Pacific Institute
for Climate Solutions

Vital Connections:

Linear Critical Infrastructure and Climate Risk in B.C.

March 2026

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Funding

This work was funded by the Ministry of Emergency Management and Climate Readiness, Government of British Columbia.

Territory acknowledgement

The main office of the Pacific Institute for Climate Solutions (PICS) is located at the University of Victoria. PICS respectfully acknowledges the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples on whose traditional territory the university stands, and the Lək̓ʷəŋən and WSÁNEĆ Peoples whose historical relationships with the land continue to this day.

PICS would like to respectfully acknowledge the territories where we gathered and express gratitude to the Nations whose historical relationships with the land continue to this day.

Clark, D, Mills, T, De Grandpre, A. Vital Connections: Linear Critical Infrastructure and Climate Risk in B.C. Victoria: Pacific Institute for Climate Solutions; 2026.

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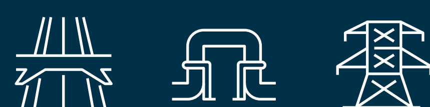
Simon Fraser Bridge, spanning the Fraser River in Prince George. *iStock*

Executive Summary

B.C.'s prosperity and safety depend on critical infrastructure. Built linear critical infrastructure systems—including powerlines, pipelines, road and ferry networks, railways, and telecommunication networks—deliver essential services like electricity, clean water, health care access, and internet. Because these systems are interconnected and often operated by single providers with limited redundancy, a failure in one can cascade across sectors with substantial consequences to communities and B.C.'s economy.

Critical infrastructure systems face growing risks from climate change and geopolitical pressures. National studies show damage to physical infrastructure is Canada's top climate risk. Even the Department of National Defence warns that protecting infrastructure is a growing priority.[1-4]

Climate-induced disruptions to built linear critical infrastructure are no longer hypothetical. In the last five years, climate impacts to these systems have resulted in billions of dollars in direct damage and tens of billions in economic impacts from productivity loss and transportation delays.



Built linear critical infrastructure:

Large-scale, human-made systems that span wide areas or connect communities, including roads, pipelines, and electrical transmission lines. These networks are vital to ensuring reliable service delivery across the province.

Like many regions of Canada, B.C. is unprepared for the risks ahead. This report highlights four systemic challenges: gaps in how risks are measured; poor coordination across systems; limited access to data; and finite public and political support.

Unless addressed, these gaps will continue to drive higher costs, slow recovery, and deepen disruptions every time hazards hit.

This report addresses that gap by:

- Identifying critical pinch points where climate-related hazards could cause the greatest disruption
- Highlighting gaps in monitoring and regulatory frameworks
- Assessing the barriers to future-proofing infrastructure
- Recommending concrete, actionable steps governments can take to strengthen resilience across sectors

This report draws on published research; conversations with operators, experts, and government staff; and geospatial analysis to assess vulnerabilities, interdependencies, and initiatives to improve resilience. A case study on the 2021 atmospheric river further illustrates the economic and societal consequences of unmanaged risks. We focus specifically on the following built linear critical infrastructure:

- Road, rail, and ferry transportation infrastructure
- Water and wastewater infrastructure
- Energy pipelines and electrical transmission lines
- Information, communication, and technology (ICT) infrastructure
- Ports—though largely a "point" infrastructure—are also included, given they are critical nodes for ferry and shipping transit

Our findings underscore that climate resilience is not optional. Decisions made today about infrastructure investment and standards will lock in safety, affordability, and sustainability for decades. Governments and operators must act now—shifting from reactive disaster recovery to proactive resilience planning.

Businesses depend on reliable services and infrastructure. Resilient systems reduce long-term government costs from disasters and also strengthen supply chains, making B.C. a more attractive place to invest and grow.

> *"Resilient systems strengthen supply chains, making B.C. a more attractive place to invest and grow."*

Resilience requires leadership. Strong direction is needed to align owners, operators, and regulators around a shared vision for safeguarding vital services. To get there, this report outlines four pathways to resilience.

1. Put service delivery front-and-centre

a. **Challenge statement:** You can't manage what you don't measure. Without consistent methods to assess vulnerabilities and shared standards for vital services, B.C. lacks the common ground needed for coordinated resilience planning.

b. **Pathways to resilience:** The Government of B.C. should coordinate with regulators to adopt essential service delivery standards and performance metrics; improve shared language and methods to incorporate criticality and equity across scales; and improve understanding of B.C.'s vital services and the implications of linear critical infrastructure disruptions.

2. Unlock existing data and knowledge

a. **Challenge statement:** Fragmented methods create fragmented resilience. Operators use inconsistent approaches to assess climate risks, reaching conflicting conclusions from the same evidence. Without shared standards, B.C. lacks the common ground needed for coordinated resilience planning.

b. **Pathways to resilience:** Consistent, transparent data is the foundation of coordinated resilience. Oversight bodies should set clear guidance for data use and risk assessment, require disclosure of findings, and create shared systems that ensure every operator—large or small—has access to credible, comparable information.

3. Improve collaboration and coordination

a. **Challenge statement:** Splintered systems breed splintered responses. With operators siloed, data locked away, and no central authority, coordination falls short and essential services are at risk.

b. **Pathways to resilience:** B.C. needs an accountable body with the authority to coordinate across owners, operators, and regulators, ensuring resilience is treated as a shared mandate rather than a patchwork of siloed actions. This body would drive compliance, foster collaboration, and embed continuous learning into the province's critical infrastructure systems.

4. Build public appetite for critical infrastructure investment

a. **Challenge statement**: People rarely notice what keeps them safe—until it fails. The public focuses on today, but leaders must safeguard tomorrow—or communities will pay far more when disasters strike.

b. **Pathways to resilience:** Increasing public and political support is critical to moving resilient infrastructure up the priority list. Owners, operators, and policy organizations should work together to raise awareness, strengthen trust, and equip both the public and elected leaders with the knowledge needed to support proactive investment.

Ferry crossing between Vancouver and Vancouver Island. *iStock*

Introduction

Infrastructure is vital to the prosperity and security of British Columbia. British Columbians rely on linear critical infrastructure—roads, railways, pipelines, transmission lines, ferries, ports, and water systems—to connect, access essential services, and prosper economically. When these systems fail, the consequences cascade across sectors, affecting everything from health care and food supply to trade and emergency response.

Many of B.C.'s assets are aging and were designed for past climate conditions. At the same time, climate change, population growth, and shifting hazards are exposing them to new and compounding risks. Hotter summers, heavier rainfall, and more frequent wildfires are already testing infrastructure, as seen during the 2021 heat dome and atmospheric river. Growing interdependencies mean that a failure in one system, such as a power outage, can quickly disrupt others, amplifying costs and impacts.

This report analyzes climate-associated impacts and vulnerabilities for built linear critical infrastructure in B.C. It focuses on transportation (road, rail, ferries, and ports), water and wastewater, energy pipelines and electrical transmission lines, and information and communications technology (ICT). These lifeline systems underpin the functioning of all other sectors. Infrastructure failures do not stop at physical systems; they cascade into essential services like electricity, clean water, health care access, and internet services, amplifying societal impacts.

> *"Hotter summers, heavier rainfall, and more frequent wildfires are already testing infrastructure."*

Below, we examine vulnerabilities, interdependencies, and examples of resilience efforts underway for each infrastructure sector. We also review the cascading impacts of the 2021 atmospheric river to illustrate critical infrastructure interdependencies. The report concludes with cross-cutting pathways to strengthen resilience.

Canada's National Adaptation Strategy

Canada's National Adaptation Strategy includes the following transformational goal for infrastructure:
"By 2050, all infrastructure systems in Canada are climate resilient and undergo continuous adaptation to adjust for future impacts, to deliver reliable, equitable, and sustainable services to all of society".[8]

Aging infrastructure is putting B.C. on a backfoot.[4b] In 2019, the Canadian Infrastructure Report Card reported that nearly 40 per cent of roads and bridges and 30 per cent of water and wastewater infrastructure were in fair, poor, or very poor condition.[5] According to a 2018 federal government report, the infrastructure gap—the shortfall between current assets and what is needed for reliable service—ranged from $50 billion to $750 billion depending on methodology.[6]

At the same time, infrastructure systems have become deeply interdependent. For example, power outages can disrupt everything from communication networks and health systems to wastewater pump stations. With limited redundancy, the consequences of a single failure can quickly cascade across systems, amplifying both social and economic impacts.

There are large emerging and intensifying threats to critical infrastructure. Because of their age, most roads, electricity systems, pipelines, and ports in B.C. were designed for past conditions. Yet, climate change, geopolitics, and population growth are rapidly shifting the environment and threats. This report focuses on climate hazards, though many findings apply more broadly.

As B.C. residents know, the climate here is changing. Summers are getting hotter and drier, winters more extreme, and precipitation patterns increasingly variable. The intensity and frequency of hazards like wildfires, heatwaves, and floods are rising. These hazards can directly destroy infrastructure or disrupt its function. Further, climate change is increasing demand on some services. For example, rising temperatures are driving higher electricity use for cooling, while shifting precipitation patterns are affecting water supply. The result is that aging systems are under growing stress.

B.C. faces a mounting fiscal crunch, making it difficult for governments to prioritize costly resilience upgrades even as climate risks accelerate. Yet, the evidence is clear: Canada's largest infrastructure focused climate study shows the scale of risk. By mid-century, costs for flood damage to homes and buildings could rise five fold; roads and rail damage up to $5.4 billion annually; and electrical infrastructure repair more than double—and potentially triple by century's end.[7] Yet, proactive resilience measures can reduce future losses by 80 to 90 per cent, delivering massive long-term savings.[7]

> *"The consequences of a single failure can quickly cascade."*

Infrastructure choices shape future resilience. Infrastructure is usually built with the expectation that it will deliver services for multiple decades. Location and design choices also shape future patterns of housing, business, and community growth, locking in either resilience or vulnerability.

On the flip side, investment can spur economic development and reduce upkeep costs in the long run.[8, 4b] For example, Canada's National Guidelines for the Flood Resistance of Buildings report a benefit-cost ratio of 11:1—meaning every dollar invested in flood-resistant measures saves $11.[9] This underscores the importance of forward-looking, climate-informed planning and decision making.

Report purpose and content

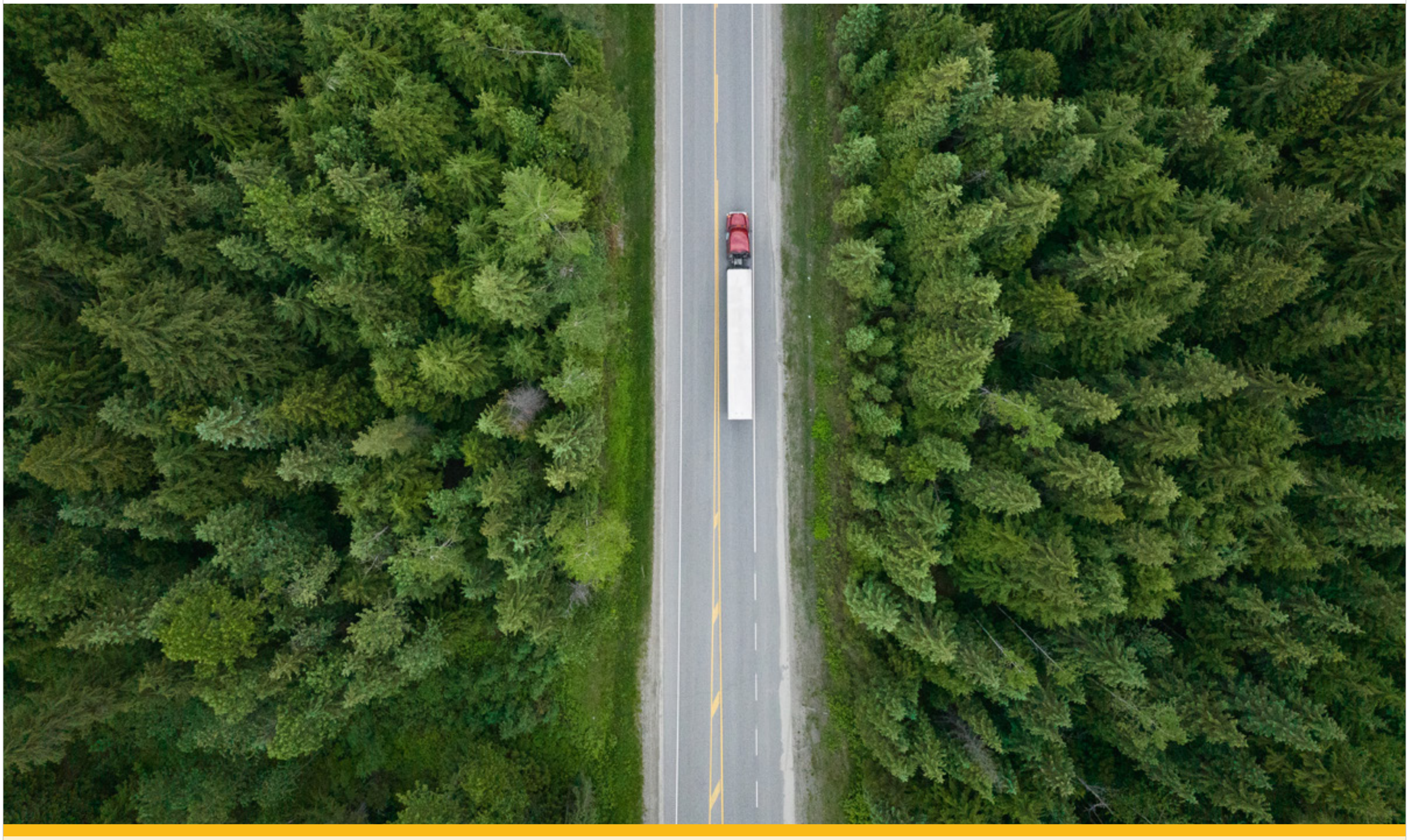
In the last five years, climate impacts on B.C.'s built linear critical infrastructure systems have resulted in billions of dollars in direct damage and tens of billions in economic impacts from productivity loss and transportation delays.[10] These cascading impacts reveal how exposed B.C.'s economy and communities are to even brief disruptions in service. To manage the risks, governments, municipalities, and private operators require a shared understanding of vulnerabilities, interdependencies, and clear, actionable standards for resilience.

In this report, we analyze climate-associated impacts and vulnerabilities for built linear critical infrastructure services in B.C. We synthesize impacts and vulnerabilities across sectors, highlight cross-cutting challenges, and outline pathways to strengthen resilience.

This analysis is part of a research portfolio led by the Pacific Institute for Climate Solutions and funded by the Government of British Columbia, Ministry of Emergency Management and Climate Readiness. Parallel analyses led by PICS are focused on improving the integration of climate science into risk assessments; modelling cascading infrastructure impacts; and reviewing adaptation policy options. Together, this research portfolio highlights both the technical and policy levers required to address infrastructure risks under a changing climate and constrained fiscal environment.

The remainder of this report is broken into five distinct sections.

1. **Methodology:** a description of the study scope as well as the data collected and analysis
2. **Linear critical infrastructure state of play:** an overview of climate change trends in B.C. and context of built linear critical infrastructure vulnerabilities in B.C.
3. **Atmospheric river case study:** an example of interdependencies and cascading impacts drawing from the 2021 atmospheric river
4. **Deep dive:** B.C.'s built linear critical infrastructure by sector: reviews each built linear critical infrastructure sector, the climate impacts and vulnerabilities, and examples of climate risk and resilience work underway in B.C.
5. **Pathways for resilience:** actions to better manage risks and build resilience in B.C.



Container truck driving along a stretch of the Trans Canadian Highway. *iStock*

Methodology

Study design and scope

To analyze the climate-associated impacts and vulnerabilities for built linear critical infrastructure services in B.C., we drew data from a literature review, conversations with owners and operators, and geospatial datasets.

Our analysis emphasizes the linear components of infrastructure—such as roads, railways, transmission lines, pipelines, and distribution networks—rather than "point" assets like treatment facilities, reservoirs, or power plants. This focus reflects the importance of networks in enabling service delivery and cascading risks.

To situate this study within Canada's broader framework, we reference the National Strategy for Critical Infrastructure, which identifies ten sectors.[11] Four "lifeline" sectors—energy and utilities, information and communication technology, transportation, and water—are the focus of this report, given their linear nature and role in enabling all other services. The remaining sectors (manufacturing, safety, finance, food, government, and health) depend on the resilience of these lifelines. While this report focuses on built linear critical infrastructure, these systems are inseparable from the broader critical infrastructure ecosystem. Linear assets interact with point-based facilities (e.g., treatment plants, substations, hospitals) and underpin the delivery of essential services. Findings should therefore be understood as both sector-specific and ecosystem-relevant.

The built linear critical infrastructure types covered in this report include:

- Road, rail, and ferry transportation infrastructure
- Water and wastewater infrastructure
- Energy pipelines and electrical transmission lines
- Information, communication, and technology (ICT) infrastructure
- Ports and ferry infrastructure (although largely "point" assets, they function as linear connectors that enable transportation networks in B.C.)

We focused on climate-related threats to critical infrastructure. Specific climate-related threats included:

- Extreme heat
- Temperature shifts (freeze/thaw cycles and gradual warming)
- Wildfire and smoke
- Inland flooding (pluvial and riverine)
- Coastal flooding
- Drought
- Debris flow and landslide
- Extreme weather (tornado, wind, heavy snowfall, ice storm)

B.C.'s built linear critical infrastructure also faces many non-climate threats (e.g., earthquakes, cyberattacks, foreign sabotage, tsunamis, and volcanic activity). These fall outside the scope of this report but remain critical for future analysis.

Data collection

First, we reviewed relevant literature: scholarly articles, reports, and climate data. This review provided breadth of evidence across infrastructure types, hazards, and B.C.'s geography, while also highlighting important knowledge gaps.

Second, we had 19 semi-structured conversations with infrastructure operators, regulators, and experts across B.C. in fall 2024. Topics included:

- Identifying climate-related hazards of the greatest concern
- Pinpointing areas of the province where there may be greater exposure to climate-related hazards
- Understanding interdependencies between linear critical infrastructure systems
- Identifying resilience work underway by linear critical infrastructure owners and operators
- Listing unknowns that are affecting the resilience of critical infrastructure
- Outlining pathways and priorities for improving the resilience of critical infrastructure to climate change in B.C.

We selected individuals for the discussions through purposive sampling, targeting those with direct expertise and operational involvement. Conversations were anonymized to encourage open discussion, and no direct quotes are attributed.

Finally, we used geospatial data to analyze system distribution, pinch points, and potential interactions with hazards. We obtained data from government databases, utility regulators, and through academic data sharing networks.

Data analysis and presentation

We collated findings from literature deductively, based on themes. Expert perspectives are presented alongside literature sources; while a full critical evaluation was beyond scope, this remains an important next step.

We used ArcGIS to visualize geospatial patterns of each infrastructure. We then used R Cran to analyze pinch points and hazard interactions. Specifically, we looked at road networks and the electricity transmission network due to data availability (see box).

GEOSPATIAL NETWORK ANALYSIS

This project develops a new method for identifying "pinch points" in infrastructure (places where damage could cause widespread disruption downstream). How it works:

1. **Turning maps into networks**
We begin by turning road maps into a network of lines (edges) and points (nodes). Think of it like a spider web: roads are the strands; intersections are the connecting points. This structure allows us to trace how a disruption in one location might isolate other parts of the network.

2. **Breaking the network**
To test vulnerability, we simulate damage to specific parts of the network and measure what happens. For example, what happens if one road is washed out by a flood? What happens if a group of nearby roads is blocked by a wildfire? We look at how many other roads or intersections become unreachable as a result. The more places that are cut off, the more "vulnerable" that original location.

3. **Realistic hazard patterns**
Rather than randomly damaging roads across the province, we simulate hazards that act like real disasters: Damage is concentrated in a small area (10 km x 10 km regions). Within that region, damage clusters tightly, reflecting the spread of fire, flooding, or landslides. This makes the simulations more realistic and helps us identify areas that are truly exposed to hazard-style failures, not just random ones.

4. **Measuring vulnerability or resilience**
We assign a resilience score to each area. This tells us how much of the network is lost when a given location is damaged. But to keep the analysis fair, we adjust the score to reduce bias: If only one road is removed and a huge part of the network is disconnected, that gets a high vulnerability score. If many roads must be damaged before the same amount of disconnection happens, that gets a lower score, indicating redundancy. To balance things out, we use a formula that avoids giving too much credit to locations just because they have a lot of roads. We use a logarithmic or square-root adjustment, so that urban and rural areas are treated fairly.

5. **Monte Carlo simulation**
We repeat the simulations over 100,000 times, each time picking a new location and simulating a new type of damage. This helps us identify areas that are frequently vulnerable, no matter the hazard location, and areas that are sometimes vulnerable, depending on which other parts of the network are affected. This approach captures not only if a place is a pinch point, but how fragile the system is when exposed to multiple hazards or cascading failures.

Why this matters

This tool allows planners, emergency managers, and communities to:

- Identify pinch points that need reinforcement, redundancy, or rerouting
- Compare neighborhoods by the resiliency of their infrastructure
- Prioritize investments where they'll make the most impact in terms of avoiding system-wide failure

Limitations and recommendations for further analysis

Scope constraints

The report focuses on built linear critical infrastructure and excludes a detailed assessment of other connected components or systems, including point-infrastructure and vital services. Expanding scope in future studies could better illuminate interdependencies.

Given that our scope focused on establishing a high-level baseline summary of risks and activities, we did not engage with service users. Engagement with service users, including First Nations and underserved communities, was beyond scope but is essential for equitable policy development and risk identification.

B.C. built linear critical infrastructure is also exposed to non-climate-related hazards. System resilience to earthquakes and tsunamis is also important in B.C. Further, interviewees consistently expressed concern about cyber threats and risks posed by hostile state and non-state actors. While these non-climate hazards were outside scope for this research, increased resilience to climate-related hazards often improves resilience to these non-climate hazards too.

