

Chapter 6: Floods

KEY FINDINGS

- Flooding events have historically been the **costliest and most destructive environmental disasters** in Canada. The atmospheric river event of November 2021 is estimated to have caused upwards of \$8.7 billion in damage in B.C., with catastrophic impacts to communities, the economy, the environment, and critical infrastructure.
- **Flood risks to people living in B.C. are substantial and continue to grow**, due to land-use pressures and climate change. Larger and more frequent extreme precipitation events are projected to further increase flooding risks in B.C. Riverine flooding and coastal flooding are predicted to have high overall health, social, environmental, and economic consequences.
- Extreme precipitation and flooding can **also have cascading impacts**, such as landslides and debris flows, and impacts to vital transportation corridors, drinking water safety and quality, food safety and security, indoor air quality, and infectious diseases.
- Flooding impacts the short- and long-term **mental health** of a population, including psychological distress, anxiety, depression, and post-traumatic stress disorder (PTSD).
- Flooding **does not affect all populations equally**. Considerable socioeconomic differences exist between populations living in high and low flood risk areas. In B.C., some of the most impacted include Indigenous Peoples, women, older adults, low-income and underhoused people, farmers, and migrant farm workers.
- Flooding **impacts the health system** by directly disrupting the delivery of health care due to power outages and damage to water supply and transportation networks. Loss and damage to medical equipment, health care facilities, and infrastructure can lead to longer-term disruptions in service delivery and, in some cases, evacuation of patients.
- Many of the levers to increase flood resilience lie outside the health system and **rely on strong local leadership and partnerships across sectors and scales**. Several provincial adaptations to improve flood resilience are underway, spanning strategy, monitoring, mapping, and communications.

6.1 Exposure to floods in B.C.

Flooding events have historically been the costliest and most destructive environmental disasters in Canada ^[13], accounting for 37 percent of all environmental disaster costs in the Canadian Natural Disaster Database since 1970 ^[414]. Floods are common in B.C. and can happen at any time of year ^[415]. The province has experienced several flooding events in the past decade, leading to significant impacts to communities, the economy, the environment, critical infrastructure, and, in some cases, loss of life (Table 4).

Table 4: Timeline of major flooding events in B.C. since 2016

Year	Description of flood event
2016	Northeastern B.C. (June)—Severe flooding for Dawson Creek and Chetwynd. ^[416,417]
2017	<p>Interior B.C. (April–June)—Widespread flooding of Okanagan and Nicola Lakes, impacting more than 73 communities, including 15 First Nations communities ^[75]. Tragically, one person lost their life ^[418] and one person was reported missing and presumed deceased ^[419].</p> <p>Northwestern B.C. (October)—Widespread flooding of the Skeena River, with significant damage and evacuations ^[420,421].</p>
2018	Southern Interior B.C. (May)—Extensive flooding in the Interior Kootenay Boundary and Okanagan-Similkameen regions. Lakes flooded, including Okanagan Lake, Kalamalka Lake, and several smaller lakes in the Okanagan, as well as Stump Lake in the Nicola Valley and Shuswap Lake in the Columbia-Shuswap region. More than 4,000 people evacuated (including 2,600 in Grand Forks and Osoyoos). Grand Forks experienced devastating damage, with 400 homes and 100 businesses destroyed ^[422–424] . Evacuation orders and alerts impacted six other regional districts and eight First Nations around the province ^[422] .
2020	<p>South Coast B.C. (February)—Flooding and landslides on the B.C. South Coast, including Cowichan Valley Regional District, which declared a local state of emergency after flooding shut down roads and prompted the evacuation of around 30 residents ^[425].</p> <p>Interior B.C. (April and July)—Flooding impacts Village of Cache Creek, with multiple properties on evacuation order ^[426,427].</p> <p>Southeastern and Northwestern B.C. (July)—Heavy precipitation leads to flooding and landslides across the province, closing major highways in Southeastern B.C. and Northwestern B.C., and completely cutting off Telegraph Creek when a landslide closes the only road into the remote community ^[428].</p>
2021	<p>Northwestern B.C. (June)—Flooding due to a rising Skeena River. Damages and evacuations reported for the communities of Old and New Remo, and one fatality reported ^[429].</p> <p>Southwestern and Central B.C. (November)—Atmospheric river events cause destructive flooding in many communities (Abbotsford, Merritt, Princeton), landslides, and the failure of multiple highways and bridges across the province, triggering a province-wide state of emergency.</p>
2023	<p>Northwestern B.C. (May)—Flooding along the Skeena River, with 90 properties evacuated and impacts to waterways across Wet'suwet'en and Gitxsan territories ^[430].</p> <p>Interior B.C. (April–May)—Village of Cache Creek flooded, destroying homes and inundating the firehall and many businesses, closing Highway 97 and Highway 1 ^[431]</p>

The B.C. Flood Strategy's [From Flood Risk to Resilience: An Intentions Paper](#) identifies four major types of floods in B.C., and their causes of flooding can vary ^[13] (Figure 9).





Flood Type	Description	Causes
 Riverine Floods	Water levels in a river, lake, or stream overflow onto adjacent lands or infrastructure. Erosion is also typical during these types of floods.	Intense rainfall, atmospheric rivers
		Rapid snowmelt
		Ice jams
		Structural/operational dam failure
		Natural dam failure/glacial outburst
		Debris floods in steep terrain
		Two or more of the above (e.g., rain-on-snow events)
 Coastal Floods	Seawater inundates lands in coastal zones.	Storm surge wind and wave action
		Tsunamis
		High tides
		Sea level rise
 Local Pluvial/Stormwater Floods	Extreme rainfall creates local flooding away from water bodies.	Heavy rainfall exceeds the capacity of stormwater sewers, culverts, and landscapes to absorb + convey flows
		Blocked urban drainage systems
 Groundwater Floods	Rising underground water table floods basements or parkades.	Regional flood events Areas with high water tables

Figure 9: Major causes of floods in B.C. ^[13]

Between 2007 and June 2023, the province experienced 264 days with one or more water basins under flood warning and 579 days under flood watch (Appendix 1 – Table A1.8 and Table A1.9)³⁵. Over this period of approximately 16 years, Northern Health and Interior Health experienced the most days with one of more water basins under flood warning (179 and 173 days, respectively) and flood watch (449 and 383 days, respectively); the Northern Interior and Thompson Cariboo Shuswap health service delivery areas (HSDAs) were particularly affected. During the 2021 AR-flood events (November 14– December 1, 2021), one or more water basins in the province were under flood warning for 18 days (with the most days in Interior Health, Fraser Health, and Vancouver Island Health regions) and under flood watch for 12 days.

The 2019 [Preliminary Strategic Climate Risk Assessment](#) projected that severe riverine flooding and severe coastal flooding³⁶ could be up to five times more likely to occur in B.C. by the 2050s, with high overall consequences³⁷ relative to other climate hazards assessed. Moderate local-level flooding risk was also projected to increase due to rises in extreme precipitation and snowmelt, though with lower overall consequences ^[30]. Precipitation-related drivers of flooding are projected to increase in B.C. by the 2050s as well, including more frequent and greater-magnitude heavy precipitation events ^[433].

35 Flood warnings (level 3) are issued when river levels have exceeded bankfull or will do so imminently, with flooding of adjacent areas. Flood watches (level 2) are issued when river levels are rising and will approach or may exceed bankfull, with potential for flooding of adjacent areas ^[432].

36 Severe riverine flooding defined as a 500-year flood of the Fraser River. Severe coastal flooding defined as 3.9 m storm surge during a king tide and 500-year winter storm along the B.C. coast.

37 Overall consequences including impacts to health, social functioning, natural resources, and economic vitality

Precipitation-related climate projections for B.C.'s health regions by the 2050's

Across B.C.'s health service delivery areas (health regions), the magnitude and frequency of heavy precipitation events each year are projected to increase ^[433]. Some regions may be disproportionately impacted (see Appendix 1 – Table A1.2 for more details). For example, projections include rises in:

- Maximum one-day total precipitation, with the highest total increases projected for some southwestern B.C. regions.
- Total number of days with heavy precipitation (>20 mm), with the largest total increases projected for some southwestern B.C. regions.

Atmospheric rivers as drivers of extreme precipitation and flooding

Atmospheric rivers (ARs) are key drivers of precipitation and extreme precipitation in B.C., particularly in coastal areas. ARs are long (averaging more than 1,000 kilometres) and narrow (averaging 400 kilometres) flows of moisture-laden air ^[434] which transport water vapor from the warmer tropical regions towards the poles ^[434,435]³⁸. These “rivers” of moist air are carried by strong winds, travelling over B.C.'s coastal mountain ranges where the air cools and condenses, resulting in rain or snow ^[435,438].

Between 1948 and 2016, the coast of B.C. and southeastern Alaska experienced 35 ARs per year, on average. They were most frequent in the fall months (with more than one-third of all ARs), and least frequent (~14 percent) in spring ^[439]. ARs contribute up to one-third of total annual precipitation in B.C., accounting for almost all (up to 94 percent)³⁹ of the annual extreme precipitation along the coastal regions of B.C., and up to 60 percent of extreme precipitation in the Columbia and Rocky Mountains ^[440]. AR conditions occurred during 25 of 32 (78 percent) flood-related environmental disasters in B.C. between 1979 and 2016 ^[441].

