a good idea became widespread.”

Land use planning has come a long way since the 19th century. Today, legal restrictions are imposed on the location, scale, density and type of buildings allowed in flood risk areas. Those areas are often mapped based on estimated “return period” of certain floods, which help determine the margin of safety.

Different communities chose different levels of protection. A common standard is the 100-year flood, meaning one that has a 1 per cent probability of occurring in any given year.

But many municipalities, engineering firms and flood mitigation experts regard that as a bare minimum; Most urban areas in Canada protect themselves to a higher 200-year standard, according to a 2016 report by the federal Parliamentary Budget Officer. On the high end is the Red River Floodway, which protects Winnipeg to a 700-year standard.

Despite such rules, some communities nevertheless choose to increase their exposure. A couple of years ago, the Canadian Climate Institute analyzed building permits within the City of Vancouver. It found that during the three-year period between 2017 and late 2020, 10 per cent of the building permits issued by the municipality were for new structures within a 100-year floodplain.

Flood mitigation experts provide various reasons for such behaviour, but they boil down to conflicting priorities and perverse incentives.





B.C. Minister of Transportation and Infrastructure Rob Fleming, (below, right) examines the work to rebuild a portion of Highway 8 washed away by flooding in November 2021 west of Merritt, B.C.

DARRYL DYCK/THE CANADIAN PRESS

From a municipality’s perspective, allowing floodplain construction leads to additional property taxes and development fees. “There’s immense pressure on municipal governments to approve development of all kinds, because it’s their source of revenue,” said Dan Henstra, a professor of political science at the University of Waterloo. “Vacant land is taxed at a low rate, highly developed land is taxed at a higher rate.”

Jason Thistlethwaite, a professor in Waterloo’s environment department, said some municipalities deliberately ignore floodplain maps. Developers also hire consultants to challenge the official maps in a manner “that sort of meets the municipality’s requirements, so they don’t need to be concerned about that exposure.” Provinces often have rules restricting floodplain development, but lack authority to compel municipalities to follow them.

When neighbourhoods flood, municipalities rarely shoulder most of the resulting financial burden. Typically, someone else pays the bulk of recovery costs – individual homeowners, the insurance industry or higher levels of government, through disaster recovery programs.

All considered, experts say, the temptation for local officials to rubber-stamp permits can be irresistible.

“From a probability perspective, a flood is not likely to happen in the term of office of the folks who make these decisions,” observed Mr. Ness.

A flood of regret?

Dr. Thistlethwaite said many municipalities “have been burying their heads in the sand” about the hazards of floodplain development. But the risks are becoming increasingly visible, and not just when neighbourhoods are inundated. Flood maps are increasingly becoming available and accessible. Moreover, overland flood insurance markets continue to develop, so more homeowners may find out from insurers that their homes lie within known floodplains.

He also warned that yesterday’s permits could become targets for tomorrow’s litigation. “There hasn’t been a discussion of who’s going to own this legacy liability,” Dr. Thistlethwaite said. “That, to me, is one of the million-dollar questions.”

There’s public support for holding municipalities accountable. According to a 2016 survey conducted by Dr. Thistlethwaite and his colleagues, 64 per cent of respondents thought governments should compensate property owners for flood damages if they allowed owners to build in high-risk areas.

“They were the ones that issued the permit,” he said. “They’re the ones that declared that land safe for development. They can certainly be held liable.”

About our analysis

To understand the scope of floodplain development across Canada and identify cities with the highest exposure, The Globe and Mail acquired nationwide floodplain models from the University of Western Ontario. The data was created by a team led by Slobodan Simonovic, and was released late last year [on the web](#).

Western's flood models cover the entire country using a consistent methodology. To our knowledge, they're the first such maps made publicly available in Canada. However, readers should be aware that the maps have significant limitations .

To begin with, Western's models only cover river (also known as fluvial) floods. They do not consider pluvial floods (surface water flowing toward rivers) or coastal floods. The maps also don't distinguish between unprotected areas and those defended by dikes or other infrastructure.



Last November rainstorms triggered massive landslides and floods in Abbotsford, B.C.

JENNIFER GAUTHIER/REUTERS

Moreover, Western's data is low resolution: Floodplains are delineated in blocks covering one square kilometre each. For this reason, our results likely overstate risks in small communities, such as Arctic hamlets of a few hundred people where most structures are located near river banks. In contrast, most localized flood studies are conducted at much higher resolutions – say, blocks of 30 square metres.

Partly to counteract this tendency, we performed our analysis using one of Western's 100-year floodplain maps. (Dr. Simonovic's team also calculated 200-year flood levels, which is a more common regulatory standard for mapping and protection across Canada.)

Western produced four maps depicting the size of current floodplains, and eight others that capture projected changes expected due to climate change. We selected a map based on runoff data for the period from 1980 to 2019 – that is, we relied on historical data rather than future projections.

To assess how many buildings exist within floodplains, we cross-referenced Western's map that with Canada-wide building footprints produced by Microsoft Corp. Using ArcGIS Pro, a geographical information systems software package, we calculated the total number of buildings within floodplains in each of Canada's roughly 150 census metropolitan areas (CMAs) and census agglomerations (CAs).

(According to Statistics Canada, a CMA is one or more adjacent municipalities with a combined population of at least 100,000, which is centred on a population centre known as a "core." This geographical unit was created for studying large urbanized areas; they're usually known by the principal city forming their core, such as Toronto, Calgary or Halifax. CAs have populations of more than 10,000.)

We were then able to calculate the proportion of their buildings located within river floodplains in each CMA or CA.

To verify accuracy, Dr. Simonovic said he compared his flood models with official floodplain maps in six Canadian cities. "Our level of accuracy based on these six different cities is 82 per cent," he said. "This is considered to be very high for a global type of model."

In some cases we were able to compare Western's maps to others produced by provinces or municipalities. Sometimes they matched closely, as in Chilliwack. High River is a different story: Official maps agree with Western's that much of the town is within the floodplain, but disagree on the outline of the floodplain.

Montreal, however, offers a vivid example of how Western's data can diverge strikingly from official sources.

Western's maps depict the entire northeastern portion of the Island of Montreal as a river floodplain. Consequently, our analysis identified more than 130,000 buildings at risk in that city – a result that also placed Quebec as the province with the largest proportion of its buildings in floodplains.

But official flood maps tell an entirely different story.

Nicolas Milot is a research advisor in the Montreal Metropolitan Community, which has been mandated to map floodplains throughout the Montreal area. He said Western's flood data in Montreal is simply incorrect. He pointed to Mount Royal, the small mountain

immediately west of downtown Montreal. A portion of the mountain appears to be in the floodplain on Western's map. But it's more than 200 metres above sea level, he said.



Residences in the Montreal suburb of Sainte-Marthe-sur-le-Lac are submerged in flood waters after spring floods broke record levels in April 2019.

SEBASTIEN ST-JEAN/AFP/GETTY IMAGES