Sampling and representativity

This analysis involved a small number of staff representing critical infrastructure operators, regulators, and experts. While personal bias may have been somewhat offset by the inclusion of literature, further work is required to diversify perspectives and confirm our findings. Focus groups and workshops could provide cross-pollination of ideas, strengthening insights on interdependencies.

Data availability

We identified a number of gaps in publicly available datasets. For instance, there is limited information regarding climate impacts to renewable energy systems, as pointed out by the Fraser Basin Council in their regional report.[12] This report therefore provides limited information on biomass, wind, and solar, and excludes geothermal energy.

The rebuilt Highway 8 between Merritt and Spences Bridge restores connectivity to residents, Indigenous communities and the local forestry and mining industries. More than seven kilometres of Highway 8 was completely lost due to the atmospheric river event of 2021. *iStock*

> *“There is a broad concern about cyber threats and risks posed by hostile state and non-state actors.”*

There is also limited information on interdependencies between systems. As noted in the “Pathways” section, operators recognize the importance of interdependencies, but structured mechanisms for sharing information are limited. Further, this report does not develop a full typology of interdependencies across sectors. Future work could expand our high-level analysis by developing a structured typology.

Confidentiality and data sensitivity

Critical infrastructure operators were limited in the information they could share due to security concerns and risks associated with public disclosure of sensitive information. Geographic-specific vulnerability and exposure data was considered highly sensitive, preventing public identification of “hotspots.”

Future work should focus on developing trusted spaces and protocols for securely sharing sensitive infrastructure data, as outlined in the “Pathways” section.

The scorched remains from a forest fire in southern British Columbia. *iStock*

Linear Critical Infrastructure State of Play

This section provides an overview of:

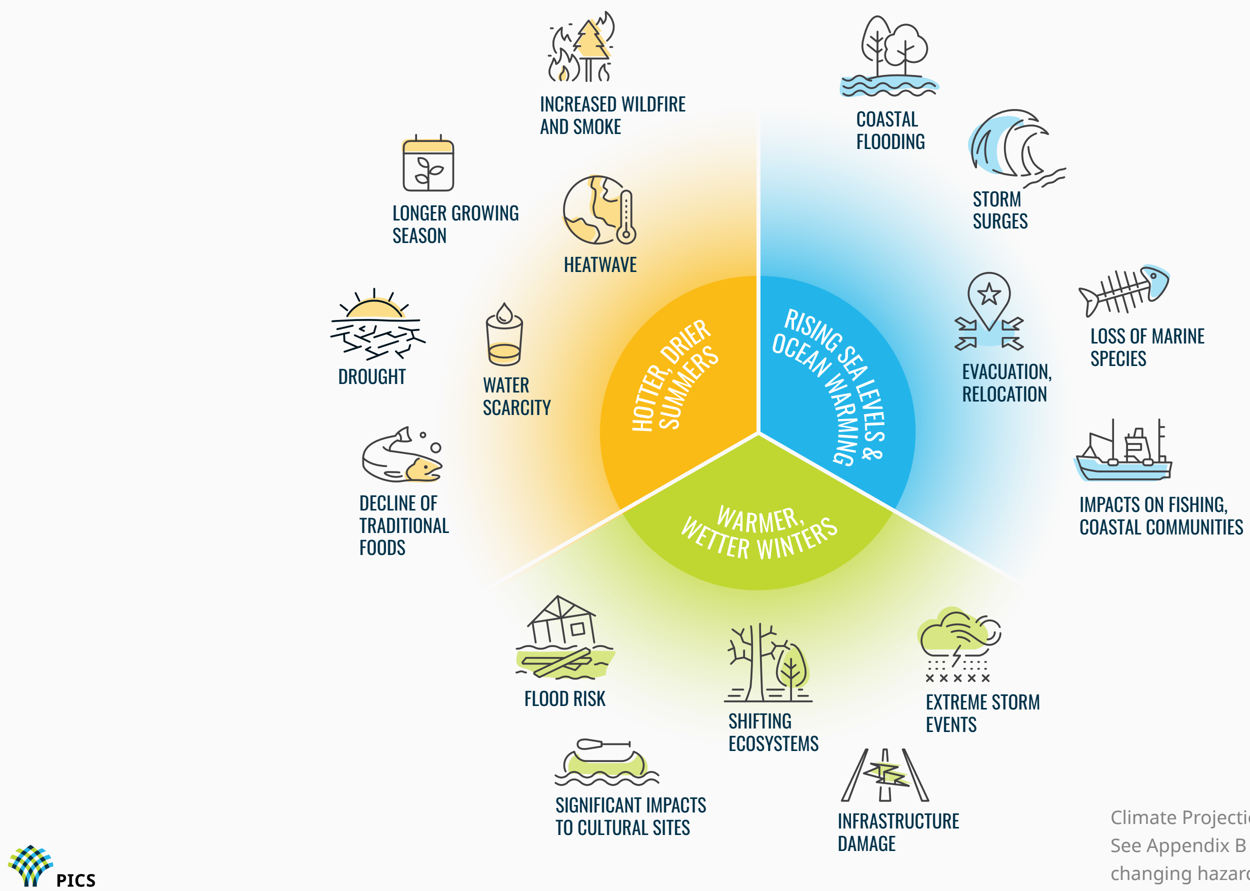
- » Anticipated climate change for B.C.
- » Common built linear critical infrastructure vulnerabilities
- » Typical impacts on infrastructure and the essential services they support
- » Principles of resilient infrastructure
- » Examples of existing Canadian resources related to critical infrastructure
- » Insurance

Summary of anticipated climate change for B.C.

Over the past century, average temperatures in B.C. have risen by 1.2°C and annual precipitation has increased by approximately 20 per cent.[13,14] These trends are projected to accelerate, driving more frequent and intense hazards, such as wildfires, heatwaves, inland flooding, and coastal flooding.[15] Climate change is also driving longer-term shifts across B.C., such as rising sea levels and spread of invasive species. This will drive more frequent and intense hazards, including wildfires, heatwaves, inland and coastal flooding, alongside longer-term shifts such as rising sea levels and the spread of invasive species.

The B.C. Climate Preparedness and Adaptation Strategy summarize the anticipated climate trends for the province as three broad shifts: hotter, drier summers; warmer, wetter winters; and rising sea levels with ocean warming.[16]

FIGURE 1: BRITISH COLUMBIANS ARE FACING NUMEROUS CLIMATE RISKS



Climate Projections and Impacts in B.C. (16). See Appendix B for more details about B.C.'s changing hazards.

Common vulnerabilities across built linear critical infrastructure

Key features of B.C.'s built linear infrastructure are making make it especially vulnerable to damage and service disruptions. These include:

» **Age and condition:** Much of B.C.'s municipal infrastructure is more than 20 years old and rated in poor or very poor condition, designed for historic climate conditions rather than today's or tomorrow's risks.[5] Underinvestment, combined with inadequate maintenance and increased climate stress, is accelerating deterioration.[9]

» **High exposure to hazards:** B.C. has approximately 57,100 km of paved roads, 9,600 km of rail tracks and tens of thousands of kilometres of power and communications lines.[17] By nature, linear infrastructure spans long distances across multiple climate zones and terrains, exposing it to a wide range of hazards. These systems are disproportionately located near rivers, forests, steep slopes and along coastlines—areas highly susceptible to climate risks.[15]

» **Fixed routing of and limited redundancy:** Routing is often dictated by geography, land use, and ownership, leaving little flexibility to relocate. Lack of redundancy means that failures at pinch points can disrupt entire networks.

» **Sensitive to land instability:** Linear infrastructure systems such as roads, railways, and pipelines are susceptible to damage and disruption from land erosion and slope failures. Climate change is affecting freeze/thaw cycles, precipitation patterns, soil infiltration of water (e.g., after wildfire), and other drivers of slope instability.

- **Compound and cascading hazards:** Each region faces unique combinations of hazards that can interact, producing cascading and compound events. Owners and operators emphasized uncertainty around these complex interacting risks.
- **Interdependencies:** Because systems depend on one another, impacts in one can ripple quickly across others. Ownership fragmentation (public, private, multiple regulators, and jurisdictions) compounds the challenge of coordination.
- **Upfront capital cost of adaptation:** Most infrastructure was not built for today's hazards, let alone future risks. Replacing or retrofitting is costly, and fiscal and political barriers—including low public awareness, difficulty quantifying avoided losses, and historic underinvestment—continue to stall resilience upgrades. Experts we spoke with also also highlighted the limited capacity of asset managers to incorporate climate risk into their operations.
- **Disconnect between owners and users:** Essential service providers (e.g., hospitals, grocery stores, ferries) face high costs when infrastructure fails, yet users rarely see the vulnerabilities. Owners and operators, meanwhile, are insulated from many of the indirect costs of failure—weakening incentives for investment in resilience.

Common climate impacts to built linear critical infrastructure and the essential services they support

The following summarizes the recurring impacts of climate hazards on linear infrastructure systems:

- **Increased service disruption:** Direct damage leads to more frequent and prolonged outages.
- **Higher maintenance and operational costs:** Extreme events require repeated repairs, higher cooling demands, protective retrofits, and more frequent emergency mobilization.
- **Reduced lifespan of assets:** Climate stresses accelerate wear, forcing earlier-than-expected replacement.
- **Reduced efficiency or functionality:** Systems may operate below design standards due to changing environmental conditions (e.g., de-rating electrical lines during extreme heat, slower traffic from smoke or debris, pump stations overheating).
- **Cascading failures:** Failures in one system can trigger knock-on failures in others (e.g., power outage halting ICT and water pumps).
- **Workforce disruptions:** Hazards can limit staff access to sites and create direct health and safety risks for workers.

Essential services depend on resilient infrastructure. Public Safety Canada defines essential services as: energy and utilities, ICTs, finance, health, food; water, transportation, safety, government, and manufacturing.[11] Critical infrastructure failures cascade into these essential services, directly affecting society.

The following cases illustrate how these disruptions translate into real-world consequences:

Health care and older adult care

In addition to a surge for medical services when climate events occur, broad impacts to the health system can occur when built linear critical infrastructure such as power, ICT, and roads are compromised. Facilities can be directly affected by power outages and climate events, e.g., the hospital evacuation due to wildfire in Fort McMurray in 2016. Supply chains can be disrupted as they were during B.C. events like the 2017, 2018, and 2021 wildfires, the 2021 atmospheric river floods, and the 2021 heat dome. These disruptions affected the delivery of essential supplies such as blood products, oxygen, and chemotherapy treatments. An ICT outage could disrupt hospitals' access to critical patient records, emergency dispatch and coordination, or cause a delay for other medical responses.

The 1998 ice storm in Quebec disrupted service to patients dependent on home oxygen and dialysis treatments. The prolonged power outages reduced access to safe drinking water and refrigerated medicines.

Storm surge and high tide on Dallas Road, Victoria. *iStock*

Increased cases of foodborne illnesses and dehydration cases were reported in emergency rooms. Rural and remote health services were disproportionately affected due to transportation disruptions and power failures.[18]

Financial services

In 2012, Hurricane Sandy caused a two-day closure of the New York Stock Exchange due to power outages with cascading impacts through the financial sector. The 2004-2005 hurricane season along the American Gulf Coast severely affected banking operations, including unavailable personnel, inadequate cash supply, and loss of communications and power. Electronic payments collapsed, forcing cash-only transactions in storm-damaged areas. Delivery of cash was constrained by damaged transportation and competing emergency priorities, underscoring how dependent financial services are on uninterrupted ICT, power, and transport systems.[19]

Emergency management and emergency services

Disruptions and damage to build linear critical infrastructure can hamper emergency response, with deadly consequences. An interviewee described difficulties communicating during the 2015 Port of Vancouver fire, as onlookers flooded ICT infrastructure with videos of the fire. During the 2021 atmospheric river event, entire communities were cut off and damaged highways delayed evacuations. Due to experiences during the 2021 heat dome event, B.C. Emergency Health Services now provides some flexibility so personnel can work closer to home if they cannot access their assigned work location.

Food cold supply chain

Temperature control of perishable food products from harvest to processing to the consumer affects food quality, shelf life, and food waste, and occurrences of foodborne illness. The cold supply chain is highly vulnerable to climate shocks. Transportation disruptions delay shipments; power outages interrupt refrigeration; and extreme heat increases equipment failure. These disruptions lead to food waste, higher costs, and increased food insecurity risk.[20]

Industry - Port of Vancouver

The Port of Vancouver handles $1 of every $3 of Canada's trade in goods outside North America. The port handles approximately $550 million per day of shipping activity.[21] The atmospheric river event in November 2021 damaged inland rail and road supply chain connections to the port. This disruption raised demurrage fees, spiked freight costs, and forced production cuts in forestry and agriculture. Provincial labour market impacts are estimated at $810 million to $1.4 billion, underscoring the economic scale of climate-related supply chain disruptions.[22]

Correctional institutions

The Fraser Valley Regional District's hazard, risk, and vulnerability assessment identifies the Ford Mountain Correctional Centre as a critical facility and identifies the risk of the facility losing access to major transportation routes during a flood event.[23] These facilities often lack redundant supply chains or backup logistics capacity, leaving them highly exposed to infrastructure failures.

Education and community facilities

Transportation disruptions and power outages that occur due to climate-related hazards such as flooding and wildfire often result in the closure of educational facilities or classroom disruptions. The evacuation of the town of Merritt during the 2021 atmospheric river also resulted in extended school closures. During COVID-19, the shift to online learning further underscored dependence on reliable ICT and electricity. Community facilities that provide essential services and refuge capacities (e.g., cooling and warming centres) are similarly reliant on uninterrupted services but often lack adequate backup power or depend on a small number of contractors for generator refuelling, creating a false sense of preparedness in large-scale events.

Principles of resilient infrastructure

The B.C. Ministry of Transportation and Transit has drawn inspiration from the Colorado Department of Transportation (CDOT) Risk and Resilience Program to inform resilience planning in B.C. This includes following CDOT's "4Rs of Resilience".[24] Infrastructure systems that embody all four "Rs" are better positioned to withstand and recover from climate impacts.

The R4 Framework for critical infrastructure resilience
Research identifies four core determinants of resilience:

- **Robustness:** Ability to withstand hazards without major performance loss
- **Redundancy:** Capacity for substitution when systems are degraded
- **Resourcefulness:** Ability to prioritize problems and mobilize resources quickly
- **Rapidity:** Ability to restore functionality promptly to contain losses

Broader principles from the literature
Resilient infrastructure also reflects a set of complementary design and governance principles:[25-27]

- **Diversity:** Alternative pathways maintain service if primary systems fail.
- **Modularity:** Segmented systems limit the spread of failures.
- **Interdisciplinary approach:** Collaboration across engineering, governance, Indigenous knowledge, community engagement, and technology fields
- **Anticipating novel and complex failures:** Standards may need to exceed minimum requirements, with performance-based design ensuring functionality after extreme events.
- **Nature-based solutions and co-benefits:** Green infrastructure and natural assets can reduce hazard exposure while delivering ecological and community benefits.
- **Knowledge sharing and engagement:** Best practices, community input, and rights-holder engagement must be sought routinely, and findings transparently shared with the public.
- **Adaptability:** Systems evolve with new risks and technologies and assumptions are reassessed (e.g., the level of a 200-year flood historically may not hold true anymore, therefore design standards must shift).
- **Secured funding:** Long-term investments should include transparent resilience criteria and leverage both public and private capital.
- **Capacity is built to enable adaptation:** Governments, operators, and communities require training, resources, and mechanisms for learning from near misses and failures to continuously improve.

Taken together, the 4Rs and the broader principles highlight that resilience is not only a technical attribute of infrastructure systems, but also a function of governance, financing, and community capacity.[11, 24] Infrastructure that integrates the 4Rs with broader principles is not only more likely to endure climate shocks, but also to sustain the essential services, public trust, and economic stability that B.C. depends on.

Critical infrastructure programs and insurance

Existing programs to support critical infrastructure

Since 2013, federal and provincial initiatives have expanded support for resilient infrastructure, including:

- National and regional climate services (Pacific Climate Impact Consortium, Canadian Centre for Climate Services, climatedata.ca)
- Training and capacity-building programs (Climate Risk Institute, PIEVC, SCC)
- Updated codes and standards (Climate-Resilient Buildings initiative, SCC)
- Federal funding tools (Climate Lens, DMAF), though many of these programs are time-limited and set to expire after 2025, creating uncertainty about their continuation
- Programs for First Nations communities (First Nations Infrastructure Fund, Resilience Toolkit)
- B.C.'s DRIF fund supporting local governments and First Nations with resilience planning

However, the effectiveness of these programs is constrained by short-term funding cycles, fragmented responsibilities across levels of government, and uneven uptake.[7, 10] These factors undermine the sustained, system-wide investment needed to embed resilience into B.C.'s infrastructure planning.

Insurance

Insurance helps distribute financial risk and enable recovery, yet the industry does not consistently incentivize proactive resilience. Instead, as hazards intensify, communities in high-risk areas face rising premiums or outright loss of coverage, shifting financial burdens from insurers onto governments and individuals.

Motorists travel through a downpour on Highway 1 from Burnaby to Coquitlam. *iStock*

Historically, linear municipal infrastructure was uninsurable, as failures were attributed to asset management shortcomings. Parametric insurance—in which payouts are triggered if events exceed specific thresholds—has gained attention recently. While parametric insurance payouts do not replace the full value of an asset, they can provide partial financial support.

> *"As hazards intensify, communities in high-risk areas face rising premiums or outright loss of coverage."*

Nearly 80 per cent of local governments in B.C. are members of the Municipal Insurance Association of BC (MIABC).[28] MIABC is a self-insurance program in which members pool resources to insure one another. Local governments that are not members typically purchase insurance through brokers. MIABC's liability insurance protects local governments against claims related to public injuries, property damage, or financial losses caused by their operations.

Many climate-related claims from MIABC members stem from stormwater systems overwhelmed during intense rainfall, followed by freeze/thaw damage to roads, accelerated wear from extreme weather, and slope failure impacts.

W.A.C. Bennett hydro-electric power dam on Peace River. *iStock*

For governments, integrating climate change into asset management is now imperative. Courts and insurers increasingly reject claims that hazards were "unforeseeable" given today's data and projections. Proactive climate risk assessments, explicit risk tolerance criteria, and transparent investment decisions are essential to preserve both insurability and investor confidence.

Interdependencies across critical infrastructure types

"Interdependencies" describe how the functionality of one type of built linear critical infrastructure depends on another. This interconnectedness means that disruptions to one system—such as hydroelectric power—can cascade across others, potentially leading to widespread disruption and slowed recovery. Public Safety Canada identifies power and ICT as "lifeline" infrastructures, essential to the operation of other systems, including water treatment, hospitals, and airports.[11] Disruption of these systems can trigger catastrophic risks to health, safety, the economy, and public confidence.

In B.C., little has been published on interdependencies to date. Our analysis confirmed that operators are acutely aware of these risks, but there are no systemic standards for tracking or reporting them across sectors.

Understanding interdependency in B.C.: matrix

The matrix below illustrates interdependencies identified by owners and operators and literature. These relationships are simplified; interdependencies vary by time, geography, and seasonality.

Disruptions can compound across infrastructure systems. For example, a prolonged power outage may only affect households initially, but as backup supplies run out it can lead to cascading failures: boil water advisories from pressure loss, ICT breakdown as generators lose fuel, and emergency services losing coordination capacity. Transportation disruptions during floods can also block crews from repairing other critical infrastructure systems. Over time, these compounding impacts escalate into systemic crises.

The numbers (or colours) indicate the degree to which each critical infrastructure type is dependent on another.

These ratings indicate how crucial one type of infrastructure is to the functioning of another. The interdependency ratings exclude essential service reliance (e.g., health, education, food), which should be examined in future research. Interdependency ratings are categorized as follows:

3	Required for service to function
2	Important but can partially function and/or has full backup
1	Minimal requirement for service to function
0	Not required

How to read the matrix: To understand how reliant a specific infrastructure type is on others, locate that type in the left column of the matrix. For example, to see rail interdependencies, find "rail" in the left column and read across the row. The numbers in the row indicate the degree of dependency on other infrastructure types, with higher numbers representing greater reliance.

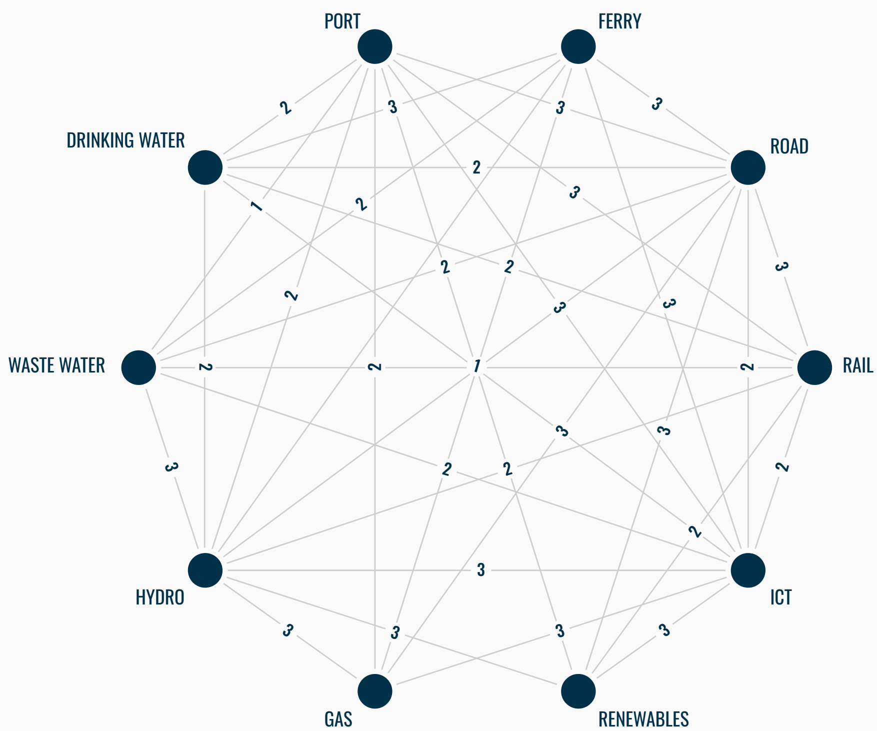
The matrix shows there are three keystone lifelines in B.C.: road access, electricity (hydro), and ICT. Nearly every system relies on roads to operate or be repaired. Power and digital control are the other cross cutting enablers: wastewater, gas, and ICT require electricity, and ports, ferries, renewables, gas, and rail depend on ICT. Marine transportation is tightly coupled with land networks. Ports require rail, ICT, and roads while also relying on all other utilities. Water services are energy intensive: drinking water and wastewater depend on electricity, and both need road access.