The probability of AR-related precipitation, extreme precipitation and frequency of ARs has been increasing over time in B.C. ^[439,440], and future projections indicate a continuation of this trend. An increase in the frequency, duration, and magnitude of ARs and associated extreme precipitation is projected for B.C.'s coastal regions ^[442,443], including a fourfold increase in the frequency of ARs and associated flood events in the Fraser River Basin by the 2080s ^[444]⁴⁰. Climate change is shown to be driving these trends; one study estimated that B.C.'s 2021 AR-flood events were at least 60-percent more likely to have happened due to climate change ^[37].

38 ARs have sometimes also been dubbed “Pineapple Expresses,” referring to ARs originating from the tropics around Hawaii, though not all ARs impacting B.C.'s Pacific coast originate from this region ^[436,437].

39 Based on analysis of data between 1979 and 2012.

40 Based on RFP8.5 high emissions scenario, historical (1980–2009) vs future (2070–2099).



THE 2021 ATMOSPHERIC RIVER FLOOD IN B.C.—A RECORD-BREAKING EVENT

On November 17, 2021, the Province declared a province-wide state of emergency^[43] after an atmospheric river unleashed record amounts of rain on southwestern B.C.^[445]. Warmer temperatures also exacerbated snowmelt, leading to record-breaking streamflows^[37]. Significant flooding occurred in the Interior region, leading to surges in the Tulameen River in Princeton and the Coldwater River in Merritt^[44]. Merritt residents experienced their second evacuation of the year^[44]. Destructive flooding and landslides led to multiple highway and bridge failures across the province^[37,446,447].

Hundreds of drivers were stranded when major highways were cut off. The municipality of Hope was isolated. For nearly 72 hours, Hope accommodated more than a thousand stranded travelers, and faced significant and prolonged power outages that forced the closure of restaurants, gas stations, and businesses^[448]. Fraser Canyon Hospital was one of the few structures equipped with backup generator power, and served as a temporary location for Hope's municipal Emergency Operations Centre^[448].

Highway 1 and all direct road connections between Chilliwack and Abbotsford were closed. The Lower Mainland and southwestern B.C. were effectively cut off from the rest of Canada for several days^[37]. The destruction of Highway 8 through the Nicola Valley caused significant damage and cut off access for many First Nations communities, including the Shackan Indian Band, Cook's Ferry, and Nooaitch First Nations (see Figure 10)^[449–451].

THE 2021 ATMOSPHERIC RIVER FLOOD EVENTS BY THE NUMBERS

Health-related impacts:

- **320** Interior Health staff were placed on evacuation order or alert^[42,358]
- **~300** patients were evacuated from 5 Interior Health facilities^[358]
- EOCs in the Fraser Health region were activated for a total of **23** days to support over **10** communities, two acute facilities, and Mental Health & Substance Use and long-term care clients^[448]
- **> 100** flights were coordinated by the health system with their partners to move patients, staff equipment, medical supplies, and specimens throughout the Fraser East Corridor^[448]
- **6** people tragically lost their lives^[44,446,452]

Broad impacts:

- **63**-day-long provincial state of emergency^[45]
- In many areas, monthly precipitation totals were more than **200**-percent above average^{[446]41}
- **4** water basins under flood warnings for up to 20 days⁴²

- **5,610** people impacted by evacuation orders and alerts in the Fraser Valley^[454]
- **7,000+** people impacted by a city-wide evacuation order in Merritt due to a wastewater plant failure caused by rising waters^[44]
- **24** highways closed due to damage or landslides/debris flows, including highways connecting Vancouver to the rest of Canada^[44,455]
- **275+** drivers stranded by landslides and debris flows between Agassiz and Hope^[446]
- **1,100+** farms impacted in the Sumas Prairie in Abbotsford^[44]
- **>2.5** million livestock affected^[456], including an estimated 630,000 chickens, 12,000 pigs and 450 cows lost^[44]
- **258,000+** BC Hydro customers impacted by power outages^[457]
- An estimated **\$675 million** in insured damages^[458] and up to **\$13.5 billion** in non-insured damages, income losses, and public expenditures^[44] made it the costliest severe weather event in B.C. history^[459]

41 Two-day precipitation totals reached 312 mm on southwest Vancouver Island, and more than 400 mm north of the Fraser Valley, making this a 1-in-50 to 1-in-100 year event^[37]. In many areas, monthly precipitation totals were more than 200-percent above average^[446]. Note: a 1-in-50 year event reflects the probability of an event occurring; e.g., for a 50-year flood event, there is a two-percent probability of it occurring in any given year (or once in every 50 years)^[453].

42 Data source: B.C. River Forecast Centre (see Appendix 1 for more details)

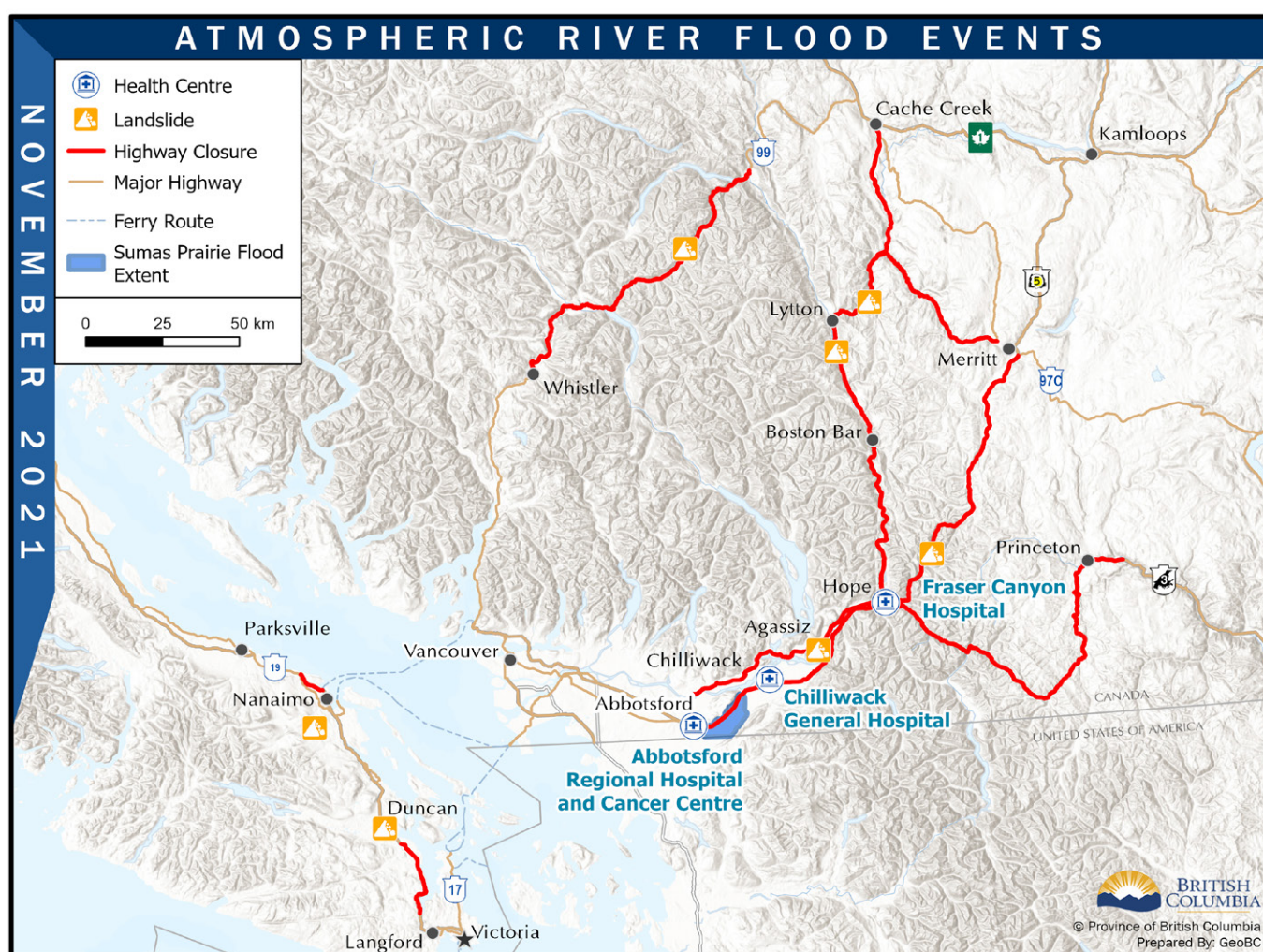


Figure 10: Highway closures and landslides impacting access to health facilities during the 2021 atmospheric river-flood event

Sea-level rise and storm surges as drivers of coastal flooding

Rising sea levels, with more frequent seasonal wind events and high tides, are increasing the risk for coastal flooding in B.C.'s coastal communities ^[11-13]. Coastal flooding poses a threat to infrastructure, transportation route access, and health for many B.C. communities; there are more than 27,200 kilometres of coastline in B.C., and more than 75 percent of the provincial population lives in coastal areas ^[11-13,460,461].

Communities on the southern tip of Vancouver Island, on Haida Gwaii, in Squamish, and in the metropolitan area of Vancouver are among the most exposed to sea-level rise in Canada, with an increased risk of coastal flooding ^[11]. According to estimates prepared for the Lower Mainland Flood Management Strategy, a major Fraser River flood could displace more than 311,000 B.C. residents, while a major coastal flood could displace 261,000 residents, if sea-level rise meets the average forecast of one metre by 2100 ^[462]. Health-related infrastructure, including a number of hospitals and ambulance stations, would also be at risk of inundation ^[462].

Storm surges arise when severe storms and high tides coincide at the same time, and strong winds can cause flooding inland ^[463,464]. Extremely high tides, known scientifically as spring tides (and sometimes referred to as king tides), can occur at any time throughout the year, but most frequently impact B.C. during winter months (December–January) ^[463-465]. They typically occur once or twice per year in B.C. ^[466], and have led to significant damage and put lives at risk ^[467-471].

Cascading impacts from extreme precipitation and flooding

Extreme precipitation and flooding can have cascading impacts such as landslides and debris flows, with impacts to drinking water safety and quality, food safety and security, indoor air quality, and increases in infectious diseases. Some B.C. examples are described below.

Landslides and debris flows are sometimes associated with extreme precipitation and flooding events in B.C. [472–475]. Other factors that can increase landslide risks include melting permafrost, wildfires (with damaged root systems and hydrophobic soils leading to unstable slopes), and drought [476–478]. Climate change may increase landslide frequency in B.C. by up to one-third by 2050, according to projections [479].

Impacts to the safety and quality of indoor air, water, and food: Extreme precipitation events can increase the incidence of gastrointestinal illnesses such as cryptosporidiosis and giardiasis (caused by parasites *Giardia lamblia* and *Cryptosporidium parvum*) [480,481]. Heavy precipitation can also lead to more soil and debris being transported into surface water supplies, elevating turbidity and diminishing water quality [482].

When evacuated residents return to flood-damaged homes and communities, they also face numerous potential hazards [483,484], such as:

- Flooding can saturate insulation, carpets, and furniture, creating favourable environments for mould development. Exposure can lead to health impacts when people inhale mould in indoor air (and less frequently through ingestion or direct skin contact), including illnesses due to allergic or hypersensitivity reactions; eye, nose and throat irritation; and respiratory infections in people with compromised immune systems [485,486].
- Perishable foods can become spoiled if electricity has been off, and non-perishable foods can have water contamination [487], increasing health risks from foodborne illness.
- Contaminants can infiltrate the environment, increasing the risk of infectious disease and harm to crops, plants, and animals, if concentrations exceed unsafe limits. An assessment in December 2021, after the AR-flood event, identified a number of contaminants in soil, sediment, and surface water samples in the Fraser River and Sumas Prairie areas, including total coliforms, fecal coliform, arsenic, *E.coli*, chromium, nickel, and phenanthrene [488]. The assessment concluded that the concentration of contaminants was unlikely to pose a risk to human health. Water samples from a separate risk assessment at Sumas Prairie also identified multiple contaminants, with excess water spilling debris flow, animal carcasses, and diesel fuel into salmon habitats. Contaminants included fecal coliform, pesticides, pharmaceuticals, illicit drugs such as cocaine, hydrocarbons, metals, and excess nitrogen and phosphorus, with implications for salmon habitats in the region [489].
- Flooding can damage essential water treatment and sanitation infrastructure. During the 2021 AR-flood events, the City of Merritt's sanitary sewer system, wastewater treatment plant, rapid infiltration basins, and water-supply system were damaged. When some water lines broke and some water-system areas were depressurized, the City issued a Contaminated Drinking Water notice. Interior Health issued a do-not-consume advisory, and Merritt was placed under a boil-water advisory for almost three weeks [491].



Princeton, B.C. cleanup after November 2021 flood event

Disease-associated total coliforms, fecal coliforms, and *E. coli* were found in soil and undisturbed sediment deposited on land by the flood, while total coliforms and *E. coli* were found in groundwater samples. These contaminants are a concern for people that have private water wells, or people that use surface water for drinking, irrigation, or for livestock ^[491]. Presence of total coliforms, fecal coliforms, and *E. coli* can indicate contamination of drinking water sources, such as pathogens that can cause gastrointestinal illnesses ^[492,493].

6.2 Flood impacts on B.C. population health and the health system

A wide range of potential exposures can lead to short- and long-term health impacts of flooding ^[494–499] (Figure 11). In global literature, flooding is also shown to impact the mental health of a population, with psychological distress, anxiety, depression, and post-traumatic stress disorder (PTSD) most commonly identified ^[154,495,500–503]. There are often longer-term impacts resulting from broader disruptions in the community as well, such as limited access to health and social care ^[501,504].

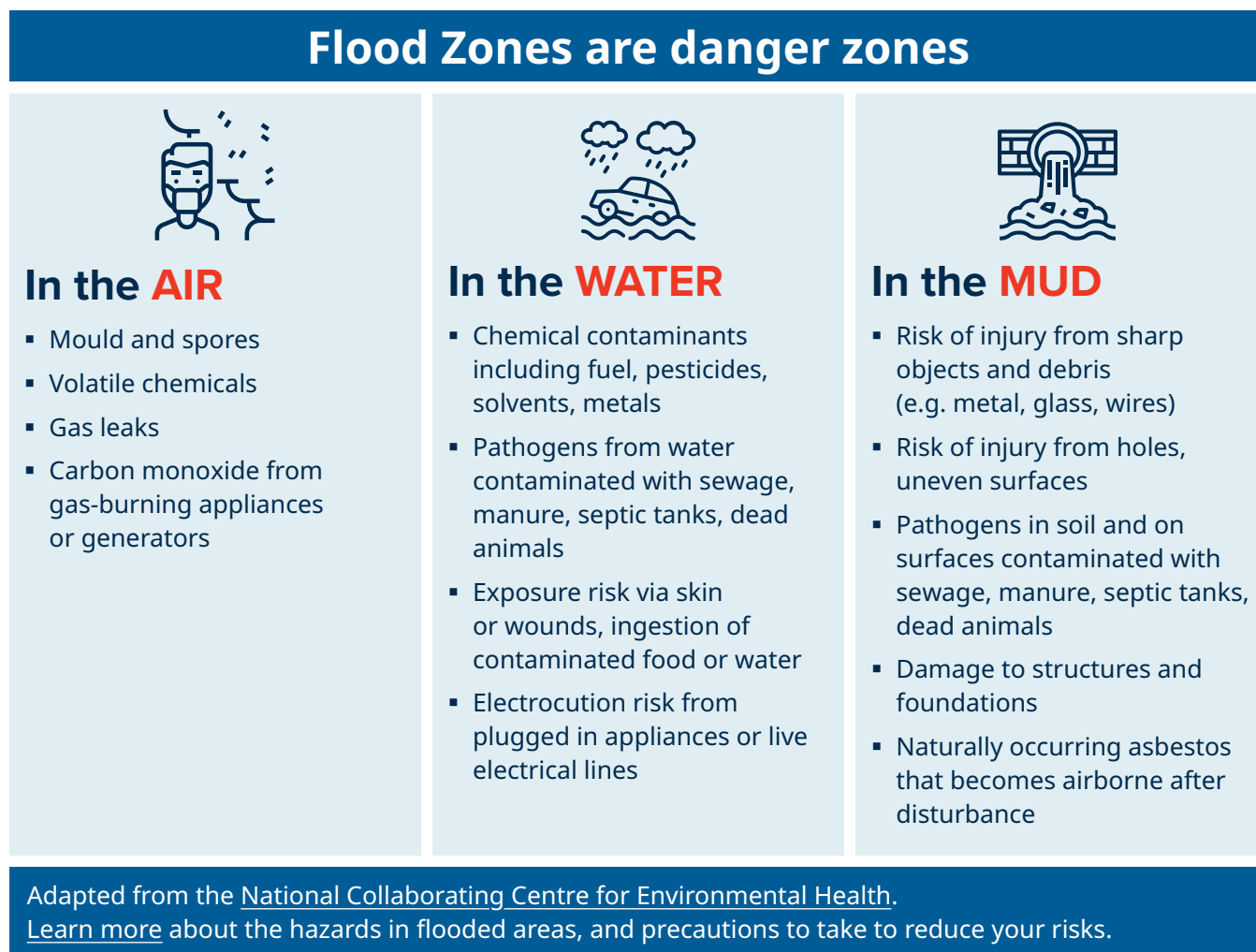


Figure 11: Potential hazard exposures in flooded areas ^[505]

Landslides and debris flows can cause death and injuries from rapidly flowing water and debris ^[476]. Broken power lines and/or water, gas, and/or sewage pipes can also result in injury or illness, such as waterborne diseases, electrocution or lacerations from falling debris, while short- and long-term mental health effects can occur due to loss of family, property, livestock or crops ^[476]. Landslides can also impact health and the health system through damage to critical infrastructure, such as power and communications lines, municipal water facilities, wastewater facilities, and hazardous materials storage sites ^[476].