TABLE 1. CRITICAL INFRASTRUCTURE INTERDEPENDENCY MATRIX FOR B.C.

Matrix of B.C. critical infrastructure interdependencies. Findings highlight roads, electricity, and ICT as keystone lifelines; their loss drives the broadest cascades. Essential service dependence is excluded; scores are directional (row > column).

		Dependent types of infrastructure									
		Rail	Road	Ferry	Port	Drinking water	Waste water	Hydro	Gas	Renewables	ICT
Infrastructure affected by hazard	Rail		3	0	2	0	0	2	0	0	2
	Road	0		0	0	0	0	0	0	0	0
	Ferry	0	3		0	3	2	2	2	0	3
	Port	3	3	0		2	1	2	2	0	3
	Drinking water	2	2	0	0		0	2	0	0	1
	Waste water	2	2	0	0	0		3	0	0	1
	Hydro	0	3	0	0	0	0		0	0	2
	Gas	0	3	1	0	0	0	3		0	3
	Renewables	2	3	0	2	0	0	3	0		3
	ICT	0	2	0	0	1	2	3	0	0	

FIGURE 2: INFRASTRUCTURE DEPENDENCY NETWORK



PICS

Gas systems are among the most interdependent, requiring roads, electricity, and ICT, with minor ferry reliance. Renewables integrate through hydro and ICT and transport links. In short, disruptions to roads, electricity, or ICT would produce the broadest cascades across sectors. A network map further depicts these relationships (Figure 2).

Water overflowing the banks of the Similkameen River after an atmospheric river event. *iStock*

Atmospheric River Case Study

In November 2021, British Columbia experienced an unprecedented atmospheric river event, described as the worst flood in B.C. history. The event and its cascading effects illustrate the scope of impacts on various built linear critical infrastructure that can occur during a climate event.

The atmospheric river caused an estimated $696 million in insured damages and billions in recovery costs.[29], [30] At least five lives were lost, and Vancouver was cut off from the rest of Canada by road and rail. The Centre for Canadian Policy Alternatives estimated the combined cost of extreme weather events in 2021, including this event, at $10.6 billion to $17.1 billion—equivalent to three per cent to five per cent provincial GDP.[22] Studies show that human-induced climate change increased the probability of such an event by approximately 120 to 330 per cent.

Leading up to the storm

Conditions preceding the event primed the system failure. Wildfires in summer 2021 may have left slopes more unstable by removing vegetation and reducing water storage capacity. For example, ten per cent of the Similkameen Basin upstream of Princeton and 15 per cent of the Coldwater Basin upstream of Merrit were burned that summer, amplifying runoff risk.[31]

In October and November 2021, heavy rainfall saturated soils at low elevations while snowpack accumulated at higher elevations. Rising freezing levels during the storm triggered rapid snowmelt, compounding flood severity.

The event

The twentieth atmospheric river of fall 2021 struck between November 13 to 15, delivering 200 mm to 300 mm of rain in 48 hours. Rainfall exceeded 50- and 500-year return periods, causing river flooding, lateral river migrations of hundreds of metres and debris flows.[22, 32]

Impacted watersheds included:

- **Sumas/Nooksack:** Sumas Prairie inundated; thousands of livestock lost.
- **Coquihalla River:** flooding and debris flows destroyed highways, isolating communities.
- **Coldwater River (Merritt)**: flooding forced evacuation of the entire city.
- **Nicola River (Spences Bridge):** major flood damage and isolation.
- **Tulameen/Similkameen (Princeton):** record water levels damaged homes, farms, and businesses.
- **Shuswap River:** local communities flooded.
- **Fraser River system:** tributary flooding caused transport shutdowns and infrastructure damage.

A provincial state of emergency was declared November 17 to January 18. Orders restricted fuel use and non-essential travel on damaged highways. The disaster displaced about 18,000 people, affected 17 regional districts and 60 First Nations, and caused $675M in insured losses and $1.6 to $4.9B in non-insured damages. Supply chain and labour disruptions added $897M to $1.5B in economic losses.[33] Agriculture was hit hardest: 20,500 hectares flooded and >640,000 livestock died.[34]

This event demonstrated:

- How pinch points in transportation (e.g., Coquihalla) create province-wide cascading failures
- That service delivery disruptions in health, food, and energy quickly multiply beyond the initial hazard
- That current monitoring is not systemic (data on infrastructure vulnerabilities and service delivery gaps was inconsistent, delaying effective response)
- That the lack of redundancy leaves communities and supply chains highly exposed

Water overflowing the banks of the Similkameen River after the atmospheric river event. *iStock*

Owners and operators noted that First Nations communities were severely affected, yet systematic engagement in resilience planning remains limited—a key gap for future research and policy. Below we outline the impacts in greater detail for each built linear critical infrastructure system.

Roads

At the event's peak, 24 highways were closed, including Highways 1,3, 5 and 99 that connect the Metro Vancouver area to the rest of B.C. and Canada (Figure 3). Communities were stranded, evacuations delayed, and critical goods movement halted. Landslides on Highway 7 stranded drivers; on Highway 99, five people were killed by a debris flow. Multiple sections of the Coquihalla Highway were destroyed, including five bridges.

Highway closures meant emergency staff could not reach worksites and supply chains were severely disrupted. Medical supplies, including Covid-19 vaccines, were delayed and agricultural products spoiled. Damage to transportation corridors also led to blockages and delays in getting agricultural products to the market, leading to mass spoilage and economic losses for farmers. For example, one dairy farmer explained how their operations were disrupted as the typical two-hour commute from dairy farm to processing plant increased from two to 16 hours.[35] Further, innumerable small businesses across the Lower Mainland were affected by shipment delays, travel restrictions, and supply chain outages.

FIGURE 3: B.C.'S 2021 ATMOSPHERIC RIVER LED TO MAJOR HIGHWAY OUTAGES

Map indicates sections of highway that were affected by the 2021 atmospheric river.[38]

Economists estimate there was a 1.5 per cent loss in B.C.'s real GDP growth in 2021 due to trade and output losses, with ripple effects across Canada. Direct highway repair costs reached about one billion dollars, covering more than 300 sites and thousands of workers.[36, 37]

> *"Lack of redundancy leaves communities and supply chains highly exposed."*

Rails

Damage occurred to 30 sites along the Vancouver–Kamloops corridor. Rail shutdowns increased Port of Vancouver congestion and halted imports and exports.[39] CN Rail deployed more than 400 staff and more than 110 pieces of heavy equipment.[22] Limited service resumed within eight days (November 23) but proactively shut down for the next atmospheric river six days later. Lines were fully restored by December 31. Canadian Pacific Kansas City (CPCK) was also affected, amplifying delays.

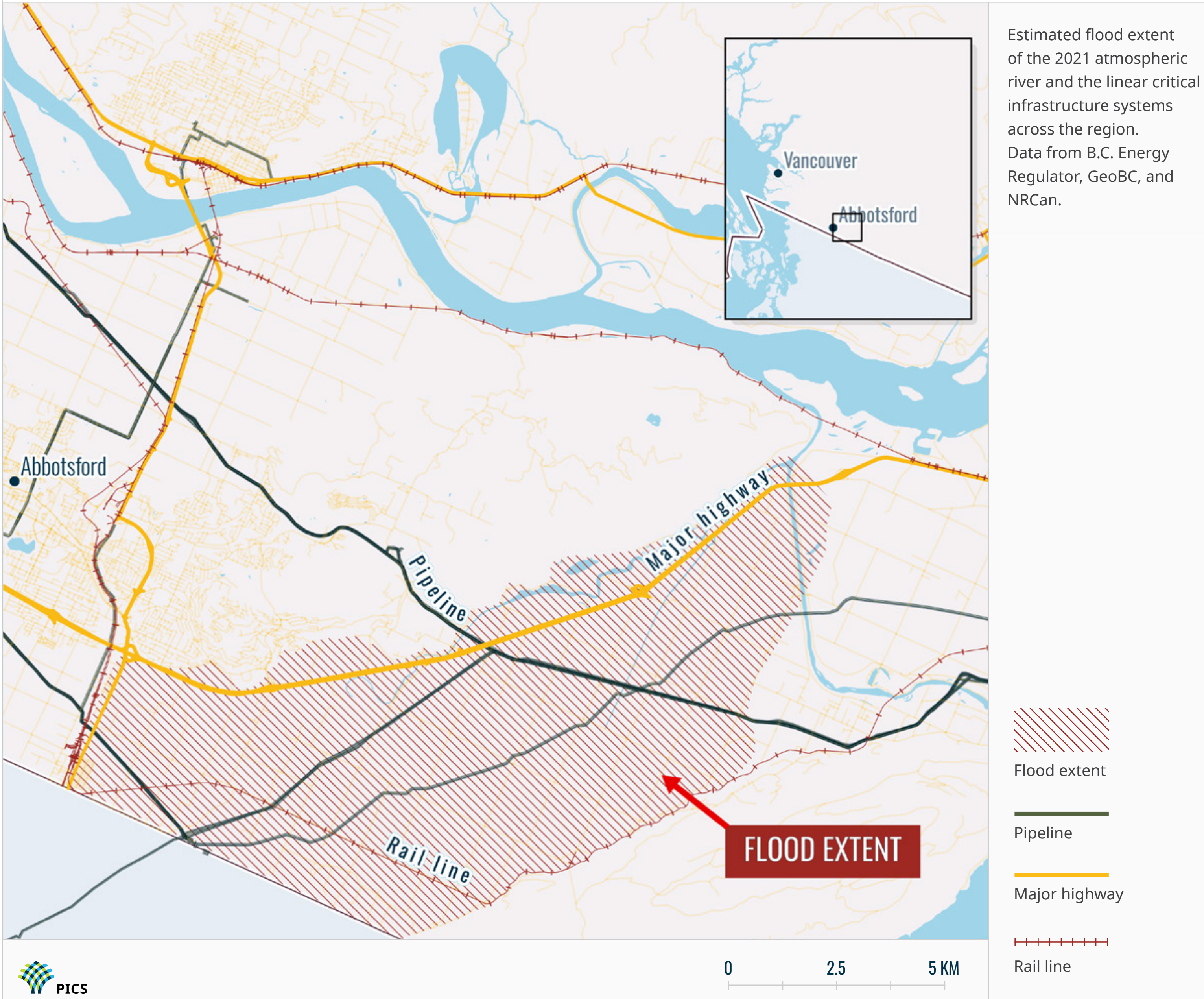
Ports

The Port of Vancouver—handling about $559M/day—was cut off from rail and road for eight days. Ships idled offshore, demurrage fees climbed, and costs spread to consumers. By late November, 24 grain vessels were waiting on about 1.4M tonnes of grain. Grain car unloads dropped 83 per cent compared to average, threatening export value as global prices shifted. Forestry, coal, and agricultural sectors curtailed output.[40]

Ferries

With the Malahat Highway damaged, ferries became pinch points connecting Victoria and Vancouver Island. Emergency vehicles were prioritized, but staffing shortages disrupted sailings as workers could not reach terminals. This highlighted ferry dependence during road failures and limited redundancy in coastal lifeline services.

FIGURE 4: B.C.'S 2021 ATMOSPHERIC RIVER LED TO MULTIPLE CRITICAL INFRASTRUCTURE OUTAGES



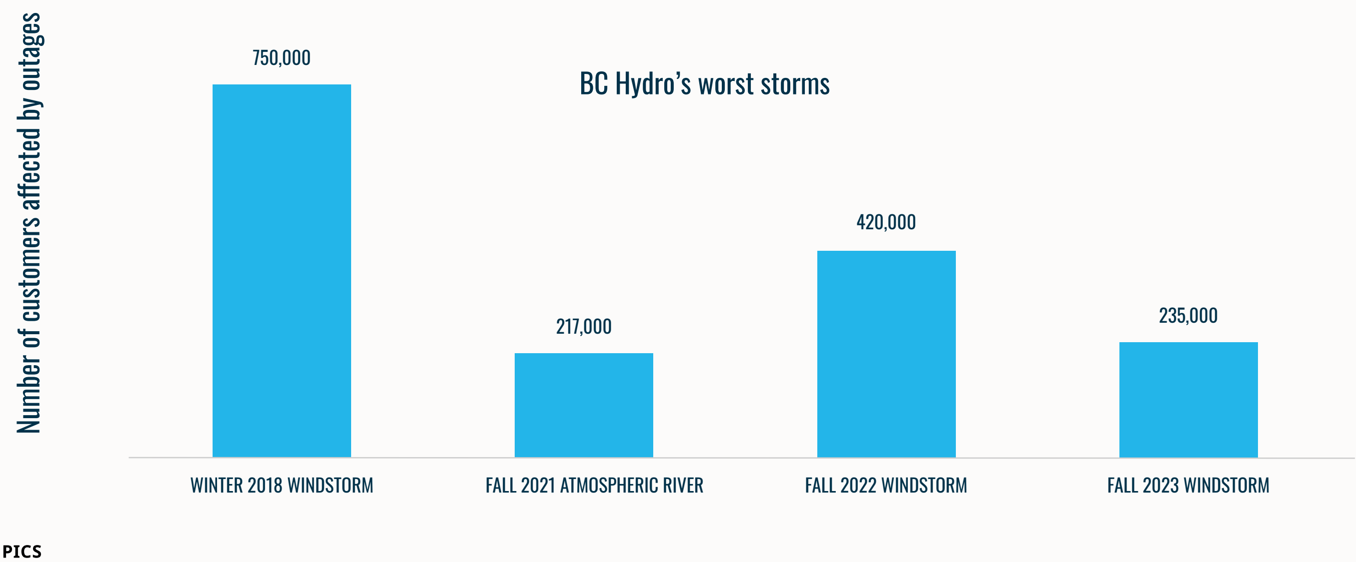
Estimated flood extent of the 2021 atmospheric river and the linear critical infrastructure systems across the region. Data from B.C. Energy Regulator, GeoBC, and NRCan.

Oil and refined petroleum products

The Trans Mountain pipeline was shut Nov. 16 after Coldwater River flooding exposed 14 sections. Repairs required shutdown of 21 days—the pipeline's longest in 70 years. Gasoline quotas were imposed in the Lower Mainland to preserve supply for emergency vehicles.

Losses included $35M in Parkland Corporation profits, six million barrels of fuel undelivered, and fuel price spikes. The The Burnaby Refinery (owned by Parkland Corporation in 2021) also struggled due to disrupted ethanol shipments (rail failures), demonstrating how interdependencies compound risks. The Province capped gasoline prices to protect consumers.[36, 41, 42]

FIG 5: MORE THAN 217,000 B.C. HOUSEHOLDS LOST POWER DURING THE 2021 ATMOSPHERIC RIVER



Comparison of number of customers affected by BC Hydro's worst storms.[43]

Electricity

The flooding in the Fraser Valley during the atmospheric river event put the footings of several major hydro structures that bring power from the Interior to the Lower Mainland underwater for several weeks (Figure 4). While this did not disrupt power, the long-term impacts to the infrastructure are unknown. The 2021 atmospheric river and flooding affected more than 217,000 customers with power outages.[43, 44] While this outage did not break records for effected customers (see Figure 5), the damage to other critical infrastructure caused by the 2021 atmospheric river did present challenges to power restoration. For example, road washouts and major highway closures made it difficult to get personnel, equipment, and materials to locations where repairs were needed. Despite these challenges, BC Hydro crews worked around the clock and were able to restore power to approximately 85 per cent of customers affected within 48 hours.

Potable water

A landslide knocked out Mission and Abbotsford's main drinking water intake, disabling 85 per cent of supply for almost two months. Secondary water sources (Cannell Lake, groundwater wells) sustained service due to low seasonal demand. This underscored the vulnerability of single-source supply and the importance of redundant systems now being pursued.[45]

Wastewater

Merritt (pop. 7,000) was fully evacuated after municipal water and wastewater treatment systems failed. Public works staff prevented worse damage by sealing the electrical room, but infiltration basins were filled with debris. Temporary permits allowed treated wastewater to be discharged to the Coldwater River until the basins were repaired and reopened in July 2022. The event showed how critical wastewater systems are to public health and how limited redundancy magnifies displacement impacts.[46, 47]

CN Rail Locomotive and mixed freight cars in train yard. *iStock*

Deep Dive: B.C.'s Linear Critical Infrastructure by Sector

B.C.'s built linear critical infrastructure underpins daily life and economic activity across the province. The network includes more than 57,000 km of paved roads, nearly 9,600 km of railways, the Port of Vancouver—Canada's largest port—as well as transmission water mains, sewer systems, ferries, and power lines[17, 48]. Together, these systems form the physical foundation for essential services such as electricity, clean water, health care access, and internet service. Their scale also underscores why climate impacts on even a single asset can cascade widely and why resilience at the system level—not just the asset level—is critical for B.C.'s future.

> *"Resilience at the system level is critical for B.C.'s future."*

The following section introduces the climate impacts experienced by B.C.'s built linear critical infrastructure systems within the scope of the analysis. We focus on impacts from both acute climate events and gradual-onset risks such as long-term warming and sea level rise. The sections highlight infrastructure vulnerabilities, system interdependencies, and examples of resilience initiatives currently underway in B.C.

Table 2 reflects the climate-related hazards and gradual-onset risks identified by owners and operators for each built linear critical infrastructure type. It illustrates relative level of concern across hazard categories. A "low" ranking indicates only one to two impacts raised, while a "high" ranking indicates more than five distinct impacts associated with that hazard.

TABLE 2. CLIMATE-RELATED HAZARDS AND GRADUAL ONSET RISKS (WARMING, SEA LEVEL RISE) OF GREATEST CONCERN TO LINEAR CRITICAL INFRASTRUCTURE OWNERS AND OPERATORS

		Extreme heat	Temperature shifts	Wildfire and smoke	Inland flooding	Coastal flooding	Drought	Debris flow and landslide	Extreme weather
Transport	Rail	High		Low	Mod	Low	Low	Low	Low
	Road	High	Low	Low	High	Low	Low	Mod	Low
	Ferry	Low		Mod	Mod	Mod	Low	Low	High
Ports	Ports	Low		Low	High	High	Low	Mod	Low
Water	Water and wastewater systems	Mod	Low	Mod	High	Low	High	Mod	High
Energy	Hydro electricity infrastructure	High	Low	Mod	Low	Low	Low	Mod	High
	Oil and gas	Low		Low	Low		Low	Low	
	Renewables	Mod		Low	Low				Low
Information and communications technology (ICT)	Telecommunication	High		Mod	Mod	Mod	Low	Low	Low

The matrix underscores that climate risks to B.C.'s linear critical infrastructure are uneven but deeply interconnected, with certain hazards cutting across multiple systems.

- Extreme heat emerges as a high risk for rail, roads, hydroelectricity, and telecommunications, due to both direct impacts (e.g., track buckling, grid stress, fibre optic disruption) and indirect ones such as wildfire ignition.
- Flooding—both inland and coastal—poses acute risks for roads, water systems, ferries, and ports, as observed in our atmospheric river case study.
- Wildfire and smoke are high to moderate risks for ferries, ports, and water systems, consistent with observed service disruptions and health impacts.
- Drought and shifting precipitation regimes threaten water and wastewater systems most severely, while debris flows and landslides remain critical for mountain rail and road corridors.

ICT stands out as a sector of cross-cutting importance, facing high exposure to heat and moderate exposure to multiple other hazards. Taken together, the findings highlight that adaptation priorities must address both direct risks and interdependencies. Assets with high exposure and high consequence—such as roads, rail, water, and ICT—are critical. However, even moderate hazards to one sector can ripple outward, magnifying disruptions across supply chains, emergency response, and community well-being.

Transportation systems

We reviewed three modes of B.C.'s transportation system: roads, rail, and ferries. The functioning of these networks is vital to the everyday lives of British Columbians and to the province's economic health. They move goods, services, and people; enable access to work, education, and health care; distribute food, medicine, and fuel; and support emergency response.

According to a review of Canadian infrastructure from the International Institute for Sustainable Development, climate change affects transportation in three main ways: acute events, structural degradation, and reduced service life.[9] Critical events can cause loss of life, service interruptions, and costly repairs.

Long-term exposure to climate-related hazards also undermines structural integrity—for example, through bridge scour, erosion, and thermal expansion—ultimately shortening the lifespan of assets and raising replacement costs.

Roads

We identified 55,975 km of paved roads in British Columbia based on public data (Figure 6). Additionally, there are at least 79,000 km of unpaved roads across the province. The B.C. Ministry of Transportation and Transit (MOTT, formerly MOTI) oversees the provincial highway system and has ownership and jurisdiction over provincial highways that are in municipalities. As of 2024, MOTT is responsible for more than 15,000 kilometres of numbered highways.[49] Municipalities manage local roads, bridges, and travel routes under the Community Charter. Most roads in rural areas, including those in regional district electoral areas, are under the ownership and jurisdiction of MOTT. This division of responsibilities underscores the importance of provincial–municipal coordination in planning for climate resilience.[50, 51]

Resource roads represent a critical but often overlooked component of B.C.'s transportation system: they provide industrial, community, and emergency access across Crown lands, yet fall outside the provincial highway network. These roads include forest service roads and permit roads that support forestry, mining, agriculture, rural residents, and recreation. They are also used for environmental management, wildfire response, and access to high-value ecological areas. Many are maintained through permits issued by the Government of B.C., while others are managed directly by the Province. Roads no longer needed—or where maintenance costs are prohibitive—are typically deactivated or decommissioned.[52]

Impacts

Using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol and available climate information, we concluded that the most important climate risks facing B.C. highways are those caused by increasingly extreme precipitation because of climate change.[53] Owners and operators consistently emphasized that short, intense rainfall events damage culverts, bridges, and embankments, saturate the sub-base, and trigger costly washouts. These rainfall events also increase the likelihood of landslides and debris flows, compounding risks to road corridors.