Mud and rock slide on Highway 16 near Terrace, B.C. — May 2007

6.2.1 Flood impacts on B.C. population and public health

Though infrequently reported, deaths have been directly attributed to flooding events in B.C. ^[285,418,429,446] There have also been reports of injuries, mould-related exposures, and illnesses associated with flooding events in B.C. ^[506–508] Six months after the 2018 Grand Forks flood, for example, some residents reported experiencing health impacts, along with reports of mould and standing water ^[509]. However, the incidence of flood-related injuries and illnesses is currently not well-described in B.C., as there is no targeted surveillance for flood-related morbidity.

Landslides are rarely fatal, and rates of death due to landslides have been declining in B.C. since the early 1960's ^[472]. However, there have been reports of deaths and injuries due to landslide and debris flow events across all regions of the province, often associated with heavy precipitation events and flooding ^[510–518]. B.C. has the highest number of deaths due to landslides among Canadian provinces, with almost half (45 percent) of all 786 fatal landslides in Canada occurring in B.C. ^{43 [519,520]}. From 2007 to 2019, there has been an estimated one death per year due to landslides in B.C. ^[472]. Debris flows cause most landslide deaths, and those killed tend to be members of the public travelling on highways or at home ^[472]. Other deaths have been reported among workers during logging operations, when landslides were triggered by heavy precipitation and extreme weather conditions ^[512,521]. Injuries have also been reported due to landslide and debris flow events. In 2021, for example, serious injuries were reported among people caught in the debris flow on Highway 99, including a youth who was critically injured ^[522,523].

43 As recorded in the Canadian Disaster Database up to 2019.

Extreme precipitation events have also been associated with increased rates of illness due to waterborne pathogens in B.C., with increased rates of giardiasis and cryptosporidiosis detected four to six weeks after extreme precipitation events in the greater Vancouver region ^[480]. The annual rates of cryptosporidiosis and giardiasis are projected to increase in the greater Vancouver region by approximately 16 percent by the 2080s (corresponding to 55–136 additional cases each year), due to projected increases in extreme precipitation events ^[481].

6.2.2 Disproportionate impacts of floods on populations in B.C.

Flooding does not affect all populations equally. In the global literature, evidence shows that a number of intersecting factors are associated with increased health risks from flooding, including: flood exposure (e.g., those living on floodplains, and the duration and number of severe storm events experienced ^[524]); having pre-existing cardiovascular and gastrointestinal conditions; pregnancy; housing status (e.g., unhoused or renting); and certain occupational types (e.g., outdoor workers) ^[525]. Evidence shows links between stress in pregnant women affected by flood disasters and lower birth weights ^[526], and impaired social functioning in their children ^[495]. Lower socioeconomic status⁴⁴ can increase the risk of adverse health impacts ^[527,528].

Intersecting risk factors were evident in recent B.C. floods, where those most impacted included women; older adults; Indigenous Peoples; and low-income, unhoused or precariously housed people ^[509]. In general, these groups were more likely to lack financial or housing security, live in the floodplain, and have lower capacity to personally respond to the flood because of financial insecurity ^[273]. Many of the disproportionate risks from flooding are mental health related and are discussed in more detail in Chapter 9: Mental Health.

In B.C., populations that have been disproportionately affected by floods include:

People living in floodplains or low-lying coastal areas: Over 500,000 people in B.C. (roughly 10 percent of the population) live in floodplains and are therefore more exposed to floods. The greatest number of people living on floodplains is in southwestern B.C., around the Fraser River, and the population centres of Duncan, Nanaimo, Kamloops, Squamish, Osoyoos, Prince George, and Terrace ^[529].

Rural and remote communities: When roads are washed out, rural and remote communities can become isolated, creating challenges for accessing critical supplies, medicine, and health services. During the 2018 Grand Forks flood, some community members had to shelter in place when the only access road was impassable ^[424]. In 2017 and 2021, the Fraser Canyon community of Boston Bar became inaccessible due to landslides and bridge washouts, and alternative methods of delivering health care, including virtual care and flying in supplies, were employed ^[82,530]. Flood-related damage to infrastructure can also have long-lasting impacts in rural communities, as they do not often have access to the same resources as urban centres.

Women: A study of the [Social Impacts of the Grand Forks Flood](#) ^[509] found that women (particularly single mothers and older women) were significantly impacted by the floods, as they often played a caregiving role for family and community members in times of crisis. There were also reports of an increased demand for transition housing for women escaping domestic violence ^[509]. Lack of available transition spaces to support women needing safe spaces from domestic violence was also reported in some communities impacted by the 2021 AR-flood events, when hotel spaces became unavailable ^[531]. During the 2021 AR-flood events,

⁴⁴ In Canada, a Social Vulnerability Index for flood risk calculates local socioeconomic characteristics that influence a community's resilience to disaster events ^[524]. Considerable socioeconomic differences exist between populations living in high and low flood risk areas; populations living in areas of high flood risk in urban centres are more likely to be populated by racialized groups and consist of poorly built or maintained infrastructure ^[524].

there were also concerns about pregnant women and new mothers being isolated from their health care provider or other critical supports systems ^[532] ^[533].

Children and youth: Evidence from the 2021 AR-flood events showed that children and youth faced mental health impacts, including post-traumatic stress, and some experienced challenges with processing their experiences ^[534–536].

Older adults: Older adults living in low-cost housing were significantly impacted by the 2021 AR-flood events. In Princeton, three apartment buildings were severely damaged by the flood, including one housing many older adults. Some remained without secure housing for over a year after the event. Temporary modular seniors housing was set up for those who had been displaced for months, so that they could return to their community and support networks ^[537–539]. After the 2021 AR-flood events, older adults with health or mobility challenges faced unique barriers related to transportation to medical appointments and meal delivery ^[534], access to financial support for recovery ^[273], and post-flood waste removal ^[534].

Farmers and ranchers: The Sumas Prairie dyke breach during the 2021 AR-flood events led to 1,100 farms being placed on evacuation order or alert, and significant losses of farmland and animals ^[44]. Farmers and ranchers experienced significant mental health impacts ^[67].

Migrant farm workers: Many of the farms in the Fraser Valley impacted by the 2021 AR-flood events employed migrant farm workers. The flood exacerbated and exposed pre-existing systemic issues for migrant workers, including language barriers to accessing emergency service supports, limited social safety nets, and greater difficulty accessing disaster response funding ^[44,534,540–542].

“Probably the biggest [concern] was the migrant workers. [They] definitely had a language barrier, they were probably the most [in] need of help. They were away from home, and [had] no job because of the flood, and really didn’t know where they were going next. So, I think... probably the biggest [group] to look after was migrant workers.”

—Survey respondent, After the Flood report (2023) ^[534]

Underhoused and low-income populations: Recent flooding events in B.C. led to disproportionate impacts to underhoused and low-income populations. These populations were more likely to live in the floodplain, more reliant on public transport (and therefore lacked transportation when transit was disrupted by the flood), and more likely to live in sub-standard conditions prior to the flood ^[509,534]. Renters also experienced unique impacts. For example, the 2018 Grand Forks flood resulted in decreased supply of affordable rental properties, increased rents, and more stringent “vetting” practices, making it difficult to access housing for those already at risk before the flood ^[509].

People with complex care needs: Patients requiring life-saving cancer therapies, hemodialysis, transplants, and other treatments were significantly impacted by transportation disruptions from the 2021 AR-flood events ^[543–545] (discussed further in Chapter 10: Health Emergency Management, Evacuations and Health Service Delivery).

People with mental health and substance use conditions: Direct health impacts of the 2021 AR-flood events included increased hospital admission rates for alcohol withdrawal, lack of access to harm-reduction supplies for substance users, and delays in accessing opioid-substitution medications or treatment ^[56,546,547]. A *Risk to Resilience Project* focus group participant stressed the need to better prepare and support those with pre-existing mental health conditions during disasters.

“What struck me most were people who have diagnosed mental health illness; in these [flood] situations, they require even more care, whether it be their medication management or the need for additional services to debrief all this.”

—*Risk to Resilience Project* focus group participant

Disproportionate impacts of flooding on Indigenous communities

Many First Nations communities are situated on floodplains, where they are disproportionately affected by flooding, a historical outcome influenced by the colonial placement of reserve lands that were more marginal in nature ^[548]. Indigenous Peoples also face a greater risk of flood-related displacement and evacuations, enduring disruptions to cultural and land-based practices, emotional distress and anxiety, and impacts on drinking water quality ^[549–551] (see Chapter 9: Mental Health for more details). Indigenous communities in B.C. are demonstrating strong leadership in flood risk assessment and flood preparedness and adaptation, drawing on Indigenous knowledge systems and land-based practices.

B.C. First Nations communities provide leadership for flood preparedness

Dzawada’enuxw flood preparedness increases adaptation

A 2011 flood had devastating impacts in the community of the Dzawada’enuxw people of Kingcome Inlet ^[552]. Community members identified flood-related physical, mental, and spiritual impacts, especially youth and Elders, and exacerbated safe-housing concerns as houses were destroyed by floods ^[552]. Following the flood, the Musgamagw Dzawada’enuxw community installed a river-gate system to monitor floodwater levels and identify when belongings have to be moved to higher ground ^[553]. The community also adapted by raising homes one metre above the ground. The Musgamagw Dzawada’enuxw community’s strong adaption responses ^[553] helped to mitigate impacts from subsequent flooding in the Fall of 2017.