Highway 1 between 264th Street and Highway 11 in Abbotsford. Source

The road network in low-lying coastal areas is also vulnerable to inundation, erosion, and saltwater intrusion from sea level rise and storm surge. Disruptions to travel are also common from wildfires, snow, ice, and avalanches, each of which reduces service reliability and drives up long-term maintenance costs.

Roads provide critical connectivity for communities and emergency management. Disruptions delay medical and health supplies, refrigerated goods, and just-in-time deliveries for manufacturing and agriculture. Tourism is also affected when communities are cut off. At the local level, commuters—including first responders and emergency staff—may be unable to reach worksites during climate events. Evacuations and supply deliveries can be delayed, and remote or mountainous communities risk being fully cut off from assistance.

Table 3 includes examples of climate-related impacts to road infrastructure. Across hazards, roads experience reduced lifespan, higher maintenance demands, and increased likelihood of failure. These failures cascade outward, disrupting supply chains, limiting community access, and undermining evacuation routes.

> *"Disruptions delay medical and health supplies, refrigerated goods, and just-in-time deliveries."*

FIGURE 6: THERE ARE MORE THAN 55,000 KILOMETERS OF PAVED ROAD ACROSS B.C.

Paved roads in the province of British Columbia (dark green) and unpaved roads (light grey). Data from GeoBC, and NRCan.

Unpaved road

Paved road

TABLE 3. EXAMPLES OF IMPACTS TO LINEAR ROAD INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	Shortened life expectancy of roads, increased maintenance, and damage from: » Pavement softening leading to fatigue cracking and rutting » Increases in flushing or bleeding as excess asphalt binder fills gaps between aggregate particles » Impacts to occupational health and safety for road work crews
Temperature shifts	» Increased maintenance and inoperability from shorter winter ice road season
Wildfire and smoke	» Roads may become unsafe or inoperable due to wildfire in the area, creating transportation disruptions with cascading impacts. » Impacts to occupational health and safety for road work crews » Travel may become delayed due to heavy smoke. » Direct damage to transportation infrastructure from fire, heat, and treefall
Inland flooding	» Roads may become unsafe or inoperable due to flooding, creating transportation disruptions with cascading impacts. » Direct damage to transportation infrastructure such as complete washout, bridge foundation damage, etc. » Decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs » Loss of life or trapped travelers may occur due to quick onset hazard
Coastal flooding	» Inundation of coastal infrastructure
Drought	Damage to roads and bridges that may cause disruptions from: » Shrink/swell and/or settlement to bridge foundations and approach » Dropping water levels expose bridge pillars to oxygen, causing biodegradation » Components such as culverts that may not function as designed with water table declines » Negative impacts to maintenance and construction (e.g., dust control)
Debris flow and landslides	» Roads may become unsafe or inoperable due to geotechnical and geohydrological hazards, creating transportation disruptions with cascading impacts. » Loss of life or trapped travelers may occur due to quick onset hazard » Direct damage to transportation infrastructure
Extreme weather	» Increased ice accretion on cable-stayed bridges that adds bridge load and heightens the risk of ice falling on traffic leading to road closures » Blocked roads, bridges due to debris or snow » Soil and slope instability from heavy rainfall resulting in damage to infrastructure » Impacts to evacuation routes and transportation in and out of communities

Exposure and vulnerability

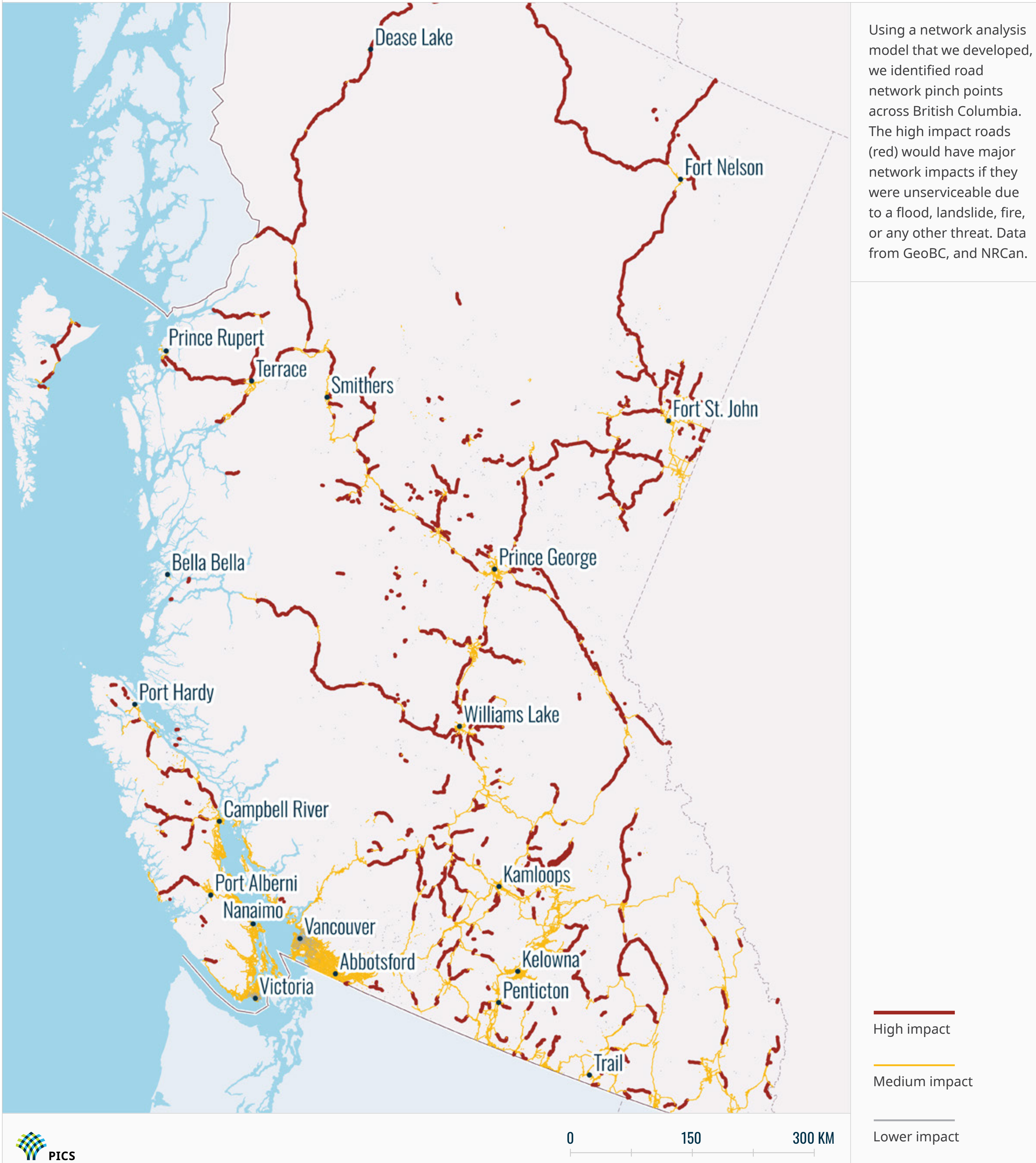
Road location strongly influences vulnerability to climate hazards. For example, Highway 14 on the West Coast is increasingly at risk from riverine and coastal flooding. In the Cariboo and Peace regions, landslides and debris flows have historically caused repeated disruptions. Resource roads across the province are especially vulnerable to intense rainstorms and associated flooding, which are projected to become more frequent with climate change.

The consequences of climate impacts on roadways also depend on who relies on them and whether detours are available. Disruptions to roads used for critical services and freight, such as fuel shipments, have outsized consequences. In communities with only one access route, a single event can cut off essential services entirely, including health care access and emergency response.

Our geospatial analysis of paved road pinch points identified more than 100 high-impact sections across B.C. (Figure 7). When these sections were removed from the network—whether due to flooding, wildfire, or landslide—the system experienced significant fractures in connectivity. As shown in Figure 7, most of these pinch points are in rural and northern regions, underscoring the fragility of access in less populated areas.

Water rising over the banks and flooding the Similkameen Valley at Chopaka Rd. *iStock*

FIGURE 7: B.C.'S ROAD NETWORK HAS DOZENS OF VUNERABLE PINCH POINTS



Using a network analysis model that we developed, we identified road network pinch points across British Columbia. The high impact roads (red) would have major network impacts if they were unserviceable due to a flood, landslide, fire, or any other threat. Data from GeoBC, and NRCan.

An aerial view of a highway in valley during sunrise in Kamloops. *iStock*

> *"Regions with lower population densities tend to have slower recovery rates."*

Research on highway recovery in B.C. shows that disruption times from climate-related hazards vary significantly by region.[49] The duration of recovery depends on several factors:

- **Hazard type and severity:** Flood-related disruptions take the longest to recover from, followed by wildfire and smoke. Full closures are more disruptive than partial closures.
- **Population density and urbanization:** Regions with lower population densities tend to have slower recovery rates due to fewer services and weaker infrastructure. Urbanized regions with denser road networks typically recover faster.
- **Road density:** Higher road density correlates with faster recovery. For example, the Thompson-Nicola district, which has the highest road density among the regions studied, recovers far more quickly than Bulkley Valley-Stikine, which has the lowest.
- **Remoteness:** Northern regions face slower recovery due to logistical challenges and limited resources. At B.C.'s northern border, disruptions last on average 46 per cent longer than those near the U.S. border.
- **Highway importance:** Highways with major economic or strategic value, such as Highway 16 linking the Skeena region to the Port of Prince Rupert, are prioritized for recovery, which accelerates reopening.

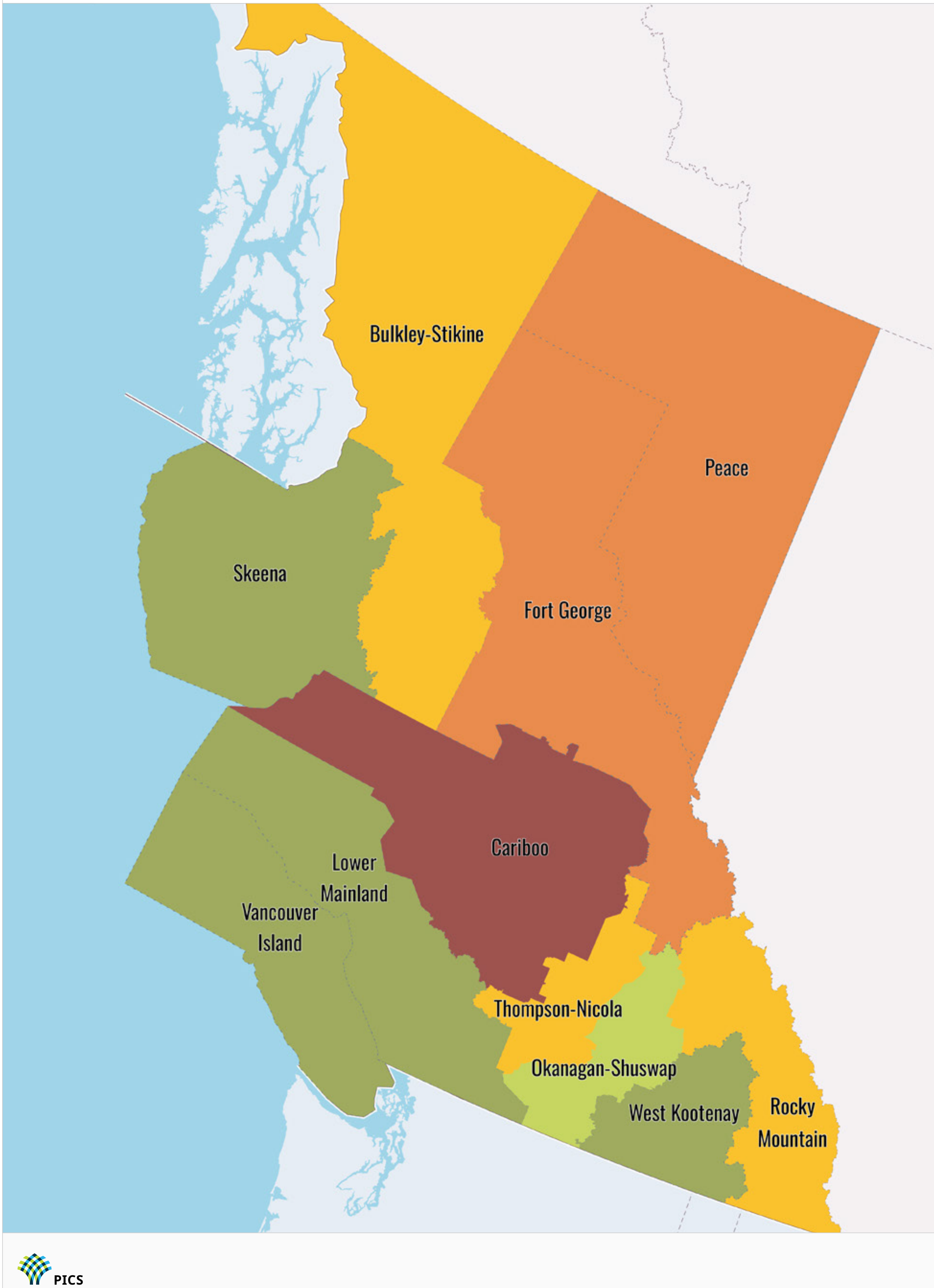
Figure 8 illustrates regional variation in recovery rates. Red areas highlight the regions with the longest delays.[49]

Interdependencies and uncertainties

Road networks underpin the functioning of nearly all other linear infrastructure systems in B.C. When roads are disrupted, the public faces travel delays, but operators of rail, hydro, gas, and ICT systems also lose access to critical sites for maintenance and repair, compounding service disruptions.

For roads, the greatest uncertainty lies in the location and timing of the next disruption, which can determine how severe the consequences will be.

FIGURE 8: ROADS CAN BE UNPASSABLE FOR WEEKS AFTER A DISASTER



Disruption recovery from climate-related hazards by regional district. Hazard ratio data from Rahman, et al.[49]

BC Transportation Districts

Hazard ratio

- Slowest recovery
- Moderate recovery
- Fastest recovery

For example, in 2023 a relatively small wildfire adjacent to Highway 4 outside Port Alberni caused weeks of disruption because of its location on a rock cliff, which created instability and required extensive scaling work before reopening (Figure 7). This illustrates how even moderate hazards in unexpected locations can create outsized impacts.

Resilience work underway

The Ministry of Transportation and Transit has advanced climate resilience efforts since 2010, moving from PIEVC assessments to more complex systems-based approaches that account for interdependencies and criticality. Actions have been driven by the need to reduce transportation disruptions and to design with climate change in mind rather than invest consistently in costly repairs. Strong leadership and staff champions have enabled MOTT to pursue resilience even in the absence of dedicated regulation or funding.

The Ministry is undertaking work to bring hazard threats together with other criteria of vulnerability and criticality to determine risk levels of various roadways. This will provide good information to decision makers on priorities for proactive adaptation investment.

The Ministry has applied Engineers Canada's PIEVC protocol to assess climate risks on five highways. These include Coquihalla Highway 5; Yellowhead 16; Highway 37A in the Bear Pass region; Highway 97 in the Pine Pass region; and Highway 20 in the Bella Coola area.[54] The results informed a provincial best practices guide for integrating climate adaptation into highway management, design, operation, and maintenance. MOTT continues to apply the PIEVC High Level Screening Guide to highways to prioritize proactive investments.

Three PIEVC pilot projects were completed on forest service roads, leading to guidance on climate vulnerability assessment and design of crossings in resource road planning. In parallel, MOTT and Engineers and Geoscientists BC have developed professional practice guidelines for climate-resilient highway design, updating the 2015 T-04/15 Technical Circular in 2019.[55]

Through over a decade of this work, MOTT has recognized the need for a systems-based approach to resilience. In 2023, Infrastructure Canada and the Government of B.C. released the Systems-Based Approaches to Climate Resilient Infrastructure guidebook, which provides a framework for embedding interdependencies into infrastructure planning.[55, 56]

Municipal governments are also advancing resilience through asset management planning. Asset Management BC and the Union of B.C. Municipalities (UBCM) collaborate to build capacity and embed climate risk considerations into local road asset management portfolios. We did not, however, find much evidence of collaborative risk reduction and knowledge sharing across the various levels of government.

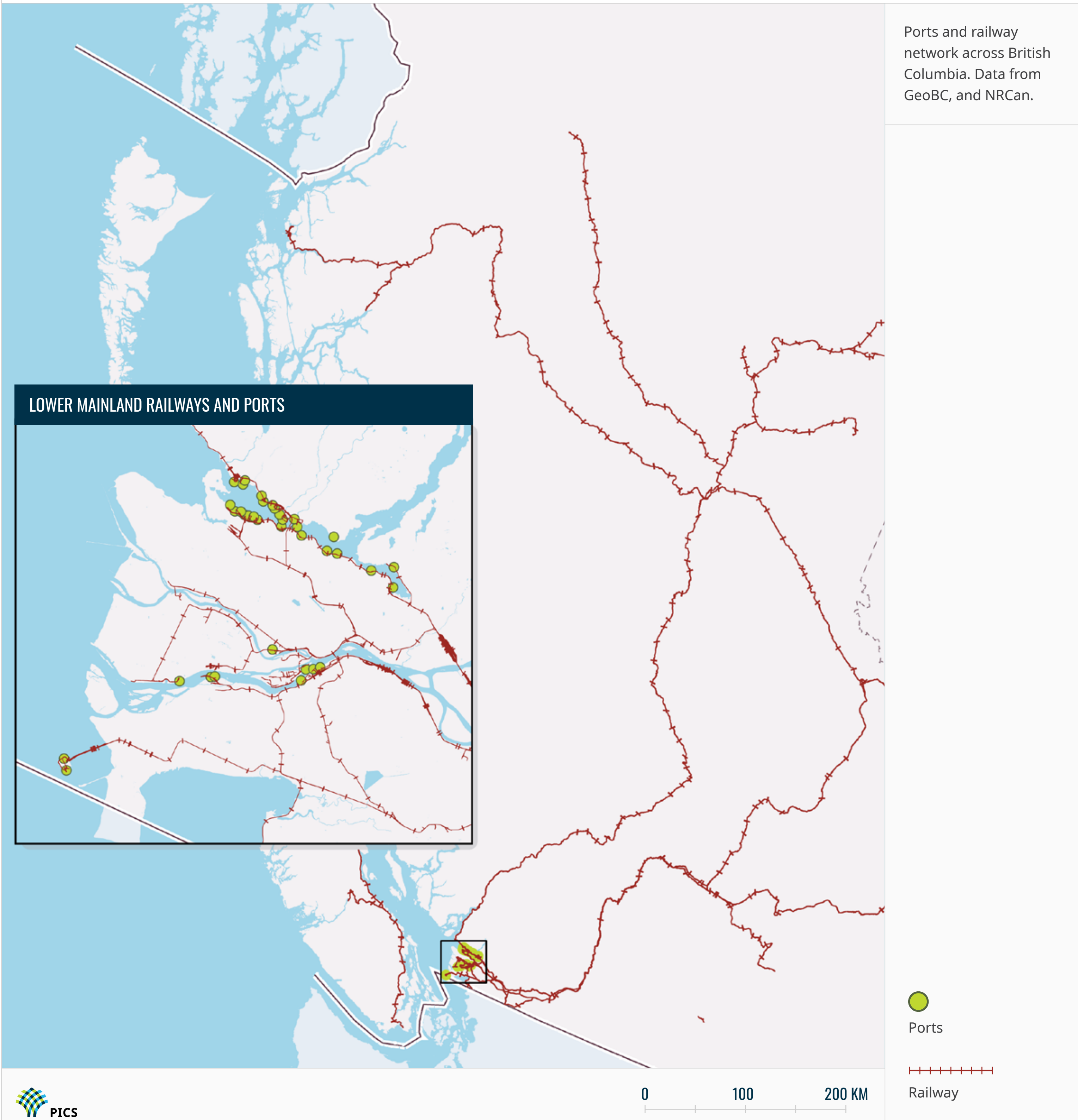
> *"The sheer scale of the network means local disruptions quickly cascade."*

B.C.'s road network is vast and indispensable, but its exposure to floods, landslides, wildfires, and coastal hazards makes it increasingly fragile. While the Ministry of Transportation and Transit has advanced resilience work, the sheer scale of the network means local disruptions quickly cascade into supply chain breakdowns, community isolation, and delayed emergency response. Without coordinated investment in redundancy and climate-ready design, road failures will continue to be among the most visible and costly consequences of climate change.

Rail

Based on our analysis of geospatial data, B.C. has approximately 10,035 km of active railways (Figure 9). Canada and B.C. have two privately owned major Class I freight railways which are responsible for most freight rail traffic: Canadian National Railway (CNR) and Canada Pacific Kansas City Railway (CPKC). In 2022, CN had approximately 2,814 rail route miles in B.C., the third-largest share in Canada after Alberta and Saskatchewan.[57, 58] CPCK moves goods throughout B.C. and across Canada, the U.S., and Mexico. Together, these railways are integral to supply chains, moving more than 900,000 tonnes of goods daily, including forest products, grains, fertilizers, and manufactured goods. Rail links the country to major ports like Vancouver and Prince Rupert, anchoring both provincial and national trade competitiveness.[59]

FIGURE 9: THERE ARE MORE THAN 10,000 KILOMETERS OF ACTIVE RAILWAYS ACROSS B.C.



Ports and railway network across British Columbia. Data from GeoBC, and NRCan.

Smaller operators—including common carriers, industrial railways, and commuter rail—operate solely within B.C. under the Railway Act. Transport Canada regulates the sector through the Railway Safety Act.

Impacts

Rail is both extensive and indispensable, but also highly exposed to climate-related hazards because of its length and reliance on interconnected components.[60] Owners and operators identified heavy precipitation, floods, landslides, debris flows, and extreme heat as top concerns. The 2021 atmospheric river event was repeatedly cited as a watershed moment for understanding the catastrophic potential of heavy rainfall and uncertain geotechnical conditions.