Integrated flood risk assessment in the Syilx Okanagan territory

In 2017, the Syilx Okanagan territory was impacted by extreme flooding, threatening community and ecosystem health. Recognizing a lack of a basin-wide approach to flood risk management, the Okanagan Nation Alliance led the Syilx Okanagan Flood and Debris Flow Risk Assessment in 2018, prepared with direction from Syilx knowledge keepers ^[554]. The project took an integrated approach to risk management, combining Syilx land-based knowledge of water with western watershed management practices. The process utilized Syilx processes of decision-making and traditional knowledge to centre the story and lessons of respecting siw̓k (water) ^[554].

B.C. ranked fourth among Canadian provinces for the most First Nations flood evacuees by Indigenous Service Canada region between 2013 and 2023, with 1,866 evacuees, including 253 long-term (more than three months) evacuees ^[555]. One study found that 81 percent of the 985 Indigenous land reserves in Canada had some flood exposure that impacted either population or residential properties. Out of 40 flood risk “hotspots” in Canada (census subdivisions where high social vulnerability coincides with high exposure to a 100-year flood), B.C. has the most flood risk hotspots (13) of all provinces ^[549].

The 2021 AR-flood events impacted 70 First Nations, with 15 needing to be partially or fully evacuated ^[524]. Members of the Shackan Indian Band near Merritt were displaced for three months due to the 2021 AR-flood events, soon after being displaced for one month in the summer due to wildfires ^[44]. In 2017, B.C. First Nations communities were among the most impacted by the record-setting freshet flooding, which damaged homes and infrastructure in 15 First Nations communities and resulted in multiple evacuations ^[556].

6.2.3 Flood impacts on the B.C. health system

Flooding impacts the health system by directly disrupting the delivery of health care, often due to power outages and damage to water supply and transportation networks ^[498]. Additionally, there can be significant loss of and damage to medical equipment, health care facilities, and infrastructure, which can lead to longer-term disruptions in service delivery and, in some cases, patient evacuations ^[498,557].

Flood impacts on the B.C. health workforce

“Everybody was showing signs of burnout [during the 2021 atmospheric river]... It's the compounding impact of response [on health workers].”
—Risk to Resilience Project focus group participant

During major floods in recent years (e.g., 2021 AR-flood events, 2018 Grand Forks, 2016 Dawson Creek), B.C.'s healthcare workers have experienced cascading impacts. As in other climate events, physicians, nurses, environmental health officers, and emergency responders face increased workloads during and following the floods, challenges in accessing transportation routes to and from their places of work, and mental health impacts.

Workplace impacts

During flooding events, increased health system staff capacity is required for emergency response, treating flood-related injuries, conducting water testing/monitoring, and providing mental health services and supports. During the 2021 AR-flood events, health system staff experienced emotional and physical fatigue due to the length of the emergency itself, increased working hours, and prolonged periods away from home ^[448]. Many health care providers worked tirelessly to support evacuations of health care facilities and ensure patients with urgent needs (e.g., dialysis, radiation, chemotherapy) received life-saving care ^[558,559]. (See Chapter 10: Health Emergency Management, Evacuations and Health Service Delivery for more discussion.)

Commuting impacts

When transportation routes were closed due to flooding during the 2021 AR-flood events, the event highlighted a significant staffing challenge for many health authorities: *many staff do not live in the communities in which they work*. During floods, the inability of staff to commute to their places of work can significantly alter the availability of workers to provide short- and long-term coverage ^[448]. For example:



- In 2021, flooding on the Malahat highway on Vancouver Island cut off the Capital Regional District from the central part of the Island. One *Risk to Resilience Project* focus group participant recalled, “As the Malahat was closed, it was really difficult for a lot of health care providers who live in more remote areas to commute down. So, we’re working with limited staffing and those of us who live close to the hospitals had to pull extra shifts and cover for colleagues.” In the Fraser Valley, the 2021 AR-flood events also cut off commuter access routes to hospitals in Chilliwack, Abbotsford, and Surrey. These route closures also meant some staff were unable to return to their home communities from the hospitals ^[96,448,560,561]. When they were finally able to get home, some workers expressed reluctance about returning to work while transportation routes were still uncertain.

“We had a lot of nurses that either work in Chilliwack or Abbotsford. They either couldn’t make it back to Surrey or were in Surrey and now no longer could get back to their home sites. And so they felt an immense amount of guilt that they weren’t there to help their colleagues in this disaster.”

—Risk to Resilience Project focus group participant

- In 2016, the Dawson Creek flood cut the community in half, isolating the hospital and firehall from one other. During this event, the hospital was only accessible to roughly half of the community and its staff ^[562].

Flood impacts on health emergency management and health service delivery in B.C.

Emergency Operations Centres⁴⁵ (EOCs) were activated across impacted regions of the province during the 2021 AR-flood event:

- Local and regional EOCs were activated at Fraser Health (November 14–15) to support staff, ensure continuity of care, and assist sites impacted by the events ^[448]. A logistics coordination centre was also stood up to support the movement of clients, staff, equipment, medical supplies and specimens, and other supplies through the Fraser corridor, when traditional modes of transportation were not accessible ^[448]. Health Emergency Management BC (HEMBC)’s Lower Mainland team was focused on supporting Fraser Health’s response and had to cease providing all other services ^[448];
- Interior Health activated an EOC and two regional Incident Commands (November 15) ^[42].

⁴⁵ An *Emergency Operations Centre* (EOC) functions as a centralized location for the overall coordination of emergency response activities.

BC Cancer in action: Continuity of care for cancer patients during the 2021 floods

The Abbotsford BC Cancer team faced challenges when road closures during the 2021 AR-flood events impacted the delivery of urgent radiation therapy for patients. To ensure critical patient appointments continued without interruption, staff arranged transport and lodgings for those in need. The clinic remained open on the weekend to serve patients who had missed treatments during the week due to flooding impacts. Staff coordinated air and land transportation, hotel accommodations, a food voucher system for patients, and ensured staff from affected areas were able to safely make it to work. As the road closures continued and ground-commute times extended beyond six hours for round trips, additional air transport options were arranged for patients with mobility or pain-management issues ^[563].



After the November 2021 atmospheric river flood event in Merritt, B.C.

Flood impacts on health facilities and infrastructure in B.C.

Flooding is projected to be a dominant hazard for a number of acute care and long-term care facilities by 2100, according to an assessment of climate risks to health facilities in B.C. ^[194]. Health facility buildings built on floodplains in B.C. are at increased risk of flooding-related impacts, including foundation destabilization. In some cases, critical building infrastructure and maintenance equipment are located below floodplain levels—these include boilers, electrical systems, fuel pumps, and main telecommunication and electrical lines. Floods in these areas would cause loss of heat and sterilization capacity, localized flooding, and, in the worst case, equipment failures and even site evacuation ^[150].

When protective dykes are destabilized, pump stations, electrical sub-stations, sewage and water treatment plants, and other dependent infrastructure can be inundated with flood water, with cascading impacts on health facilities ^[150]. Flooding events can further affect roadways and impact civil infrastructure, which can impact health facility access and operations. Extreme precipitation events can also lead to water infiltration through building envelope leaks, increasing the risk of mould; while stormwater and sewer backflow can reduce water quality ^[150]. Storms may damage roofs and external building cladding, and cause power outages ^[150].

A recent flood-risk assessment for developing the Lower Mainland Flood Strategy estimated that a number of Lower Mainland health care facilities (hospitals, ambulatory health, and nursing care) would be exposed to floodwaters in the event of a major flood—13 exposed facilities during a major coastal flood and 18 facilities during a major Fraser River flood ^[564] 46. In Vancouver, where most hospitals and care facilities are located outside the flood zone, a major flood may limit access to care ^[461].

During the AR-flood events of 2021, reported impacts included issues with electrical, clinical communications, piping systems, boilers and pressure vessels, building envelopes, and standby power generators ^[228]. Health facilities in different regions of the province experienced flooding as well as communications and power outages—including sites in the Lower Mainland, the Interior, and on Vancouver Island ^[565]. The Fraser Canyon Hospital in Hope turned to generator power when the community lost its electrical supply, and was placed on evacuation alert due to riverbank erosion ^[566,567], with concerns that its basement-located laboratory would flood ^[568]. At Saanich Peninsula Hospital on Vancouver Island, flooding of the ambulance bay area led to temporary closure of its emergency department and diversion of ambulances to another regional hospital ^[569].

Heavy precipitation and high winds also have led to water penetration in B.C. health care facilities, with reported impacts including ^[150]:

- high groundwater levels leading to water ingress, sump pumps failing, and the potential for evacuation in the event of elevators failing;
- single-pane windows failing, leading to moisture accumulation inside buildings;
- roof membranes failing, leading to service delivery impacts (such as appointment cancellations and moving of patients), and potential evacuation; and
- concerns about trees—already stressed from extreme heat events and drought conditions—falling on-site.

Flood impacts on supply chains in B.C.