In their climate change and response plan, CPCK delineates climate risks into chronic and acute drivers of risk and provides actions for how they are and/or plan to mitigate this risk.[61] CN's climate strategy addresses both acute and chronic risks and lays out short- and long-term plans for risk mitigation.[62] CN prioritizes event response, rather than proactive adaptation efforts for events that are uncertain. Mitigation efforts involve refining resiliency plans, addressing rail expansion risks, and adjusting operations based on commodity market shifts due to climate.

Many of the example climate impacts to rail infrastructure in Table 4 below result in disruptions to operations which can impact supply chains, exports, and the economy generally. Maintenance, repair, replacement, and event response costs are also all increasing.

TABLE 4. EXAMPLES OF IMPACTS TO LINEAR RAIL INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» Buckling of rails and thermal expansion in structures » More frequent speed restrictions which can delay services » Shorter expected life expectancy of rail
Wildfire and smoke	» Service interruptions due to the burning of wooden bridges, warping of rail, or halting of work due to unsafe conditions » Trains cannot run through actively burning wildfires.
Inland flooding	» Washout, massive shear failure, and bridge foundation damage » Bridge scour, flooding of the tracks, depots, and buildings » Damage to electronic equipment imperative to operations » Exacerbation of disruptions in railway operations, resulting in speed restrictions, blockages, and interruptions in the supply chain » Increased replacement costs for infrastructure components such as bridges and tunnels are sometimes prohibitive, leading to long-term closure
Coastal flooding	» Inundation of coastal infrastructure
Drought	» Water table changes can result in soil changes and subsequent track misalignment » Misalignment of poles supporting overhead lines can cause transportation disruptions
Debris flow and landslides	» Debris and rock covering tracks leading to interruptions » Damage to tracks and other infrastructure, which can lead to derailment and spills
Extreme weather	» Downed power lines; structural damage and/or track misalignment by fallen trees/wind-blown objects » Intermodal transport with stacked containers may be unable to run during high wind speeds » Interruption to service and increased costs due to time-consuming nature of snow clearing, including when larger avalanches occur

Ferry as seen from Galiano Island. *iStock*

Exposure and vulnerability

Rail infrastructure's location in steep natural corridors and near water bodies makes it highly exposed to hydrogeomorphic hazards. This amplifies risks of floods, landslides, and debris flows compared to other types of infrastructure. At the same time, rail has developed a strong operational culture of response and recovery, which has enhanced resilience during past climate events.

Interdependencies and uncertainties

Rail depends heavily on B.C.'s roads, ports, power, and ICT systems. Roadways provide access to rail infrastructure for workers and equipment. While rail operators can sometimes build temporary access roads, simultaneous multi-system failures strain capacity. Power and ICT are essential for signaling: if disrupted, train operators may lose the ability to safely manage movements.[63] Ports are also critical: interruptions cascade directly into rail backlogs and supply chain delays.

Uncertainty is greatest in anticipating how multiple hazards will interact, for example, floods with debris flows or major snowfall events. Current models cannot reliably pinpoint locations for future damage, making it difficult to justify costly hardening of specific bridges or track segments. Instead, climate scenarios are used to guide design standards and maintenance priorities. Owners and operators emphasized that more detailed studies are needed to support long-term adaptation investment.

Resilience work underway

Railway operators are regarded as skilled and well-resourced in response, but less proactive in long-term adaptation. Operators highlighted a lack of clear cost-benefit analyses for risk mitigation. Still, CN and CPKC are investing in pilot projects, research, and cross-division information sharing. Both companies publicly report on climate risks through the Carbon Disclosure Project.[64, 65]

As with roads, rail operators are incorporating flexible design approaches to adapt as climate conditions evolve.

CPKC has released several climate strategy documents, including:

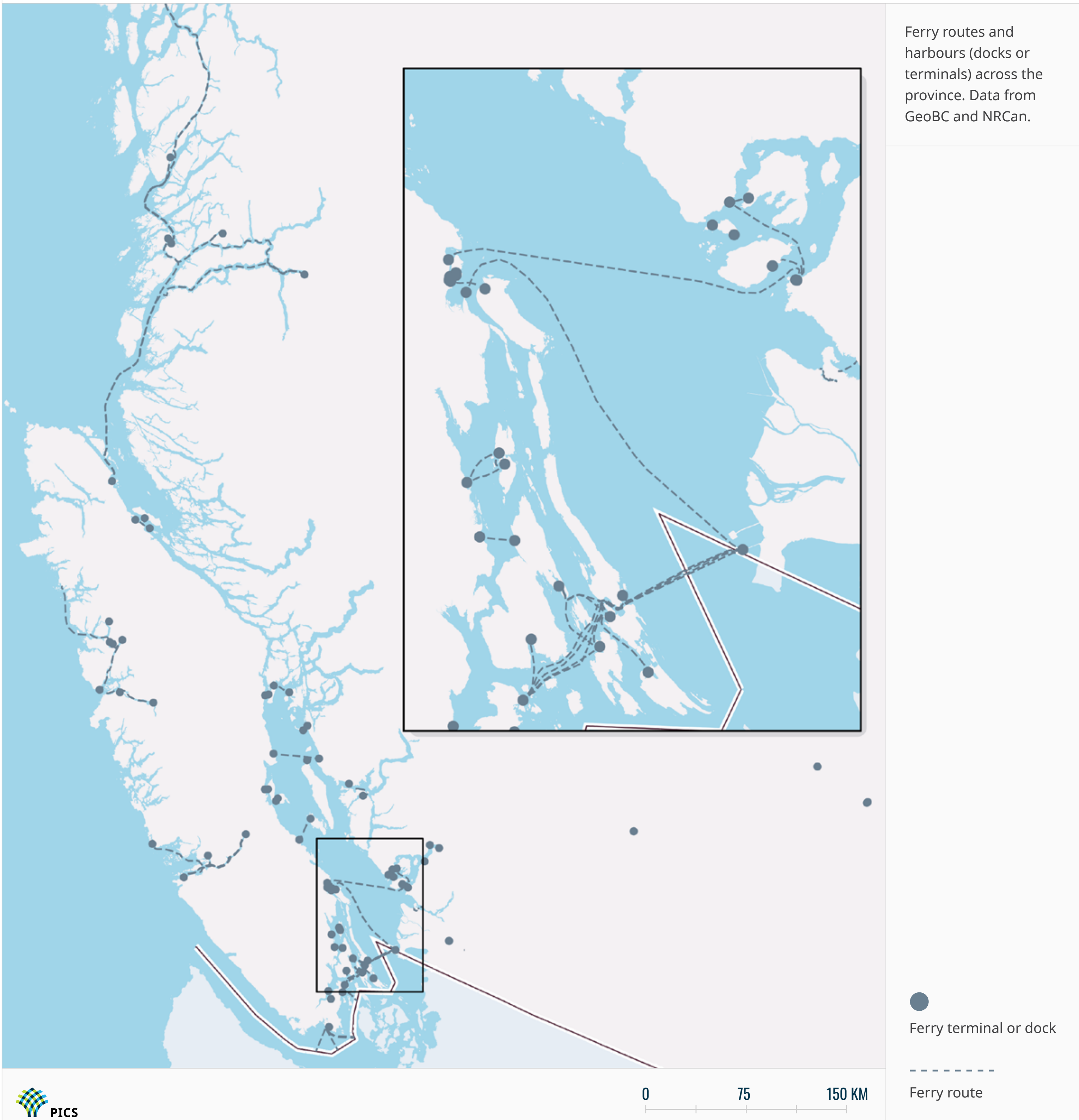
- Commitment to Climate Action, outlining adaptation and decarbonization goals[62]
- CP Climate Strategy, which explores climate scenarios and mitigation options[64]
- CP Climate Change Response Plan, detailing climate-related risks, opportunities, and performance targets[66]

Taken together, B.C.'s rail system demonstrates both the resilience and fragility of linear critical infrastructure. Operators have deep experience in responding to emergencies and keeping goods moving, but climate change is magnifying risks beyond what reactive measures alone can manage. Without stronger standards and investment in proactive adaptation, cascading failures —from ports to supply chains—will remain a persistent vulnerability for the province's economy and communities.

Ferries

BC Ferries is one of the largest ferry systems in the world, with 37 vessels supporting 25 routes with 47 terminals over 1,600 km of coastline (Figure 10).[67] They operate as a private, independent, regulated ferry service contractor within a complex legislative and economic regulatory framework established by the Government of B.C. in 2003. The sole shareholder of BC Ferries is the provincial Crown. BC Ferries holds the Coastal Ferry Service Contract with the Government of B.C. and provides passenger and vehicle ferry services to the B.C. coast.

FIGURE 10: MANY B.C COMMUNITIES RELY ON FERRIES FOR FOOD, HEALTHCARE, AND FUEL



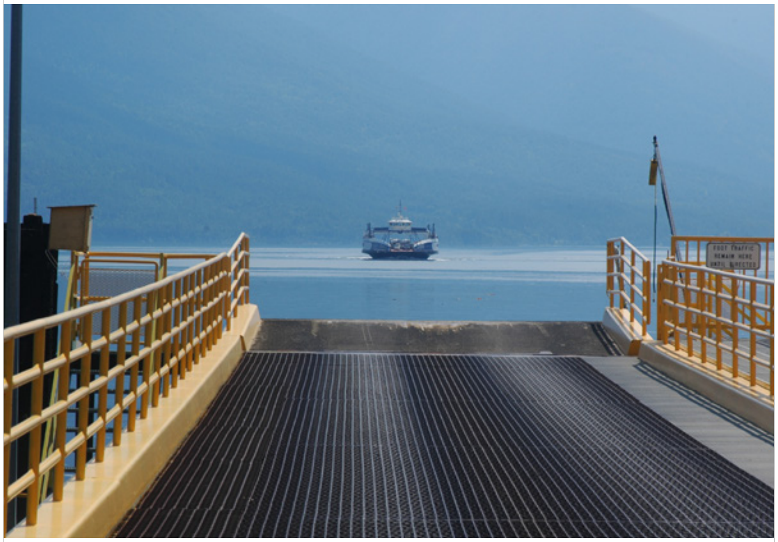
Ferry routes and harbours (docks or terminals) across the province. Data from GeoBC and NRCan.

In 2024, BC Ferries delivered 90,819 round trips—a 4.6 per cent increase over 2023—carrying 22.6 million passengers and an estimated $8 billion in cargo. Despite this, service reliability showed strain: on-time performance declined by 1.7 per cent compared to 2023, and weather-related cancellations continue to account for nearly half of all trip cancellations.[67, 68]

BC Ferries also plays a critical role in emergency response and access to health services. According to the 2023/24 SailSafe Report, the Operations and Security Centre responded to over 10,000 incidents, 92 of which required sailings to be delayed, rerouted, or prioritized for emergency services, such as BC Ambulance Service.[69]

TABLE 5. EXAMPLES OF IMPACTS TO FERRY INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» Ocean temperature affects functionality of ship radiators » Impacts to occupational health and safety for outdoor ferry and terminal staff
Wildfire and smoke	» Supply chain for fuels could be affected » ICT network failure or disruption due to wildfire could be affecting communications with the public, including booking, payment, and customer services » Impacts to occupational health and safety for outdoor ferry and terminal staff
	» Impacts roads which can disrupt staff and passengers reaching terminals and affect operations
Coastal flooding	» Access to terminals at some locations are at low elevation (causeways). Over time these will need to be raised » Berthing and docking procedures may change as water elevations change. Infrastructure is adaptable to an extent » Inundation of infrastructure in low-lying terminals over the long term » During king tide events, coastal storm surge can breach rip rap at terminals causing damage » Coastal storm surge can damage vessels as wind/waves push the vessel against terminal infrastructure » Low causeways at risk of damage from coastal flooding, cutting off access to the terminal » Erosion impacts to causeway and terminal infrastructure
Drought	» Water restrictions affect "technical water" needed to run the vessels and provide potable water to passengers. Water must be imported to fulfill operational needs which increases costs
Debris flow and landslides	» Impacts roads which can disrupt staff and passengers reaching terminals and affect operations
Extreme weather	» Terminals that were designed and built to be sheltered from winds and storms are no longer sheltered due to the changing intensity and duration of storms and wind direction. This can cause direct damage and disrupt operations » Ramps and terminal infrastructure can be damaged and generally experience an increase in wear and tear » The timing and intensity of weather-related cancellations are changing » Impacts the ability of staff to reach terminals which can result in cancellations or delays if vessels do not have sufficient staff numbers to operate » Ferries may have to take less fuel-efficient routes due to safety » Heavy snow or rain-on-snow on the flat roofs of older terminal buildings can cause the building to close for public use



Ferry boat and dock. *iStock*

Impacts

Climate-related hazards increasingly affect ferry operations. Longer storm seasons, stronger winds, and shifting wind patterns have led to more frequent cancellations and service delays, particularly on northern and minor routes. Terminals located at low elevations face growing risk from storm surge and coastal flooding, while wildfire smoke, extreme heat, and drought are adding new operational challenges.

Operational delays in 2024 were attributed 25.9 per cent to non-controllable reasons (e.g., weather, medical emergencies), compared to just 10.7 per cent for controllable reasons (e.g., loading, fueling). Experts we spoke to emphasized that ferry disruptions ripple through supply chains, cutting off food, fuel, and medical supply deliveries, particularly for island and coastal communities with no alternative transportation links.[70]

For northern routes, non-controllable reasons accounted for 37 per cent of delays and for minor routes, non-controllable reasons accounted for 27.5 per cent. In the 2023 fiscal year, of the required round trips specified in the Coastal Ferry Services Contract, 46 per cent of the 343 cancellations were defined as weather related. These delays and cancellations are assumed to have knock-on impacts to supply chain, productivity, livelihoods, access to health care and educational facilities, but are not well documented.

Exposure and vulnerability

Ferries are considered part of the highway system, and the public expects service to be reliable. Yet, given their coastal geography, exposure to climate hazards is unavoidable. Terminals vary widely in design and capacity: many lack backup shelter, cooling spaces, or flood protections, leaving passengers vulnerable during disruptions.

Emergency response operations also depend on ferries, but there is no mandated design standard for terminals to serve as safe refuges during climate events. Further, terminals are currently not set up to provide cooling space or as shelter in place refuges for all customers. There are large differences in infrastructure between terminals, with little opportunity for shelter at small or more remote locations.

Interdependencies and unknowns

BC Ferries relies heavily on fuel, water, ICT, and land-based transportation networks. All vessels have drinking water quantity requirements to sail. BC Ferries have their own wells in some locations and in other locations they rely on water provision by local governments. Ferries rely on fuel that arrives on tanker trucks and in the case of island terminals, these trucks need to sail over on the dangerous goods sailings. To date, backup supplies have sufficed when sailings are cancelled, or road network supply is hampered due to extreme weather. Terminals have generators which are also reliant on fuel. BC Ferries are also dependent on the transportation networks to move people, fuel, goods, and staff to and from the terminals, and on ICT for the customer interface and all business, including processing payments.

The greatest uncertainty lies in how wind patterns will continue to shift under climate change. Operators noted that terminals once sheltered from prevailing winds are now increasingly exposed, driving new operational risks. This poses new operational challenges. BC Ferries are uniquely challenged to meet expectations of diverse communities and tourists commonly regarded as part of the B.C. highways system yet operating as an independently managed, publicly owned Canadian company. Interruptions to sailings could pose a major challenge to the reliability of supply chains in areas such as Vancouver Island and Haida Gwaii, which are reliant on ferry service. This could have a variety of unknown and cascading impacts for the daily lives and livelihoods of residents.

Resilience work underway
Over the past decade, BC Ferries has shifted from reactive response to proactive climate planning. Measures include:

- » Improved predictive weather modeling to anticipate and reschedule sailings around storm periods
- » New vessel designs that emphasize interoperability and redundancy, allowing more flexible use across routes
- » Drought management planning to secure technical water supplies during shortages
- » Coastal flooding assessments, with infrastructure like the Richmond shipyard now being elevated to address long-term risks

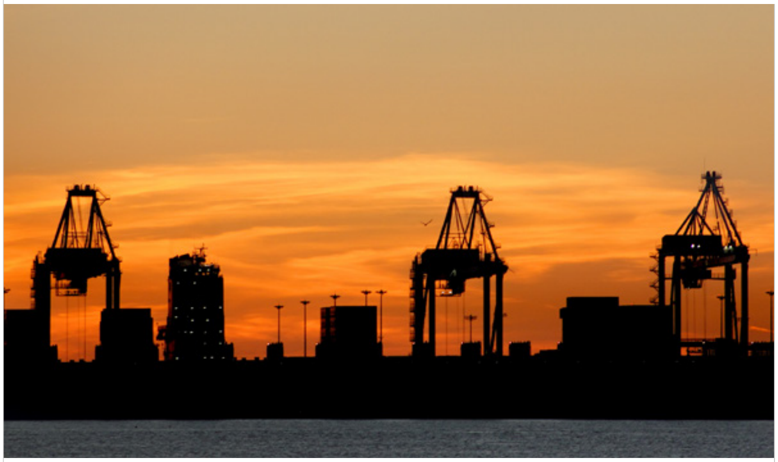
B.C.'s ferry system is not just a transportation service; it is a lifeline for island and coastal communities. Climate change is amplifying risks to vessels, terminals, and service reliability, while also raising the stakes of disruptions for supply chains, health care, and emergency response. Without investment in climate-ready terminals, resilient vessels, and standardized emergency functions, ferries will remain a vulnerable pinch point in B.C.'s coastal economy and public safety system.

Ports

Internationally, ports are increasingly focused on climate adaptation. Many ports along the U.S. west coast are prioritizing coastal flooding and sea level rise (San Francisco, Seattle, Los Angeles), while European ports, such as Rotterdam and London, have adopted broader climate risk assessments.

TABLE 6. EXAMPLES OF IMPACTS TO PORT INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» Impacts to occupational health and safety for port staff » Supply chain delays from rail disruptions due to heat (rail buckling)
Wildfire and smoke	» Disruptions to supply chains, which can cause delays or shut down operations » Impacts to occupational health and safety for port staff
Inland flooding	» Disruptions to supply chains, which can cause delays or shut down operations » Flooding of marine infrastructure, especially low-lying vulnerable infrastructure » Heavy rainfall can affect loading and off-loading, particularly for products that cannot get wet » Disruptions to vessel traffic, loading and off-loading » Access routes can be flooded, limiting staff access to the site and possibly broader supply chains » Flooding of contaminated sites poses new risks » Stormwater gravity drainage affected by higher sea levels floods property
Coastal flooding	» Seawater damage to cargo (e.g., potash)
Drought	» Fluctuations in water levels reduces inland vessel capacity (e.g., Fraser River)
Debris flow and landslides	» Disruptions to supply chains, which can cause delays or shut down operations » Adds to increased sedimentation in rivers requiring increased dredging
Extreme weather	» Shut down operations, damage to infrastructure such as breakwaters, vessel damage, difficulty berthing vessels » Storms in Vancouver can divert traffic to Prince Rupert, creating additional strain on infrastructure



The Port of Vancouver is the largest port in Canada and the fourth largest in North America by tonnes of cargo, facilitating trade between Canada and more than 170 world economies. *iStock*

In B.C., the Port of Vancouver and Port of Prince Rupert are the two key hubs. The Port of Vancouver is Canada's largest, managing approximately one-third of national trade outside North America. Both ports have completed climate risk studies through Transport Canada's Transport Asset Risk Assessment.[49] Prince Rupert has begun implementing recommendations, while Vancouver Fraser Port Authority has secured federal funding for a multi-year adaptation plan.

Impacts

Generally, climate impacts to ports include damage to infrastructure, flooding of contaminated sites, reduced functionality of stormwater and utilities, and major supply chain disruptions. Changes in wind patterns, storm surges, and rising sea levels add compounding stress. Because ports anchor both provincial and national supply chains, disruptions have cascading consequences for trade, energy, and food security. At Prince Rupert, shifting wind patterns have already disrupted operations. In 2021, a major storm broke the MSC Altair free from its moorings, grounding it on a nearby island.[71]

Exposure and vulnerability

Ports face risks at multiple scales. At the macro level, shifting trade markets and commodity flows add uncertainty. Regionally, ports depend on trucking and rail networks across B.C. and Canada, both highly exposed to climate hazards. At the operational level, low-lying cargo storage, drainage infrastructure, and underground electrical systems are all vulnerable to flooding. Infrastructure was built for historic water levels, not sea level rise, peak river flows, or more frequent storms.

Interdependencies and unknowns

Ports depend heavily on roads, rail, power, ICT, and fuel supplies. If access routes fail, port operations halt. For example, Prince Rupert's reliance on a single natural gas line makes it particularly vulnerable.

One of the biggest constraints is reliance on external partners to build resilience. Roads and rail leading to ports fall under provincial or municipal responsibility, meaning climate-related disruptions upstream can paralyze operations. The Skeena River, for example, could see future climate impacts that sever road and rail access to Prince Rupert.

Significant uncertainties remain around how climate change will alter ocean and wind conditions over the coming decades. Shifts in prevailing wind intensity and direction could undermine existing navigational safety standards and infrastructure design. The pace and extent of sea level rise also introduce uncertainty, particularly for long-lived assets like breakwaters, terminals, and drainage systems. Beyond physical hazards, the reliance on external transportation networks creates an additional layer of unknowns: disruptions may occur far upstream—such as landslides in the Skeena River corridor—that nevertheless cripple port operations. The ability of governance frameworks to coordinate across jurisdictions and invest in shared resilience remains one of the largest unknowns for the long-term performance of B.C.'s ports.

> *"Low-lying cargo storage, drainage infrastructure, and underground electrical systems are all vulnerable."*

Resilience work underway

The Vancouver Fraser Port Authority has completed flood hazard mapping, participated in regional adaptation projects (e.g., the North Shore Sea Level Rise Strategy), and is leading a multi-year initiative to engage partners and design a climate adaptation plan.[72, 73]

The Port of Prince Rupert has already taken concrete steps, including applying the Envision climate resilience criteria to utilities, developing a storm surge model with the National Research Council, and enhancing wind monitoring and navigational safety. These efforts mark progress, but without systemic coordination across jurisdictions, port resilience will remain uneven and vulnerable to external pinch points.