The 2021 AR-flood events had substantial impacts on B.C. supply chains ^[570]. The extreme precipitation and subsequent flooding and landslides heavily damaged highways and railways across southwestern B.C., effectively cutting off all road and rail access routes into and out of the B.C. south coast for several days. Some highways remained closed for multiple weeks. Rail and road operations also experienced significant delays at the Port of Vancouver, impacting the movement of grain, wheat, and gas, among other products ^[571].

Fuel shortages

“We had nursing staff waiting for two hours for the one gas station that had fuel in the area that they were in, to make sure that they could continue their shift and get out to other community-based clients.”

—Risk to Resilience Project focus group participant

46 Major flood defined as a 500-year flood

Dozens of gas stations in the Lower Mainland and Vancouver Island ran low or dry during the 2021 AR-flood events, and the price of fuel skyrocketed with increased demand ^[572,573]. For close to one month, provincial state of emergency orders prompted mandatory fuel rationing for the public across southwestern B.C. ^[573]. The critical fuel shortages impacted health service delivery and operations in B.C., and health care services were prioritized for fuel as essential services under the Provincial order ^[233]. Among the reported health-sector challenges was ensuring ambulance fleets and health care workers, including those providing home care, had enough fuel to deliver care or commute to their places of work ^[233].

Essential medications and supplies

"You just get into emergency management mode and you start thinking about how we're going to get supplies in and out, who's there, who's vulnerable, who's stuck on this side, and how you're going to manage those logistics."

—Rick McLean, Chief of the Tahltan Band Council, interviewed on CBC ^[428]

While supply-chain impacts of the 2021 AR-flood events were unprecedented, it was not the first time flooding events in B.C. had impacted the delivery of essential supplies, particularly to rural and remote communities. In 2020, for example, flooding and the resulting debris flows led to the closure of the single road into and out of the remote northwestern B.C. community of Telegraph Creek ^[428]. *Risk to Resilience Project* focus group participants described waiting more than one month for the road to reopen, and having food brought in by helicopter. It marked the third extreme weather event in as many years to impact the community; a major wildfire in 2018 destroyed structures and forced the community to evacuate, and a debris flow event in 2019 closed the road and cut off the community from food and essential supplies ^[574].

The 2021 AR-flood events also significantly impacted provincial supply chains of medications and essential supplies to rural and remote communities located in flooded areas or cut off from road access to the Lower Mainland. In the days and weeks following the flood, some patients were reported to be quickly running out of medications and essential supplies, such as chemotherapy, colostomy supplies, psychiatric medications, transplant medications, and oxygen cylinders ^[233,530,561,575,576]. *Risk to Resilience Project* focus groups recounted stories of patients sharing supplies with other patients, with the critical support of nurses.

"We had patients on peritoneal dialysis at home, and we had other patients sharing supplies with them because they didn't have enough supplies to do their treatments. So, we had a nurse who was stranded in Chilliwack moving from one house to another."

—*Risk to Resilience Project* focus group participant

Story of collaboration: Delivering supplies and medicine to affected communities

While the most impacted areas of the Fraser Valley flood of November 2021 received significant resources and assistance, isolated, rural and remote communities such as Boston Bar and Hope were left without essential supplies or medications. Every road to and from Hope was impassable. The community's population of 6,700 grew by nearly 25 percent as it filled with ~1,500 stranded motorists. As the state of emergency went on for days, Hope ran out of hotel rooms, food, baby formula, hospital supplies, and drugs—both pharmaceutical and illicit—creating dire situations for some people trapped there.

During the flood, health system staff arranged alternate means of delivering medications and supplies to patients, health facilities, and lab testing facilities cut off by the floodwaters and landslides—including transport by helicopter and boat ^[530,576].

- The Ministry of Health Emergency Management Unit worked tirelessly with a team of health professionals, including Dr. Aseem Grover (senior medical director for Fraser Canyon Hospital), emergency managers, Boston Bar First Nation, and volunteers. They arranged a Canadian Armed Forces helicopter to transport medical help and supplies, including chemotherapy, colostomy supplies, and psychiatric medication, to the community of Boston Bar. ^[530]
- When patients stranded in Hope could not access their transplant medications, staff at a local pharmacy drove medications to a helicopter pad and coordinated flights to pick up the medications on the other side of the floodwaters ^[575].
- In order to maintain continuity of laboratory services at Fraser Canyon Hospital, staff coordinated helicopter transportation for courier runs that delivered supplies and picked up samples for distribution to other labs for specialized testing ^[577].
- Helicopters, along with extensive shipping and packaging protocols, were used to ship critical blood products to Abbotsford General Hospital for testing, as couriers could no longer deliver to patients at Fraser Canyon Hospital or Chilliwack General Hospital. Hospitals in Abbotsford and Chilliwack also increased their inventory of blood products (e.g., platelets) and extended expiry dates to 10 days. The [Transparent Blood Inventory](#), which is part of the [BC Blood Contingency Plan](#) ^[578,579], enabled labs to see inventory levels across the region and move products as needed, with minimal site involvement ^[568].



Dr. Aseem Grover (fourth from left) with the Hope-based team of medical doctors and family physicians ([source](#))



NewGen Pharmachoice in Abbotsford, B.C.—part of the BC Transplant team

Climate events have required iterative and continuous improvement. Thanks to lessons learned from the 2021 flood, improvements are being made for future disasters. Fraser Canyon Hospital now stockpiles more food, and a steel bin in its parking lot holds emergency supplies, including lanterns and batteries, gloves and gowns, disposable bowls and water, bedpans and urinals, extra stretchers, linens, and IV pumps ^[566]. These experiences and learnings can help other rural communities be better prepared for future disasters, just as previous disasters helped inform responses in 2021.

While the 2021 AR-flood events impacted Fraser Health and Interior Health Authorities most directly, focus group participants noted that the impacts rippled across the health system province-wide. For example, other health authorities experienced cascading effects due to blocked supply transportation routes between health authorities. Some *Risk to Resilience Project* focus group participants described realizing “*that events are not just siloed to one [health] authority. [There was an] increase of utilization across health authorities supporting each other.*”

Food shortages

The flooding was the biggest agricultural disaster in B.C.’s history, – with more than 1100 farms and 2.5 million livestock affected, along with severe losses for dairy, poultry, swine, beef, horticulture, fruit and vegetable growers, and land-based fish producers ^[456]. There were significant impacts on food supply chains as a result of this reduced production in flooded areas, and the disruptions to food cold supply chains and blocked transportation routes ^[456,580]. Disrupted food supply chains triggered public panic and hoarding of food and essential supplies, leading to empty shelves in some grocery stores across the province ^[572,581,582].



Water quality

“[Water] sampling was a real challenge with the breakdown of transportation infrastructure; it really impacted the ability for access to laboratories within the 30-hour window, because the transportation networks that couriers would usually use were wiped out.”

—Risk to Resilience Project focus group participant

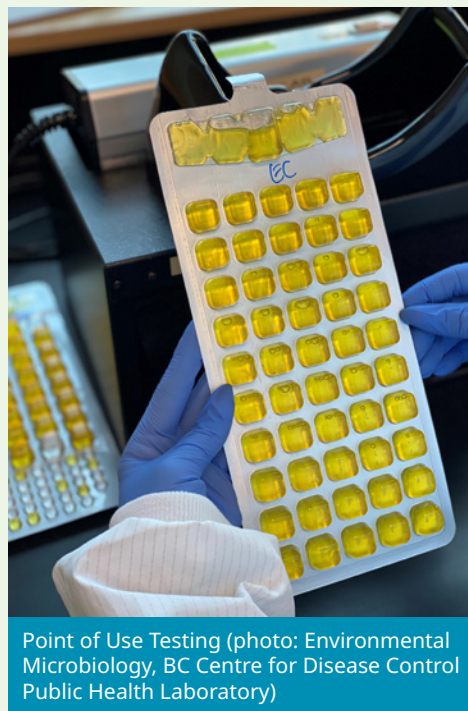
The 2021 AR-flood events also impacted the continuity of some diagnostic laboratory services ^[577]. The breakdown in transportation impacted time-sensitive laboratory testing, and provincial laboratories in Vancouver faced challenges delivering timely water-quality testing ^[583].



Collaboration was key to support innovative drinking water solution for residents affected by the floods ^[583]

Extreme rainfall and flooding from the 2021 AR disrupted drinking water testing, posing challenges for communities like Hope and those along the Fraser Canyon. The [B.C. Drinking Water Protection Act](#) requires water testing within 30 hours of sample collection, but challenging road conditions made it difficult to transport samples to the BC Centre for Disease Control (BCCDC) Public Health Laboratory in Vancouver in time. Obtaining necessary testing supplies and training was also a challenge, complicated by intermittent internet access and power outages.

In response, a “Lab in a Box” solution, officially called Point of Use Testing (POUT), was developed. This innovative approach enables local utility staff to sample and test water daily for contaminants (e.g. total coliforms and E. coli) on site, without transporting samples to the BCCDC. Collaboration between various partners, including Fraser Health and the Provincial Drinking Water Officer, has been instrumental in implementing this solution to ensure the reliability of water quality during emergencies.