Information and Communications Technology (ICT)

The main players in ICT infrastructure in B.C. are primarily privately owned companies, with some public sector entities. Key private companies with linear ICT infrastructure (e.g., fiber optic, coaxial, and copper networks) include Telus, Rogers, Shaw Communications, Bell Canada, and Eastlink. Public entities, such as CityWest (owned by the City of Prince Rupert), and non-profits, like British Columbia Network for Innovation, also own and maintain some linear ICT infrastructure. ICT in B.C. and across Canada is regulated federally by the Canadian Radio-television and Telecommunications Commission and Innovation, Science and Economic Development Canada. Cellular networks deliver communications through radio waves utilizing radio access network and antenna systems that operate in licensed radio spectrum bands. While cellular service has expanded rapidly in more populated areas, B.C.'s geography means that extending service to rural and remote regions (e.g., along northern highways) has been cost prohibitive. As of January 2024, 4,800 km (32 per cent) of highways do not have advanced cellular service, largely due to lack of backbone infrastructure (e.g., fiberoptic links) and electricity needed for cell towers.[74]

TABLE 7. EXAMPLES OF IMPACTS TO INFORMATION AND COMMUNICATION TECHNOLOGY INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» The efficiency of batteries is hampered by extreme heat. » Overheating in ICT data centres, exchanges and base stations can cause outages. » Maintaining infrastructure without cooling is difficult, especially in remote locations. » Increased heat-related health and safety risks for exposed workers » Temperature increases impact the range over which wireless signals can be sent and received.
Wildfire and smoke	» Particulate contamination of the insulators on power lines » Damaged ICT wires and poles » Limbs falling across lines can cause power arcing and a line short
Inland flooding	» Buried fibre can be damaged if washouts occur » Increased erosion or flood damage to transport structures (bridges) which may expose cables » Electronics may be at the base of cell towers and damaged by floodwaters. » Reduced quality of wireless service with higher rainfall rates
Coastal flooding	» Increased coastal erosion and coastal flooding of infrastructure » Increased saline corrosion of coastal infrastructure » Potential changes in the reference datum for some ICT/ satellite transmission calculations
Drought	» Affects ground stability which in turn can result in damaged buried fibre and reduced stability of foundations and tower structures
Debris flow and landslides	» ICT infrastructure is frequently attached on the underside of bridges and nearby approaches. Debris flows hitting bridges, scouring bridges, or scouring embankments can all result in damage to the infrastructure.
Extreme weather	» Disruptions due to damaged infrastructure such as tree falls hitting power lines that also carry ICT lines

"An ICT outage could disrupt hospitals' access to patient records, emergency dispatch and coordination."

Communities across B.C. rely on a variety of internet connectivity infrastructures. Individual households and businesses are linked with the backbone infrastructure that connects to the broader internet through "last mile" infrastructure delivered through wired or wireless technology, such as cable, DSL, fixed wireless, or satellite. Fibre optic cable is replacing older cable technology, such as copper and coaxial cable connections in many parts of B.C. Fibre optic transmissions are faster and have higher resistance to electrical interference, meaning a connection is less likely to be disrupted. Fibre is also more corrosion-resistant and its broadband capacity allows easier scaling to meet current and future demand.[17] Despite these advances, many households in rural B.C. and in First Nations communities do not yet have access to internet service that meets the CRCT minimum target speeds.[74] While 96.1 per cent of all households in B.C. have access to target speeds, only 76.5 per cent of households in rural B.C. and 80.3 per cent of households on First Nation reserves and Modern Treaty Nation lands have access to the recommended internet speeds.

Impacts

Climate risks are to the ICT sector given the province's growing dependence on uninterrupted service. Climate change can impact ICT infrastructure and service provision in a myriad of ways, including[75]:

- Reduced in-service lifetime of infrastructure
- Changes to the availability or reliability of ICT services from direct impacts causing disruption and loss in quality-of-service
- Increasing repair and recovery costs due to the frequency of events
- Changes to operational business costs including heating and cooling
- Health and safety of employees due to changing working environments

Communications tower surrounded by mountains near Stewart. *iStock*

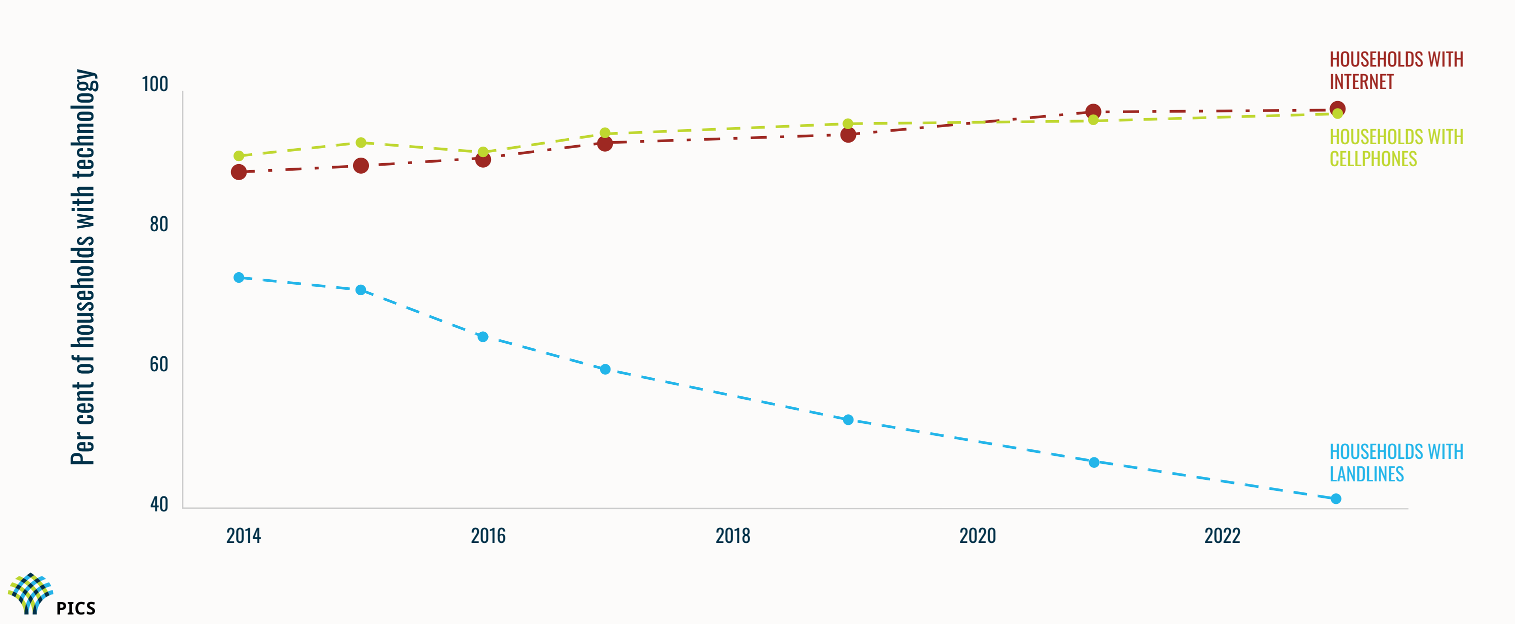
Most impacts are anticipated to affect localized areas rather than provincewide systems due to redundancies and inherent resilience characteristics. The larger concern is cascading impacts to other critical infrastructure and services. ICT network failures can disrupt essential communication and data systems relied upon by sectors such as health care, transportation, emergency services, and financial services. For example, an ICT outage could disrupt hospitals' access to patient records, emergency dispatch and coordination, or cause delays for medical responses. Industries dependent on supply chain logistics, like manufacturing, agriculture, and retail, could also experience productivity losses. ICT outages are particularly concerning for ferries, which rely on ICT for booking, payments, and operations. Long-term outages could also affect coordination of power and transportation restoration and restrict access to supplies for isolated communities.

"ICT underpins nearly every other infrastructure sector."

Exposure and vulnerability

Below-ground ICT infrastructure is vulnerable to flooding, rising water tables, subsidence caused by drought or flooding, wildfires, and hydrogeomorphic risks such as landslides, debris flows, and floods. Above-ground infrastructure is at risk from precipitation, wind, unstable ground conditions, wildfires, washouts, and high humidity.[75]

FIG 11: HOUSEHOLD COMMUNICATION TECHNOLOGY TRENDS IN BRITISH COLUMBIA



Percentage of B.C. households with home internet, cell phones, and landlines.[78]

ICT is frequently co-located with transportation and electricity networks—often on bridges, near rivers, or on wooden power poles—making it more vulnerable to multi-hazard disruptions. Where single runs of ICT infrastructure exist (e.g., Prince George to Prince Rupert, Williams Lake to Bella Coola), outages can be widespread due to the absence of redundancy. The Connected Coast fibre optic network, currently being installed, will help address some of these vulnerabilities.

As B.C.'s fibre-optic network expands, shared conduits and cable bundles create both resilience and shared risk. Fibre is often bundled, with specific companies owning or leasing strands within a larger cable that is either buried or attached to "passive infrastructure" (utility poles, streetlights, conduits, and bridge attachments). Joint-venture companies typically install and maintain these bundles and become the responsible entity if the bundle is damaged. Where providers rely on the same bundle, a single failure can affect all. Where they do not, the Canadian Radio-television and Telecommunications Commission requires service sharing when a competitor's lines go down, improving continuity. However, no single entity oversees the integrated provincial network, and coordination among ICT operators often occurs only after an event via ad-hoc calls, leaving pre-event planning and joint protocols underdeveloped.

Several sources describe ICT as comparatively climate-resilient: the sector is decentralized and modular, with smaller components, shorter asset lifecycles, higher turnover, and naturally redundant network paths.[76] Redundant landlines, internet service provider diversity, emergency roaming, and portable micro-charging/backup systems all improve resilience.[77] According to Statistics Canada (2019), 52.4 per cent of B.C. households have a landline, 92.4 per cent have cellular service, and 46.9 per cent have cellular but no landline.[78] While landlines are a key layer of redundancy, mobile-only households are rising, increasing dependence on cellular networks and grid power for charging (Figure 11).[79] This trend underscores the need to expand multi-path redundancy (e.g., diverse backhaul, satellite failover) to maintain connectivity during climate events.

Owners and operators reported a high level of redundancy in many ICT networks. This means they can divert signals through alternative locations if an area is affected. A key example was seen during the 2021 Lytton wildfire, where mobile communication was quickly restored by deploying portable "cell towers on wheels", providing critical communication support for emergency response and community connections. Although cable backhaul redundancy, or the presence of multiple, alternative cabling pathways for transmitting data, remains limited in many rural and remote regions, advances in new broadband satellites systems are helping to fill some of these gaps.

Interdependencies and unknowns

ICT underpins nearly every other infrastructure sector. Pipelines, power grids, ferries, emergency management, and hospitals all depend on ICT. Yet there is no consistent prioritization of emergency users during a disaster—a hospital phone line may have the same priority level as a household call. Further, as many emergency organizations now rely on VOIP and cellular instead of landlines, there are fewer backup options during outages.

ICT also depends on electricity and water. Large data centres require constant cooling, with megawatts of power and steady water supply for chillers. For instance, a Telus data centre requires 1.5 megawatts of power continuously, 24 hours a day, seven days a week, just to sustain its cooling systems.

> *"Resilience largely hinges on individual owners' and operators' choices."*

The central uncertainty for ICT is not whether systems will be disrupted, but how operators and regulators will prioritize resilience. Questions remain about:

- Whether redundancy will keep pace with rising demand and climate risks
- How service prioritization will be managed during disasters
- Whether fragmented governance and multiple owners can coordinate effectively ahead of, rather than only during, major events

Resilience work underway

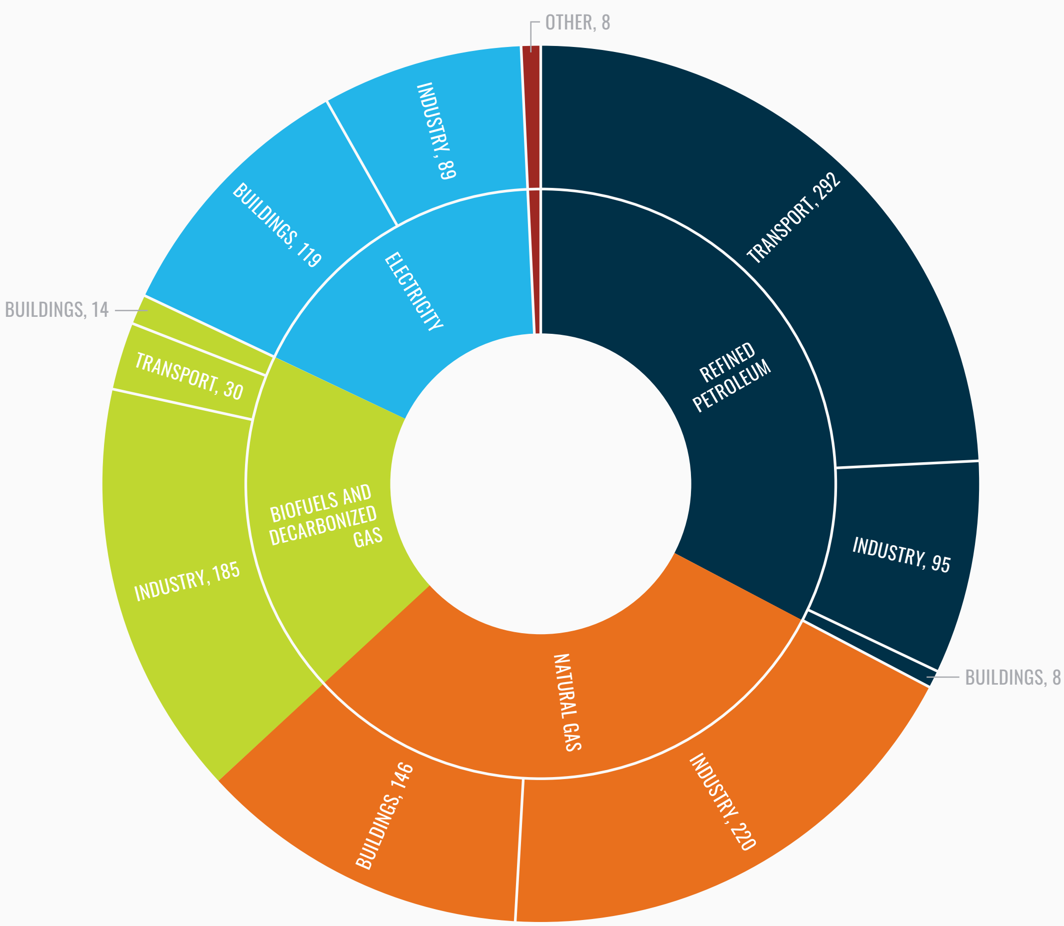
Adaptation to climate risks in the ICT sector depends on awareness and action by three key groups: ICT infrastructure and service providers, customers reliant on ICT services, and government agencies that can guide standards and incentivize resilience investments.[75] However, the Canadian Radio-television and Telecommunications Commission's limited regulation of the competitive industry has resulted in low levels of oversight and few requirements for resilience planning. Consumers often fail to connect service reliability and quality with proactive resilience investments by ICT owners and operators, leading to weak market demand for such actions. As a result, climate resilience largely hinges on individual owners' and operators' cost-benefit assessments in a competitive market. Because many operators view ICT as inherently resilient, proactive investment is often limited and reactive measures dominate.

Large ICT companies have begun integrating resilience more directly into operations. Many companies are improving early warning systems by investing in weather-linked outage forecasting. They also incorporate resilience measures when required by local governments. This often involves collaboration with other infrastructure providers, such as BC Hydro, or action when climate impacts have already been demonstrated. They are also designing with higher temperature thresholds and site-specific risks in mind, such as flood-prone infrastructure in Richmond.

Smaller community-led or non-profit ICT efforts are also supporting resilience. CityWest, a non-profit out of Prince Rupert, is supporting First Nations to expand and harden connectivity in rural and coastal communities. Columbia Basin Trust in the Kootenays owns fibre and operates its own broadband network; and LyttonNet provides internet connectivity through fibre to the local area with specific wildfire resilience measures following the 2021 fire.

A cellular tower stands on the Fraser Highway at 158th Street near a townhouse complex in Surrey. *iStock*

FIGURE 12: BRITISH COLUMBIANS RELY ON MOVEMENT OF GASOLINE, DIESEL, NATURAL GAS, AND ELECTRICITY EVERY DAY



B.C. energy use in petajoules (PJ) by sector in 2021.

Energy

The four main types of energy used in B.C. are electricity, natural gas, biofuels and renewable natural gas, and refined petroleum products, such as gasoline and diesel fuel (Figure 12).[80]

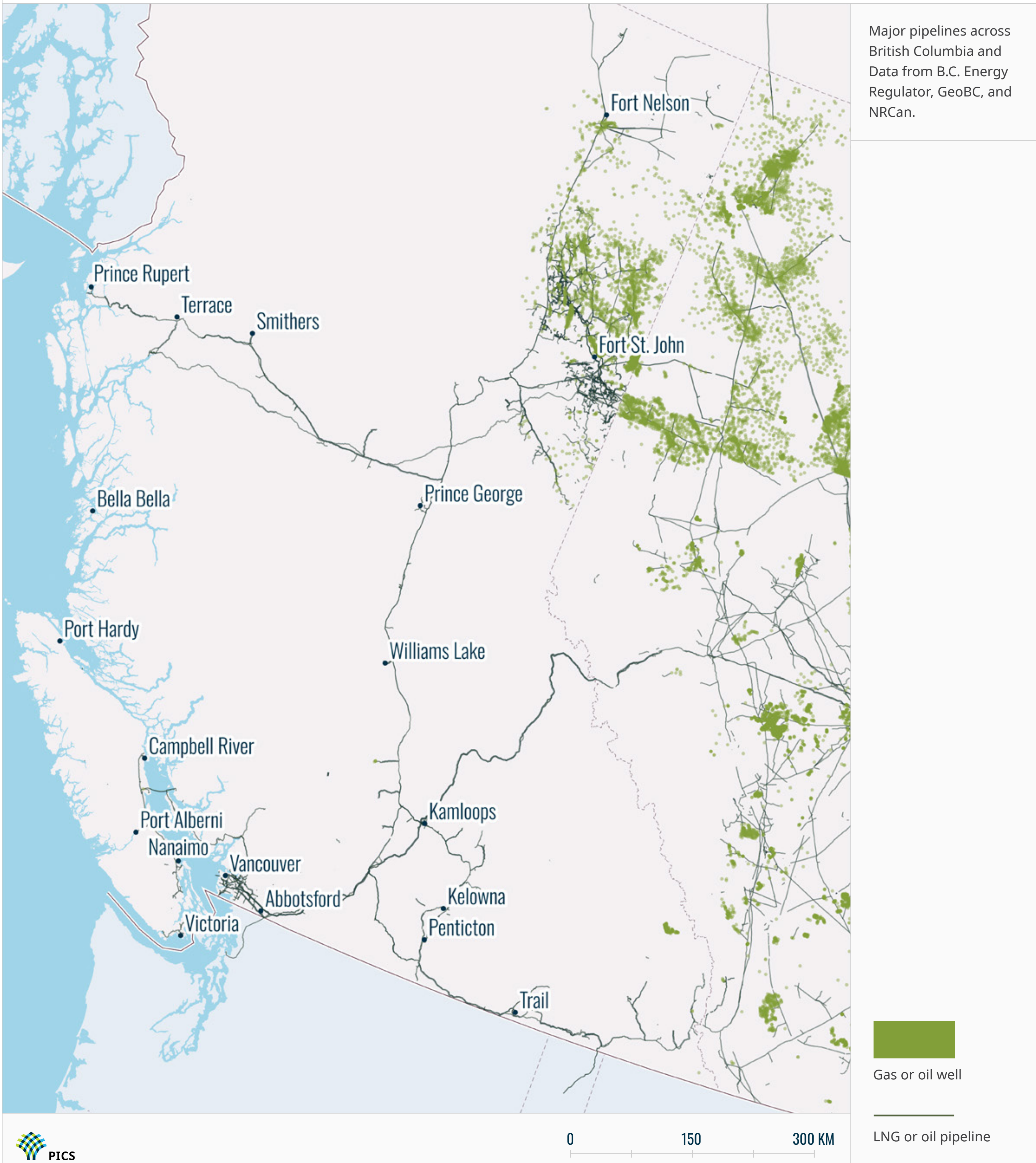
Oil and natural gas

In 2021, about 63 per cent of the energy used in B.C. was supplied by either refined petroleum products or natural gas (Figure 13).[80] The sector is dominated by publicly traded private companies, including Canadian Natural Resources Limited, Fortis BC, Enbridge Inc., and LNG Canada.

Oil and gas operations are typically described in three segments:

- **Upstream:** Exploration and production (E&P) of oil and gas, including drilling and extraction
- **Midstream:** Transportation and processing of hydrocarbons through pipeline systems, processing facilities that extract sulphur and natural gas liquids, and storage facilities. Midstream also includes other transport methods such as rail, truck, or tanker.
- **Downstream:** Refining, marketing, and distribution of products to end users, such as gasoline, diesel, and natural gas utilities (e.g., FortisBC)

FIGURE 13: PIPELINES MOVE GAS AND OIL THROUGH KEY CORRIDORS IN B.C.



Major pipelines across British Columbia and Data from B.C. Energy Regulator, GeoBC, and NRCan.

These activities are regulated by multiple authorities, often varying by segment:

- **Upstream:** The B.C. Energy Regulator (BCER) oversees most upstream exploration and production, including gathering pipelines that connect wells to processing facilities.
- **Midstream:** Transmission pipelines that cross provincial or national boundaries fall under the Canadian Energy Regulator (CER), while the BCER regulates transmission pipelines within the province.
- **Downstream:** Distribution systems reaching end users are regulated by the B.C. Utilities Commission (BCUC). Technical Safety BC also oversees the safe use of natural gas, liquefied petroleum gas, and related products in commercial applications.

Flowing south from Fort St. John, a natural gas pipeline rises over the Peace River. *iStock*

This patchwork of regulators creates a complex oversight environment. For example, FortisBC's emergency management program is accountable to nine different regulators.

The level of regulatory oversight does not always align with the scale of climate-related risks. For example, transmission pipelines that cross jurisdictions are tightly regulated for operational and safety standards, yet climate resilience requirements (e.g., adaptation to flooding, wildfire, or slope instability) are less consistently embedded. Local distribution networks, by contrast, are overseen by provincial regulators with more direct consideration of consumer protection, but with fewer explicit requirements for climate adaptation. This uneven alignment suggests that while operational safety and reliability are highly regulated, proactive adaptation to climate hazards often remains at the discretion of individual operators.

For this report, the focus is on midstream pipeline transportation. Of the pipelines regulated by the BCER, about 75 per cent carry natural gas, 10 per cent carry oil, and the remainder carry other gases or liquids used in production.[81]

Impacts

Pipelines can be damaged by singular extreme events such as wildfires. However, they are just as likely—if not more likely—to be affected by compound events. For example, heavy precipitation on burned slopes can trigger hydrogeomorphic hazards such as debris flows.[82] Pipeline owners and operators generally take an all-hazards approach given the variety of hazards that can impact the extensive pipeline network from climate-related hazards to vehicle accidents to bad actors and cyber terrorism.

Pipelines can be disrupted through proactive shutoffs—such as the Trans Mountain pipeline during the 2021 atmospheric river—or by unplanned outages when damaged prior to or following a spill.[83] The consequences for customers, communities, and the environment vary depending on the location, the extent of the damage, and the criticality of the affected pipeline segment.

The BCER's 2023 Pipeline Performance Summary reports 26 pipeline incidents with 24 involving a release or spill.[84] Experts we spoke to noted that environmental spills that are directly triggered by climate events are rare, as pipelines are closely monitored. Pressure drops are detected quickly and valves shut automatically to contain flows. Containment barriers can limit impacts, though these barriers may be ineffective during extreme events such as debris flows or river breakup. Preserving the integrity of downstream water systems is a priority since contamination during a peak draw season could be catastrophic.

Regulatory oversight emphasizes safety, spill response, and operational reliability. However, experts noted that requirements for proactive climate adaptation—such as reinforcing pipelines in floodplains or integrating slope-stability projections—are less prescriptive. This leaves resilience measures largely up to operators' discretion. For instance, while CER and BCER mandate integrity digs, pressure monitoring, and incident reporting, there is no consistent regulatory standard for addressing compound hazards that are becoming more common under climate change.

Exposure and vulnerability

The convergence of the Pembina and Enbridge pipelines near Prince George has long been recognized as a critical pinch point. A line break on the Enbridge Westcoast T-South system in October 2018 demonstrated the consequences: with one pipeline down and the other operating at reduced capacity, most of southern B.C. and Vancouver Island faced curtailed natural gas supply. Customers were asked to cut consumption, and back-up supply was temporarily sourced from Oregon—though Oregon has since indicated it will no longer provide Canadian backstops to protect U.S. domestic supply.[85] While the exact environmental impacts related to the incident are not available in public reports, we do know that approximately 100 members of the Lheidli T'enneh First Nation were evacuated as a precaution.

TABLE 8. EXAMPLES OF IMPACTS TO OIL AND GAS PIPELINE INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» Impacts to occupational health and safety for outdoor maintenance crews
Temperature shifts	» Increased damage to transmission and distribution infrastructure, including oil and gas pipelines
Wildfire and smoke	» Impeded access to pipelines for maintenance, etc. due to safety for employees (health hazards) and road closures » The stability of slopes in burned areas and the degradation of their soils can increase the risk of geotechnical and hydrogeological hazards that can impact pipelines. » Damage to any aboveground infrastructure » Force surface-level shutdowns of natural gas wells, curtailing production, and constraining supply » Impacts to occupational health and safety for outdoor maintenance crews
Inland flooding	» Flooding can erode and change soil conditions resulting in damage to a pipeline. » Flooding can cause increased scour and river migration that can damage a pipeline. » Above ground infrastructure, such as valves and pressure sensors, can be damaged if flooded.
Coastal flooding	» New floating LNG facilities (e.g., Woodfibre LNG) are tied to land-based infrastructure that, if flooded, will impact operation and functionality. » Buried lines can be affected by changing soil conditions. Increasing groundwater tables influence land stability which can impact pipelines by shifting portions. » Increased salinity in groundwater can increase pipeline corrosion rates, reducing lifespan.
Drought	» Changes in groundwater can influence ground subsidence affecting pipelines. » May affect hydroelectric generation putting more pressure on natural gas for supply
Debris flow and landslides	» Disturbed soil around pipelines can become a conduit for water movement. Debris flow and landslides can damage and disrupt pipelines.

The Burnaby Refinery (owned by Parkland Corporation in 2021). *iStock*

This event highlighted the lack of redundancy in B.C.'s transmission network and the region's dependence on a small number of corridors.

Climate-related hazards such as flooding, landslides, and wildfire can physically damage or disrupt pipelines, triggering loss of gas flow and "linepack." If linepack is lost, oxygen may enter the system, increasing the risk of ignition or explosion. Restarting a flatlined system requires specialized technicians to safely re-pressurize and relight users—a process that could take months in a dense urban region like the Lower Mainland, especially during winter when demand is highest. If this occurred in the winter, it could pose widespread thermal safety issues. The 2018 Enbridge explosion shut down the Enbridge pipeline that feeds Fortis BC's transmission line, which is the artery supplying distribution lines to users. The system came close to running flat, but the remaining available linepack and quick opening of the second Enbridge line averted more substantial consequences.

Contingency supply options exist but are limited. The 2019 BCUC inquiry into gasoline and diesel markets noted that refined product shortages in B.C. are sometimes alleviated by marine imports through the Port of Vancouver or rail shipments.[86] These alternatives, while important, are more expensive, logistically constrained, and vulnerable to the same climate hazards that affect ports and rail. In practice, contingency systems may cushion short-term disruptions but do not substitute for robust, climate-resilient transmission infrastructure.

Pipeline maintenance needs are also growing as much of the infrastructure is more than 50 years old. For example, the Parkland refinery in Burnaby, built in 1935, remains B.C.'s only major refinery. Industry hesitancy to replace or modernize this infrastructure reflects both market uncertainty and policy direction toward energy transition. This aging asset base magnifies vulnerability, as older facilities were not designed for today's climate extremes such as debris flows, wildfire-related slope instability, or coastal flooding.

Finally, there is no central system to track user vulnerabilities across the energy network. This creates equity concerns, as critical users (e.g., care homes without back-up power or emergency service facilities) are not consistently prioritized for limited resources during outages.

Regulators such as CER, BCER, and BCUC impose strong requirements for operational safety, spill containment, and market transparency. However, climate risk is not consistently embedded in regulatory standards. For example, slope stability, flood risk, and sea-level rise are not uniformly considered in pipeline siting or integrity management. This mismatch leaves resilience investments largely discretionary, dependent on operator capacity rather than systemic policy.

> *"Climate risk is not consistently embedded in regulatory standards."*

Interdependencies and unknowns

Interdependencies: Power and ICT are integral to pipeline operations. Access via highways and roads to monitor and quickly repair infrastructure is also important. Pipeline operators often build temporary access roads during emergencies, but this is resource-intensive and time-consuming, underscoring their reliance on functioning public transport networks. Rail is also important to the industry in delivering materials for refining and transporting away byproducts such as asphaltene. Because pipelines intersect with other lifeline systems—electricity for pumping, ICT for control, roads, and rail for access—the recovery of pipeline operations is rarely independent. Disruption in one sector can slow or block recovery in another, amplifying cascading risks.

Two categories of uncertainty stand out. First, non-climate risks such as cyberattacks or deliberate sabotage remain difficult to anticipate, with a near-infinite range of possible scenarios.

Second, climate change is pushing infrastructure into conditions it was never designed for: compounding hazards, unprecedented heat, and new precipitation extremes. How aging pipelines and storage facilities will perform under these stresses is largely unknown. Current integrity models are based on historic climate conditions, leaving major evidence gaps around asset lifespan, durability, and safe operating thresholds under future extremes.

Resilience work underway

Pipeline companies are incorporating climate, environmental, and operational risk factors into engineering and design activities. FireSmart principles are applied at all sites to reduce wildfire risk.

According to owners and operators we spoke to, pipeline systems have strong integrity management programs, guided by standards that require comprehensive monitoring through integrity digs, physical line patrols, aerial inspections, and increasingly, the use of drones and sensing technology. These monitoring systems are designed to detect changes in pressure, temperature, or ground conditions before they escalate into major incidents. Integrity management remains the primary resilience strategy, emphasizing early detection and rapid response rather than large-scale redesign.

B.C.'s northeast, home to a high concentration of oil and gas projects, was heavily affected by the 2023 wildfire season. In response, the BC Energy Regulator convened a multi-stakeholder Wildfire Roundtable to evaluate inter-agency coordination and safety measures. The roundtable identified gaps in spatial data sharing, prioritization of access to critical sites, and evacuation protocols, and emphasized the importance of pre-season training. These lessons highlight the growing need for collaborative, systems-based resilience planning across industry and government.

While these efforts strengthen monitoring and response, most resilience initiatives remain focused on managing current risks rather than redesigning infrastructure for future extremes. This reactive approach leaves questions about whether today's integrity programs will be sufficient as hazards intensify and infrastructure continues to age.

Lessons from the 2023 Wildfire Roundtable Report

The 2023 Wildfire Season Roundtable, convened by the BC Energy Regulator (BCER), focused on evaluating inter-agency coordination and safety measures during the 2023 wildfire season to enhance preparedness for future wildfire events.[87] The roundtable was called in response to the unprecedented severity of the wildfire season, which posed substantial risks to public safety, critical infrastructure, and the environment.

An essential lesson learned from the 2023 Wildfire Roundtable Report was the importance of collaboration and communication between emergency management and business continuity staff.[87] Critical dependencies were tested, and gaps were identified given the extended electrical power outages and overloaded phone services. Recommendations included:

- The critical need to improve spatial information sharing and reliability of GIS services
- Improved processes to ensure requests for access to critical infrastructure can be prioritized
- Pre-fire season sharing of critical contacts, check-in procedures for persons in evacuation order areas, and better reporting process for site evacuations
- Improvements to emergency plans and site fire resilience, including structural protection
- A stronger focus on pre-season training as a contributor to overall safety of both the responder community and those working in proximity to seasonal and industry risks[87]

Electricity

BC Hydro, a provincial Crown corporation, generates and delivers electricity to 95 per cent of the population of B.C., making it one of the most critical lifeline systems in the province (Figure 14).[88] Its current five-year strategy emphasizes strengthening resilience and agility. The BC Utilities Commission regulates energy utilities in the province, including requirements to provide safe and reliable service at just and reasonable rates. Legislation such as the Clean Energy Act, Hydro and Power Authority Act, and the BC Utilities Commission Act establishes the framework governing BC Hydro. FortisBC also owns and operates 7,300 km of electric transmission and distribution lines in southern B.C.[89]

> *"Snowpack loss, early freshet, and drought, directly affect electricity security."*

B.C.'s electricity system is highly renewable, with 98 per cent of supply coming from non-fossil sources: 89 per cent from hydroelectric generation, five per cent from biomass, three per cent from wind, and one per cent from solar.[80]

This dependence on hydroelectricity means climate-driven hydrological shifts, such as snowpack loss, early freshet, and drought, directly affect electricity security. While compliance with North American reliability standards (NERC) historically focused on cyber and physical security, these standards are increasingly expanding to address outages tied to climate events.

The province's reliance on hydro generation places much of the system at risk from climate-driven changes in water supply. At the same time, other renewables are diversifying B.C.'s grid. Wind currently provides about 2,160 GWh annually across ten facilities, with BC Hydro's 2024 call for power set to add nine more projects. Solar contributes only about 4 GWh annually from two small utility-scale producers, but about 10,000 residential producers participate in BC Hydro's self-generation program. Biomass is also a key contributor in rural, forestry-dependent regions.

Although small compared to hydro, renewables like wind and solar are expected to grow significantly, and their exposure to climate hazards (e.g., wildfire, storms, extreme heat) requires careful planning.

Powerlines over the Hyannis Trail in North Vancouver. *iStock*

FIGURE 14: TRANSMISSION LINES CUT ACROSS B.C.'S MOUNTAINS AND WATERWAYS

Electricity transmission lines and generation facilities (hydroelectric dams and powerplants) across British Columbia. Data from B.C. Energy Regulator, BCHydro, Fortis, GeoBC, and NRCan.

Hayward Lake, part of the Stave River hydroelectric project. *iStock*

Hydroelectricity

Impacts

Electricity demand, generation, and transmission/distribution are all exposed to climate hazards. Because B.C.'s grid is so extensive—78,000 km of lines, 900,000 poles, and 300 substations—exposure to climate hazards is high, especially in remote forested areas.[89] Impacts to any one category can cascade into province-wide consequences for homes, businesses, and essential services.[9]

> *"Strengthening resilience in Canada's electricity sector could reduce damage costs by as much as $3.1 billion annually."*

Exposure and vulnerability

The scale and location of the system create significant vulnerability. Transmission lines often cross remote forest interface zones where access is limited, making infrastructure harder to monitor and repair. In these areas, wooden poles are still common, compounding vulnerability to fire, wind, and heat. Some communities also depend on a single transmission line, creating a lack of redundancy that increases the risk of prolonged outages.

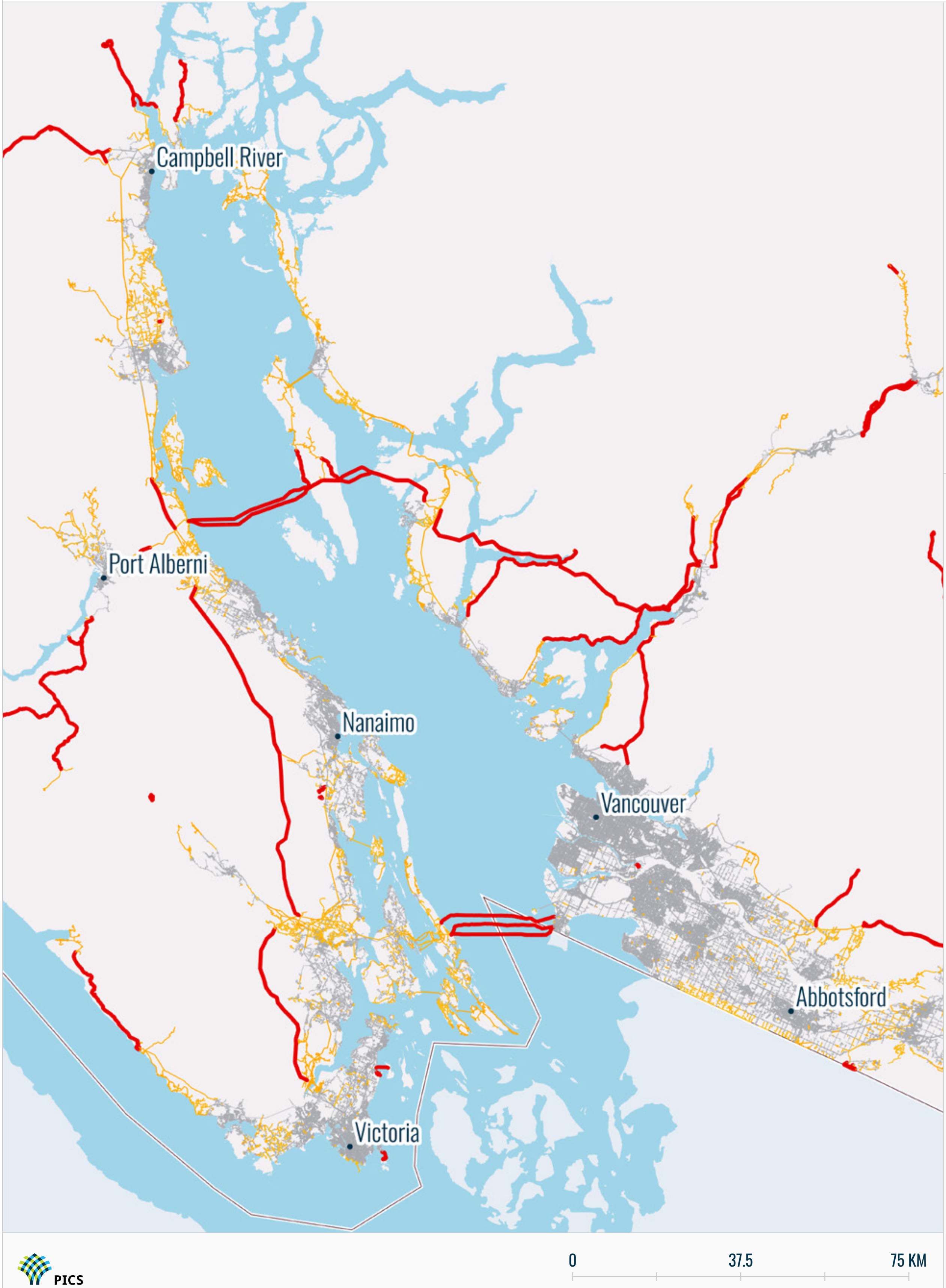
B.C.'s net-zero transition further raises the stakes: as buildings, transportation, and industries electrify, outages will have broader cascading impacts. Analysis by the Canadian Climate Institute estimates that strengthening resilience in Canada's electricity sector could reduce damage costs by as much as $3.1 billion annually.[90]

In our network analysis of electricity transmission pinch points (see box Geospatial network analysis), we identified a number of high-impact segments. Based on our model, when these powerlines or undersea transmission lines were removed from the network, whether due to a flood, fire, landslide, or another hazard, their outage resulted in significant fractures in the system. The analysis showed especially high risk for Vancouver Island communities and the Lower Mainland, as shown in Figure 15.

TABLE 9. EXAMPLES OF IMPACTS TO ELECTRICITY TRANSMISSION INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» The move away from natural gas to electricity will place pressure on the electrical grid as demand increases for air conditioning and heat pumps which provide cooling » May result in derating or failure for air cooled transformers, and sag and annealing for overhead conductors —disrupting regular operations » Damage to transformers could lead to sudden spikes in voltage and impacts to sensitive electronic devices. » Transmission circuit ampacity reductions (reduced capacity) and line sag » Melting above-ground wires causing disruptions and outages » Impacts to occupational health and safety for maintenance crews » Impacts to the lifespan of equipment
Temperature shifts	» Increased vegetation management is needed due to longer growing seasons as temperatures warm (sustained drought may counteract this to an extent) » Increasing freeze/thaw cycles can damage concrete and cause cracking and deterioration of underground vaults and cable chambers over time » Longer duration of cold temperatures leads to wear and tear on lines » Mechanical switches can freeze meaning breakers cannot trip and fail, disrupting operations
Wildfire and smoke	» Risk to transmission corridors and remote substation infrastructure » Wood transmission poles are at risk of burning » Conductors can become annealed or damaged and fail. Lines can be damaged by the heat even if they are not burned directly » Smoke and particulate matter can ionize the air, creating an electrical path away from transmission lines which can lead to shutdowns and power outages » Impacts to occupational health and safety for maintenance crews » Proactive line shut downs due to high wildfire risk
Inland flooding	» Flooding may damage transmission lines, poles, and substations when located near bodies of water, leading to power outages » Flooding may erode tower foundations and compromise their structural integrity. » Inundation of distribution assets
Coastal flooding	» Inundation of coastal infrastructure affecting transmission and distributions » Corrosion of infrastructure not previously exposed to salt water
Drought	» Localized hazard impacts that can damage infrastructure or cut off access for maintenance and repair
Debris flow and landslides	» Ice storms can snap power lines, break, or bring down utility poles and substantially increase tree contacts leading to damage and power loss » Increased damage and outages to transmission and distribution infrastructure from substantial storm events (e.g., ice, wind, rain, and wind) » Flash flooding affecting tower footings and transformer stations » Ice, snow, and rime loading of lines, towers, and insulators, including line sag and gallop can disrupt service » Extreme wind load leading to damaged and downed lines » More frequent power outages and increased repair costs

FIGURE 15: B.C.'S ELECTRICITY TRANSMISSION NETWORK HAS NUMEROUS PINCH POINTS



Using a network analysis model that we developed, we identified electricity network pinch points across British Columbia.

The model did not examine where electricity was generated but looked simply at the networks' dependence on each connection. The high impact roads (red) would have major network impacts if they were unserviceable due to a flood, landslide, fire, or any other threat. Data from GeoBC, and NRCan.

Interdependencies and unknowns

Electricity underpins nearly all other critical infrastructure, making it a "lifeline" system. Water and wastewater pumps, ICT systems, hospitals, and renewable energy installations depend on uninterrupted electricity. While many critical facilities have backup generators, these typically provide only bare-bones support for a few days.

Electricity infrastructure also depends on other systems: ICT is needed for grid monitoring and coordination, while road access is essential for repairs in remote areas.

Unknowns include the lifespan of electricity assets under repeated exposure to new climate extremes, the magnitude of future hydrological change, and how emerging technologies (e.g., energy storage) can help buffer seasonal variability. Experts note that utilities often struggle to plan for high-impact, low-frequency events and cascading failures.

Technologies may play a role in helping existing locations adapt to changes, however the advancement of these technologies is similarly uncertain. For example, certain areas may experience increases in water in the spring and decreases in the summer, necessitating increased technologies to store energy to supplement the grid during low-flow times of the year.[91]

Resilience work underway

BC Hydro and Fortis are scaling up both hardening measures and demand-side strategies to reduce stress on the system. Utilities are replacing vulnerable wooden poles with more resilient materials, expanding vegetation management, and integrating climate projections into reservoir operations.

They are also investing in early warning and real-time monitoring: BC Hydro maintains a hydrometeorological data portal providing live climate, snowpack, and water level information to anticipate risks.[92, 93]

On the demand side, BC Hydro has introduced new pricing structures and incentive programs to reduce peak demand, alongside broader conservation programs to reduce overall consumption. These measures aim to reduce stress on the grid, delay costly infrastructure expansions, and make better use of existing capacity.