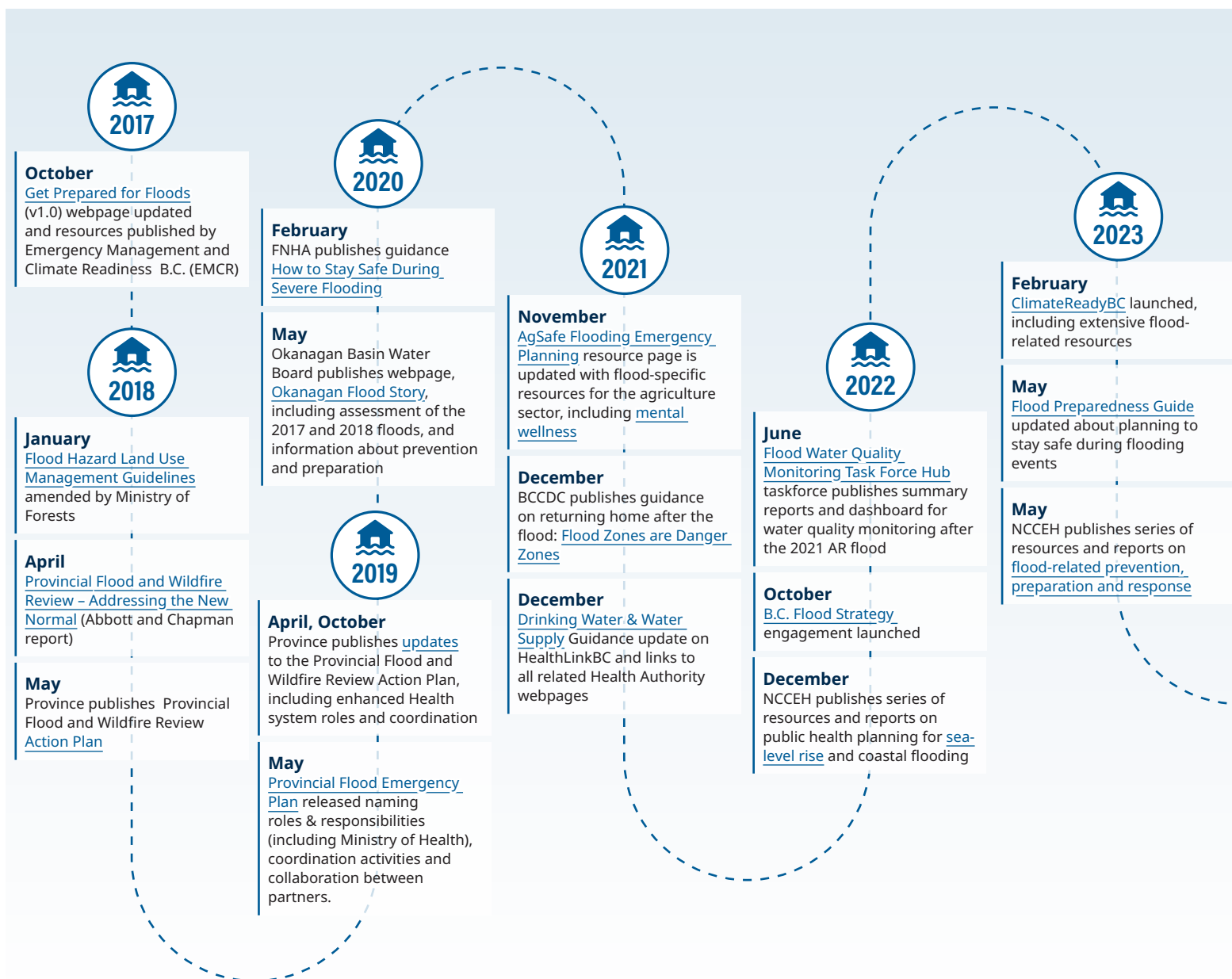


Point of Use Testing (photo: Environmental Microbiology, BC Centre for Disease Control Public Health Laboratory)

6.3 Health-related adaptations to floods in B.C.

Following the record-breaking flood seasons in 2017 and 2018, and the AR flood in 2021, provincial and regional after-action reviews have led to expanded action planning for flooding in B.C. While many flood-based adaptations are led by various sectors and partners (e.g. local governments, First Nations, and multiple provincial ministries), the B.C. health system is involved in prevention, preparedness, response to, and recovery from flood events. Some examples of health-related adaptations to flooding in B.C. are summarized in the timeline below.

A TIMELINE OF SELECT HEALTH-RELATED FLOOD ADAPTATIONS IN B.C.



Provincial flood strategy

Following the AR events of November 2021, the Province focused efforts on the development of a B.C. Flood Strategy, to be followed by a B.C. Flood Resilience (implementation) Plan. First Nations, local governments, provincial ministries (including the Ministry of Health), health authorities, federal agencies, technical experts, and community partners were engaged to provide feedback on how the vision and principles outlined in the [B.C. Flood Strategy Intentions Paper](#) ^[13] would be achieved over time through priority actions. Following this engagement, three What We Heard reports were developed to guide development of the B.C. Flood Strategy. Key takeaways, as communicated by participants, included a need for mental health and community well-being planning, food security (including considerations regarding impacts to transportation corridors), and strengthened flood risk governance ^[584,585].

The B.C. Flood Strategy, informed by the United Nations Sendai Framework on Disaster Risk Reduction, will provide a foundation and roadmap for implementing significant improvements to integrated flood hazard management over time. The Province has made efforts to collaboratively develop the flood strategy in partnership with First Nations and in consideration of the Declaration on the Rights of Indigenous Peoples Act, which aligns with the federal United Nations Declaration on the Rights of Indigenous Peoples Act.

Provincial structures and teams for flood-related monitoring and response

After the 2021 AR-flood event, a multi-agency provincial task force was formed to address concerns about water quality and inform provincial and local decision-makers. The [Interagency Flood Monitoring Task Force](#) has played a pivotal role in coordinating efforts among key governmental agencies led by the B.C. Ministry of Environment and Climate Change Strategy, and health-sector participants from provincial and regional health authorities and agencies.

The task force is actively engaged in establishing interconnected health system structures, working collaboratively to bolster health-response capabilities and share timely information. The task force supported water-quality assessments related to the floods through conceptual site models, using human health and ecological risk assessment methodology for flood-impacted areas of the Sumas Prairie, Merritt, and Princeton.

Emergency response teams for critical water and wastewater infrastructure

During flooding events, Environmental Operators work to minimize impacts of damage to water and wastewater infrastructure. The Environmental Operators Certification Program's mission is to protect human health and the environment by investing in wastewater treatment plant operators and facilities through increased knowledge, skill, and proficiency in all matters related to the water cycle. *"It's not a matter of if, it's a matter of when. When it comes to emergency response and critical water and wastewater infrastructure, we can be reactive, or we can be proactive. Let's stop being reactive. Let's learn, let's adapt, let's act now."* ^[586,587]

The disruption of food supply chains during the 2021 AR-flood events created an urgent need for food security coordination. A Food Security Working Group, chaired by the Ministry of Health with membership from across government, non-profit and private sector partners, coordinated and triaged immediate and urgent food security needs in the wake of the 2021 AR-flood events. Communication pathways were established to coordinate response efforts to address food security concerns, establish tracking and reporting mechanisms to ensure effective communication with the Emergency Operations Centre, and support food security strategies from response to recovery ^[56].

Early warning systems and data-driven public-risk communication tools

There are several interactive dashboard and mapping tools available in B.C. which provide information to the public about current flooding-related hazards. These include:

- B.C. River Forecast Centre's [Flood Warning and Advisory Notification Map](#), providing information about current flood warnings and watches;
- The Ministry of Emergency Management and Climate Readiness (EMCR)'s [EmergencyMapBC](#), showing locations of current flood warnings and watches, landslides, tsunamis, and flood and landslide evacuation orders and alerts;
- [B.C. Flood Debris Explorer](#), offering resources and tools for identifying and locating flood debris; and
- Vancouver Coastal Health/Fraser Health and Interior Health have studied and modelled some of the variables that are likely to determine community-level vulnerability to health impacts associated with flooding ^[83,84].

Early warning systems are being used to forecast flooding and flooding-related risk factors in B.C. The [B.C. Storm Surge Forecasting System](#), for example, offers six-day forecasts of storm surge and total water levels in Southern B.C., and in 2024, Environment and Climate Change Canada (ECCC) is developing the capacity to issue impact-based coastal flooding warnings ^[466,588]. ECCC is also exploring a ranking system for ARs to communicate potential impacts to the public ^[589,590].

Teamwork and innovating solutions

As with other challenging climate events, health care workers have shown many instances of teamwork, problem-solving, and resilience during flooding events. There are many examples of health care teams troubleshooting and rapidly developing and testing innovative solutions.

In many cases during the 2021 AR-flood events, health care workers went above and beyond to ensure patients, such as dialysis and transplant patients, received the critical care they needed—developing and coordinating plans to get life-saving medicines to stranded patients and, in some cases, travelling to attend to these patients themselves ^[560,575,576,591]. Teams worked together to design creative solutions for critical needs, including virtual care for renal peritoneal dialysis patients ^[592]; partnering across health authorities and with other organizations to provide helicopter care for patients; and ensuring patients received their needed medicine and supplies in the flood zone ^[560].

While health care teams should be commended for their dedication and tenacity, it is also important to recognize that these efforts can result in fatigue, burnout, and mental health impacts (summarized in Chapter 8), and it is unsustainable to rely on staff to go “above and beyond” during increasingly frequent climate events. Long-term health system adaptations are needed, as detailed in Chapters 8, 9, and 10.



Individual-preparedness and flood-risk communications

A number of guidance documents have been developed to support individuals and communities in B.C. be better prepared in advance of a flood, and to return safely to their homes after the floodwaters recede. Provincial and regional health authorities have also developed guidance and supported community flood preparation through community-resilience funding streams. Some examples in B.C. include:

- The [Flood Preparedness Guide](#), released in 2020 and updated in 2023, is a toolkit developed by EMCR. It provides guidance on flood preparation, such as creating a plan, having a meeting place in the community, and protecting homes and property. It highlights where to find information on advisories, such as [High Streamflow, Flood Watches and Flood Warnings](#), where to go during evacuation stages, and coping with flood stress. It also provides guidance for after flooding, where health-related risks and concerns include dealing with receding contaminated waters, compromised structures, and addressing and mitigating mould growth in the home.
- [ClimateReadyBC](#), a public-facing portal developed by the B.C. government, provides information to the public on natural hazards, including revised floodplain maps anticipated in 2024.
- The First Nations Health Authority has published guidance on staying safe before, during, and after severe flooding for First Nations individuals and communities, including considerations for water quality, food safety and septic systems ^[593,594].
- In 2023, the National Collaborating Centre for Environmental Health [hosted within the BCCDC] published a series of reports and catalogues identifying resources and information about [flood prevention, preparedness, response, and recovery](#); [mould assessment, remediation, and building for resilience](#); and [supporting community psychosocial well-being after a flood](#).
- BCCDC published a [list of resources](#) about returning to flooded areas, including information about hazards (such as contaminants, moulds, unstable structures, and carbon monoxide exposure) to consider before entering a flood zone, measures to reduce mould growth, and drinking water considerations ^[483].
- [Interior Health](#) ^[595] has developed and compiled extensive flood- and landslide-related guidance, including targeted guidance for food establishments and long-term care and child-care facilities.

Health authorities supporting preparedness for priority populations in B.C. communities

The Hope Citizens Emergency Disaster Planning Committee (HCEDPC) launched the Ready-Set-Go! Seniors campaign in response to the 2021 AR-flood events. They developed 200 senior-specific emergency kits with the support of a Fraser Health micro-grant. The kits include essential items, such as a blanket, flashlight, whistle, first-aid kit, water bottle, notepad, pen, and informational materials on emergency preparedness. Distribution occurs at various events, targeting housebound older adults. HCEDPC is dedicated to raising awareness and advocating for community emergency plans and encourages the community to prioritize emergency preparedness so that everyone, especially older adults, are equipped for unforeseen situations ^[596].

Floodplain mapping

Effectively addressing flood risks in a community requires a comprehensive understanding of the flood hazard's likelihood, and the community's resilience, vulnerability, and exposure. Floodplain mapping is used to assess flood risks by identifying the modelled flood extent (i.e., areas that would be affected by a given flood) ^[597,598].

Many communities in B.C. lack, or have outdated, floodplain maps ^[599]. In a December 2020 survey, researchers found that only 39 percent of the 109 B.C. local government and First Nations respondents⁴⁷ had either created or updated floodplain maps within the past 10 years, and more than half (56 percent) lacked knowledge of in-house flood management. Inadequate resources and in-house expertise were noted as significant barriers to conducting floodplain mapping ^[600,601]. Since 2015, federal and provincial funding programs have enhanced support for local governments ^[601–604] and updating floodplain mapping is a priority across Canada ^[605].

Examples of B.C. floodplain maps and tools include:

- [B.C. Flood Study Explorer](#): This dashboard showcases B.C. flood hazard studies funded by the province to better understand flood risks and related research.
- [Flood Maps in B.C. by Floodwise](#): This dashboard includes access to a range of flood maps, including floodplain, hazard, vulnerability, and risk maps; community-specific maps for river and coastal flood hazards; emergency planning maps; and regional-scale maps for the Lower Mainland flood management strategy.
- The [BC Floodplain Mapping Initiative](#): This initiative is collaboration with the Fraser Basin Council, with funding from the Province of B.C. and Government of Canada via the [Flood Hazard Identification and Mapping Program](#). It focuses on producing high-quality floodplain maps for communities facing riverine, lakeshore, and coastal flood hazards, particularly in six high-risk areas, including the Lower Fraser and Coquihalla Rivers, Nicola and Coldwater Rivers, Upper Fraser and Nechako Rivers, Bulkley and Skeena Rivers, Shuswap Lake Region, and the Upper Columbia River.

⁴⁷ Response rate to the survey was 32.3 percent.

Community- and First Nation-led adaptations

Key adaptations to reduce flood risk for communities include physical flood protection measures, such as dykes and levees, and nature-based solutions, such as widening natural floodplains, protecting and expanding wetlands, and investing in urban green spaces to reduce run-off ^[606–611].

As most impacts and adaptations to floods are place-based, many of the levers to increase flood resilience are outside the health system and rely on strong local leadership and partnerships across sectors and scales. Community and/or Indigenous-led adaptations in B.C. have included:

- The [Okanagan Basin Water Board](#) supported a valley-wide partnership of local governments and Indigenous communities to update the region's floodplain mapping. Funded by the Province, the project's goal was to enhance community understanding of flood hazards in the Okanagan watershed through information-sharing after high-water events in 2017 and 2018. The project included floodplain maps, historical accounts of flooding, information on the impact of changing climate, mitigation strategies, flood-preparedness resources, response guidelines, and recovery assistance. A similar provincially-funded initiative was completed by the Fraser Basin Council between 2018 and 2023 for the [Thompson River](#) watershed ^[610].
- The [Sea2City Design Challenge](#) was a collaborative effort to facilitate collective learning and capacity building among project partners and design teams. It involved multi-disciplinary design teams; City of Vancouver staff; local coastal adaptation experts; Host Nation representatives, knowledge keepers, and designers from Musqueam, Squamish, and Tsleil-Waututh Nations. It was guided by the values of the Host Nations, community, and design principles identified through earlier engagement, with a focus on increasing public awareness of sea-level rise and coastal flooding; promoting a reconciliation-centered coastal adaptation approach; addressing social equity, economic, and ecological challenges related to sea-level rise; and exploring adaptation options for a minimum two-metre sea-level rise along key sites of Vancouver's False Creek shoreline.
- Across the entire Lower Mainland, a First Nations-led action plan focused on flood adaptation strategies is underway. The president and tribal chief of Stó:lō Tribal Council also chairs the [Emergency Planning Secretariat](#) with representatives from 31 First Nations communities. The goal of the Secretariat is to implement a Coast-Salish-led flood management strategy for the entire region, from Yale to Tsawwassen to Squamish ^[612].

Other key flood resilience priorities identified by the Canadian National Risk Profile include enhancing whole-of-society collaboration and governance to strengthen resilience, improving our understanding of disaster risks in all sectors of society, and expanding the focus on whole-of-society disaster prevention and mitigation ^[605].



6.4 Opportunities for action

Addressing the population health and health system impacts of flooding in B.C. requires a multifaceted and collaborative approach. Some key opportunities for action include:

Coordination and collaboration

- Increase clarity on roles and responsibilities between health system agencies and other ministries, including who is responsible for communicating to the public regarding flood preparedness, impacts and recovery.
- Build capacity and guidance for health- and non-health-related actors to support rapid flood response during times of acute flood events (e.g., Flood Water Quality Monitoring Task Force).
- Enhance community-level coordination and collaboration between health agencies, local governments, First Nations, and other partners during flood events and flood recovery.

Surveillance and research

- Utilize spatial data (e.g., location of critical infrastructure related to drinking water, stormwater, and wastewater) to better understand potential water-related health impacts during flooding.
- Enhance understanding of the short- and long-term physical and mental health impacts of flooding, such as anxiety, emotional trauma, and PTSD.
- Research the differential health impacts of flooding in B.C. on priority populations.
- Explore the cascading impacts of flooding on food security.

Management of environmental determinants of health

- Continue to enhance water quality monitoring to detect contamination in water supplies during and after flooding, including sampling of water supply systems and encouraging sampling to those responsible for private wells.

- Encourage the continued use of innovative strategies (e.g., point-of-use testing) for timely water sampling during emergency flood events.
- Promote rapid response to conduct health housing inspections after a flooding event.

Communications

- Conduct public awareness campaigns to educate residents about the health risks of flooding (e.g., mould exposure, mental health) and to promote preparedness measures.
- Support timely communication of water-quality data to community partners and the public during and after flooding.

Mental health services

- Enable timely and adequate mental health services and community support programs to mitigate the adverse psychosocial effects of flooding.
- Integrate mental health support services into emergency response plans to address the psychological impacts of flooding on health care staff.

Health facility preparedness

- Include flood risk considerations in health facility climate risk assessments.
- Integrate flood risk and exposure considerations in site selection for health facilities, utilizing the most up-to-date climate data.
- Plan for flood resilience in the retrofit and design of health infrastructure, considering elevation, waterproofing, and other resilience measures.