Resilience strategies also extend to customer preparedness. Utilities are promoting outage planning and awareness, while regulatory requirements are pushing for greater climate integration into planning and investment decisions.

Piles of wood chips at the Drax Princeton Pellet Plant to be made into fuel, a byproduct of the lumber industry and a renewable resource. *iStock*

Solar and biomass electricity generation

Renewable energy systems are highly diverse, with hydro, solar, wind, biomass, geothermal, and tidal projects across B.C. As a result of the lack of available information regarding renewables in British Columbia, this section covers biomass and solar exclusively. We acknowledge this is a substantial gap, and further research should be conducted to thoroughly investigate the climate impacts and adaptation opportunities for other renewable resources.

As an area of critical infrastructure that is growing and still in its infancy, little is known regarding how renewable energy owners and operators are adapting to climate change. The Fraser Basin Council, in partnership with Natural Resources Canada, led the Renewable Energy Climate Adaptation Project.[12] For this project, the Fraser Basin Council interviewed solar and biomass energy owners, operators, and relevant organizations. The goal was to compile and share insights from past adaptation actions in renewable energy projects. These findings were then used to develop guidance on integrating future climate risk information into solar and biomass project development.

Both solar and biomass systems largely involve point rather than linear infrastructure, such as photovoltaic panels and fixed infrastructure. Most solar and biomass energy projects are small-scale installations owned by private companies, municipalities, and institutions.[94]

Some of the largest solar operations in the province are owned by Innergex Renewable Energy, Teck Solutions, and Tsilhqot'in First Nation. Key biomass owners and operators include the Drax Group and Pinnacle Renewable Energy. Biomass energy tends to be more substantial in rural communities near forestry operations, whereas solar is distributed across the province, with some of the larger installations located in Kimberley and Hanceville, B.C.

Impacts

As the industries emerge, renewable energy owners and operators are becoming increasingly aware of climate-related hazards and the potential impact to their infrastructure; however, to date, little is known or has been published regarding these impacts. One impact that is top of mind for owners and operators is wildfire, as the province continues to experience increases in frequency and intensity of wildfire, with prolonged smoky seasons over the summer months.

Extreme heat: Solar:

- Changes in solar irradiation and cloudiness affect solar power output
- Impacts on maintenance and operations: bot solar panels and batteries are less efficient in extreme heat
- Extreme heat can damage electrical infrastructure if it is not designed for high temperatures. Owners and operators said they include higher temperatures in design of solar energy components.
- Project delays due to outdoor worker productivity and safety impacts (solar farms can concentrate heat)

Wildfire and smoke: Solar:

- An increase in dirt, dust, snow, and atmospheric particles decrease energy output[95]
- Wildfire smoke can reduce production (solar). This happens at peak season, which can be an issue.
- Possible reduction of timber available for biomass production

SunMine solar energy facility in Kimberley. Source

Drought: Biomass:

- Available residual forest products used as supply for biomass facilities is reduced.

Extreme weather: Solar:

- High windspeeds can damage solar panels on rooftops
- Hailstorms can damage solar panels
- Damage to panels due to heavy snow loads
- Potential safety hazard for workers clearing snow due to smooth and slick surfaces on rooftops

Interdependencies and unknowns

Renewable energy infrastructure is particularly dependent upon transportation infrastructure, as well as power, ICT infrastructure, and ports. During wildfires and storms, renewable energy owners and operators can face challenges in moving equipment and can experience project delays, particularly in remote communities with single road access. This will also increase costs for owners and operators, potentially affecting their financial sustainability. For certain systems (e.g., fixed tilt solar systems), owners and operators require staff on the ground to operate the panels. If transportation is cut off, then evacuations may be ordered, and operations may be disrupted.

Many households and buildings with solar panels take advantage of net metering (also known as "self generation"). Unless homes have individual battery storage, most home solar systems will stop generating electricity when the power goes out to prevent backflow to the grid. However, for households with an integrated battery system, the solar panels may be able to charge the battery and supply power to essential appliances. Currently, most household solar systems in B.C. are tied to the grid without battery storage. In certain systems (e.g., remote change tilt solar), tracking systems move infrastructure to follow the sun; tracking requires ICT infrastructure.

A professional solar panel crew installs panels on the roof of a house. *iStock*

Solar panels and other parts for renewable energy are often shipped to Canada. If the ports become inoperable or experience delays, this may affect the ability of solar owners and operators to complete projects, delaying their ability to produce energy.

There are many unknown factors affecting the resilience of renewables in B.C. Overall, one of the most pervasive uncertainties across renewables is in projecting future hazards, and the unknowns encapsulated within them. Hazards like extreme heat cause damage to the equipment that is difficult to quantify and measure. Information can be gathered about the durability of infrastructure and extreme heat. However, most of the infrastructure in B.C. is facing multiple, sometimes coinciding hazards that affect critical infrastructure in ways that are poorly understood. Uncertain lifespan could lead to early and unexpected infrastructure failure, or greater vulnerability to hazards in the future.

Further, uncertain supply chains and growing disruptions due, in part, to climate change, present an important threat to biomass systems. It is increasingly difficult for owners and operators to plan for future projects and costing, which are tied to hazards such as drought, wildfire, and insect infestations. Simply put, one of the questions these operators face is how to cost their project when there is significant uncertainty about supply and the cost of supply. This makes biomass systems a more difficult investment presently, though it is the more established generation resource in B.C. compared to solar or wind.

Resilience work underway

The focus of climate resilience in the budding renewable energy sector is on siting installations away from hazardous locations. In some cases, community climate action planning has incorporated the installation and hardening of renewable energy infrastructure and in other cases, funders have required consideration of climate resilience in the infrastructure planning phase.

Consistent with other critical infrastructure systems, design of components is increasingly incorporating future climate loads. For example, many firms previously designed solar battery storage to 40°C and are now designing up to 45°C to adapt to the warming climate. These are proactive design methods in the absence of standards.

The Lions Gate Wastewater Facility in West Vancouver. *iStock*

Water and wastewater

Linear water infrastructure distributes water from reservoirs and treatment facilities to users, while wastewater systems remove liquid waste and storm water from users and from roads, buildings, etc. These systems are essential to community health, safety, and livability, yet their largely underground nature makes them less visible to the public until failure occurs.

The Drinking Water Protection Act and associated regulations govern drinking water from source to tap and set standards for drinking water and domestic water use. Responsibility lies primarily with local governments (including regional districts) and First Nations governments. The Drinking Water Protection Act governs water from source to tap, while the Environmental Management Act and the Municipal Wastewater Regulation set standards for wastewater. Smaller systems and on-site systems fall under the Ministry of Health.

According to Statistics Canada, 15 per cent of local government infrastructure spending in Canada goes to sewage systems. Between 2016 and 2020, capital expenditures on sewer infrastructure increased by nearly 50 per cent.[96] In Ontario, stormwater and wastewater linear assets are valued at $124 billion. In Ontario, stormwater and wastewater assets are valued at $124 billion, and a recent study found that without climate adaptation, extreme rainfall could raise maintenance and operating costs by 27 per cent by 2030.[97] In B.C., a 2022 survey of asset managers highlighted difficulty in assessing service levels and climate risks as an ongoing barrier to adaptation planning.

Impacts

Climate-related hazards have significant implications for linear water and wastewater systems.[4b] According to the International Institute for Sustainable Development, risks include[9]:

- Failed systems: ruptured underground pipes due to freeze/thaw cycles, overwhelmed culverts, and pipe bursts.
- Strained systems: higher energy requirements to run infrastructure and increased effluent concentration that challenges water treatment capacity
- Exceeded capacity: storm surges and downpours that overwhelm networks
- Reduced lifespan: systems designed for historic climate loads deteriorate faster under current conditions.
- Supply–demand mismatch: hotter, drier summers increase demand while reducing supply.

TABLE 10. EXAMPLES OF IMPACTS TO WATER AND WASTEWATER INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Extreme heat	» Higher temperatures lead to more evaporation from reservoirs which lowers water levels and may expose more liner material to degradation from sunlight » Increased need for water treatment as warmer waters contribute to algae in source waters » High temperatures increase the generation of corrosive gasses that accelerate the corrosion of sewer systems (wastewater) » High stream temperatures and decreased streamflow (e.g., from drought) lead to more concentrated influent flows that are harder to disinfect (wastewater) » Impacts to occupational health and safety for outdoor maintenance crews
Temperature shifts	» Seasonal temperature changes can affect the ground and buried pipes will be affected, including the movement of joints which can impact water quality
Wildfire and smoke	» Longer and more intense wildfire seasons, driven by both heat and drought, will place additional pressures on water supplies and may also present risks to supply » Smaller communities may not test fire-fighting equipment if water supply is stressed » Above-ground infrastructure like pump station kiosks could be damaged or lost (e.g., pumps are in wet wells, but power controls are above ground) » Impacts to occupational health and safety for outdoor maintenance crews
Inland flooding	» Increasing frequency and intensity of heavy rain events has increased the probability of sewer overflows, especially for combined sewer networks, leading to the release of contaminants into the environment » Increased inflow and infiltration during heavy rainfall or rapid snowmelt impacts the wastewater system and contribute to flood risk » Higher groundwater could impact water and sewer pipes causing them to be displaced, settle or crack » Flooding can damage electrical equipment in pump stations » Increased erosion at the mouth of the outflow pipe and higher flow may turn overflows into pinch points with flow surcharging upstream » Flooding causes structural changes to rivers and shorelines which may impact adjacent water and wastewater infrastructure » Pump stations located at low elevations may flood » Reduced water quality in local watercourses from increased stormwater runoff » Damaged and/or compromised wastewater systems because of increased inflow and infiltration and extreme flooding events » Increasing extreme rainfall will shorten the useful service life (USL) of some public storm and wastewater infrastructure, requiring more frequent and additional rehabilitations. This will lead to higher spending on operations and maintenance » Heavy rainfall running down overland flow routes and into sewer through sewer holes increasing the volume of water to be pumped and that enters treatment facilities affecting efficacy of biological treatment » Increased wear and tear on the pipe systems
Coastal flooding	» Risk of damage for infrastructure located at low elevations such as pump stations and marine crossings » Saltwater intrusion into pipes, increasing corrosion » Outfalls from treatment plants will be affected—will need to discharge against the head pressure of sea levels

TABLE 10 Cont. EXAMPLES OF IMPACTS TO WATER AND WASTEWATER INFRASTRUCTURE FROM CLIMATE-RELATED HAZARDS

Hazard	Consequences and implications (impact)
Drought	» Drought could lead to restrictions on non-essential water use and difficulties in managing waste » Increased occurrence of dry private shallow wells and reduced aquifer recharge » Drought conditions, combined with higher temperatures, will increase demand for drinking water during summer months, adding strain on source water storage and transmission system capacity » Cracking of earthen dams can increase repair costs or lead to catastrophic failure » Trees looking for water may tap into the water system causing damage » Increase water supplies used for irrigation » Reduced rainfall can lead to concentrated wastewater with high concentrations of pollutants, higher salinity, making the sewer system more susceptible to corrosion » Low river levels may impact industrial wastewater discharge (e.g., from a pulp mill that is required to discharge at certain flow timing will change)
Debris flow and landslides	» Debris flows can compromise water quality where they enter watercourses and reservoirs, leading to prolonged water advisories and costs related to restoring the water source » Slope instability can reduce structural integrity of dams » Rupture of water and wastewater lines and storage tanks » Anything that can affect ground conditions can impact underground pipe infrastructure (landslide, groundwater, permafrost melting, etc.)
Extreme weather	» Power outages due to storms affect pumping stations without backup power » Wastewater contamination events due to sewer overflow, clogging, or breakage » Increased run-off, turbidity, and erosion will add stress to stormwater collection and drainage systems » More intense rainfall increases inflow and infiltration to the sewer system reducing capacity

Exposure and vulnerability

Water and wastewater systems across the province experience different levels of risk depending on age, design standards, location, and operator capacity to absorb rising costs. Nationwide, sewerage infrastructure has the highest average age and lowest remaining service life of all fixed assets.[96]

Older infrastructure is especially vulnerable, as it was designed for historic climate conditions that are now routinely exceeded. Combined sewer systems are particularly at risk during heavy rainfall, as limited capacity results in more frequent overflows that release contaminants into the environment.

Pumping infrastructure faces similar challenges. Stations were built for past rainfall patterns, and many are in low-lying or coastal areas exposed to flooding or wildfire. While pumps themselves may sit in wet wells, electrical controls above ground remain highly vulnerable. Increased pumping needs during storms add strain, leading to overheating, localized flooding, and accelerated wear. Conversely, drought can also reduce functionality, with less water available to move through the system.

Land use patterns also shape exposure. Urban densification and impervious surfaces increase runoff, placing more stress on stormwater systems. Growing populations drive higher peak demand, while low-use periods force operators to maintain high pressure in networks, which accelerates system degradation.

B.C.'s 2019 Climate Risk Assessment identified short-term water supply as one of the province's top three climate risks.[15] Rising demand, more frequent droughts, and the need to maintain sufficient water for wildfire suppression pose major challenges.

The scale of adaptation required is immense: from raising dams and expanding reservoirs to retrofitting treatment plants and exploring technologies like desalination. Yet, many local governments lack the financial and technical capacity to pursue these solutions, especially smaller municipalities that rely on a handful of staff.

Interdependencies and unknowns

Water and wastewater systems are deeply interdependent with other infrastructure. They rely most critically on power systems, as well as communications and road networks. While many facilities have backup power, these systems are limited; generators can fail or fuel supplies can run out. As one interviewee noted, two operators can run a wastewater plant with power, but without it, a dozen staff would be needed to keep it functional. Supervisory Control and Data Acquisition systems, which control and monitor operations, also require redundant power.

Communications are essential during disruptions, especially for issuing boil water advisories. Supply chains add further interdependencies, particularly for treatment chemicals such as chlorine, which can be delayed by rail or trucking disruptions. Access for staff is equally critical, yet public works yards, vehicles, and equipment are often located in hazard-prone areas, making them hard to reach during floods, fires, or other emergencies.

The greatest unknown is not whether water and wastewater systems will be stressed by climate change, but how governance and policy will respond. Public willingness to support the massive expenditures required for upgrades remains uncertain, even as demand grows with urban densification and possible climate migration. A second major unknown is the ability to coordinate the many authorities and jurisdictions involved in water and wastewater services during disasters—a persistent governance gap that risks delaying both decisions and recovery.

Resilience work underway

Across British Columbia, resilience planning for water, stormwater, and wastewater systems is advancing. Federal funding requirements, such as Canada's Climate Lens, local adaptation planning, and the integration of climate risk into asset management have prompted municipalities to act.[98, 99] Communities engaged in climate planning now have a clearer picture of their hazard exposure and are putting proactive interventions in place. Improved instrumentation and local weather forecasting are enhancing early warnings of capacity issues, enabling storm crews to respond quickly. Learning networks are helping practitioners share lessons, spare parts, and best practices.

> *"Funding remains heavily weighted toward post-disaster recovery."*

Stormwater management is supported by well-established best practices, with growing emphasis on the co-benefits of natural assets and green infrastructure alongside traditional systems. For water supply, utilities are incorporating wildfire protection in source watersheds, evaluating long-term supply security, and adapting treatment processes as temperatures rise.

These requirements and planning processes have strengthened the integration of climate considerations into the design, operation, and maintenance of infrastructure. Many coastal municipalities are adapting to sea level rise and heavy rainfall by redesigning drainage and retrofitting assets to accommodate future water levels. Pump stations are being upgraded with back-up power, reflective coverings, and elevated electrical systems, while redundant power is added at critical facilities. Updated intensity-duration-frequency (IDF) curves, based on future climate projections, are now standard in stormwater design, giving engineers clearer guidance on rainfall risks.

Finally, working groups and practitioner networks across B.C. are providing important collaboration spaces. From regional non-potable water committees to local adaptation collaboratives, these groups are enabling knowledge-sharing and coordinated action on critical issues such as greywater reuse, asset management, and resilient infrastructure design.

Despite this progress, funding remains heavily weighted toward post-disaster recovery rather than proactive upgrades. Standards are inconsistent, with federal guidance often too high-level to be directly actionable for municipalities. This leaves local governments improvising case-by-case approaches, even as demand for consistent standards grows.

Aftermath of the White Rock Lake fire in Thompson-Nicola Regional District. *iStock*

Pathways for Critical Infrastructure Resilience

Climate change is reshaping the risks facing B.C.'s built linear critical infrastructure. Recent events, such as the 2021 atmospheric river and record-breaking wildfires and heat waves, have shown how quickly cascading failures can occur. Disruptions can ripple through transportation, energy, water, ICT, and port systems, with devastating consequences for both people and the economy.

Fragmented, asset-by-asset adaptation will not be enough. Without consistent ways to measure vulnerabilities, operators cannot build a common foundation for resilience planning. Without a central body to coordinate across silos, response remains slow and investments misaligned. Without open data and shared standards, knowledge stays locked away and lessons are lost. And without public demand, political will to fund resilience lags.

What is needed now is clear direction and coordination. The Province's roadmap to resilience should consider:

- Putting service delivery front-and-centre
- Unlocking existing data and knowledge
- Improving collaboration and coordination
- Building public appetite for critical infrastructure investment

Taken together, these steps represent a roadmap for resilience. They will reduce the long-term costs of disasters, strengthen investor and public confidence, and ensure that B.C.'s infrastructure continues to deliver vital services under worsening climate conditions.

The Mission Bridge spanning the Fraser River, connecting Mission and Abbotsford. *iStock*

The pathways outlined here provide a foundation for B.C. to move from fragmented, piecemeal adaptation toward a coordinated, service-focused system that safeguards lives, communities, and the economy. Their success will depend on decisive provincial leadership. By acting now, B.C. can shift from reactive recovery to proactive resilience—protecting people, services, and prosperity under a changing climate.

1. Put service delivery front-and-centre

Key findings:

- Linear critical infrastructure service delivery and performance standards are not consistently articulated or coordinated across B.C.
- Because of limited guidance from the Government of Canada, Government of B.C., or regulating entities, it is challenging for critical infrastructure owners and operators to identify essential systems.
- Although the Emergency and Disaster Management Act (EDMA) creates important space for the Government of B.C. to regulate critical infrastructure resilience, there are presently no business continuity targets (e.g., service restoration timelines).
- In the absence of guidance, critical infrastructure owners and operators are developing their own approaches to defining service criticality. Further, owners and operators across B.C. are also using various thresholds to define acceptable levels of risk.
- There is limited information on how dependent essential services are on linear critical infrastructure. The economic impacts from outages and disruptions are not well understood either, making it difficult to analyze the costs and benefits of policy options.
- There is a lack of guidance to support equitable delivery of essential services to populations that may be disproportionately impacted by service interruptions.
- New resilience initiatives are viewed as positive but are constrained by resources and capacity. Individuals working across the infrastructure operation and emergency response domains are currently at full capacity; new roles, assessments, and regulations will require more capacity and funding.
- Prescriptive approaches may be viewed as reducing liabilities but may bar creative alternatives that ultimately allow for safe failure and service continuity during events.

Challenge statement:

You can't manage what you don't measure. Without consistent methods to assess vulnerabilities and shared standards for vital services, B.C. lacks the common ground needed for coordinated resilience planning.

Pathway to resilience:

The Government of B.C. should coordinate with regulators to adopt essential service delivery standards and performance metrics; improve shared language and methods to incorporate criticality and equity across scales; and improve understanding of B.C.'s vital services and the implications of linear critical infrastructure disruptions.

- **Improve shared language and methods of incorporating criticality and equity across scales.** Developing a common definition of "essential service" and criteria for asset criticality reduces duplication of effort across ministries and agencies. Shared methods streamline planning, reduce inefficiencies, and ensure public funds are directed to the assets and services with the greatest impact on affordability and equity.
- **Identify provincially significant essential services and the implications of linear critical infrastructure disruptions on these services.** By zeroing in on essential services like electricity, clean water, health care access, and internet, the Government of British Columbia can focus resources where disruptions would hit hardest. Bringing in community-level insights ensures these priorities reflect real needs on the ground, helping avoid costly service failures while keeping critical services reliable and affordable.
- **Set clear service delivery standards and performance metrics.** Establishing consistent benchmarks for essential service delivery creates accountability and helps government spend smarter. Clear standards cut red tape, give infrastructure owners certainty, and ensure public investments deliver affordable, reliable services rather than costly stop-gap fixes.
- **Maximize returns on capital investments through shared benefits and transparency.** By embedding resilience goals and data-sharing requirements into planned capital projects, government can stretch every dollar further, strengthening essential services while avoiding duplicate costs. Improved transparency and open data make it easier for communities, regulators, and operators to align efforts, identify co-benefits, and ensure investments deliver lasting affordability and efficiency across sectors.

2. Unlock existing data and knowledge

Key findings:

- Climate projections are readily available in B.C. and Canada. However, there is no consistent approach for which scenarios to use, or other assumptions required to assess climate risks, making it difficult for comparison across sectors and scales.[100]
- While climate data is available in a number of different formats and scales, hazard data is not widely available (e.g., detailed flood risk maps, landslide risk maps, and wildfire risk maps).
- Larger owners and operators are procuring private datasets and more complex analyses to evaluate their asset risks (e.g., private flood maps and debris flow data).
- Smaller owners and operators often do not have the capacity to project hazard exposure, assess risks, and integrate findings into asset management.
- Owners and operators generally agree that linear critical infrastructure risks should be assessed at the regional or provincial scale instead of locally or by each owner and operator.

Challenge statement:

Fragmented methods create fragmented resilience. Operators use inconsistent approaches to assess climate risks, reaching conflicting conclusions from the same evidence. Without shared standards, B.C. lacks the common ground needed for coordinated resilience planning.

Pathways to resilience:

Consistent, transparent data is the foundation of coordinated resilience. Oversight bodies should set clear guidance for data use and risk assessment, require disclosure of findings, and create shared systems that ensure every operator—large or small—has access to credible, comparable information.

- **Develop a hub for hazard information.** Owners and operators consistently flagged the need for a single, reliable place to access hazard and risk data. While climate projections exist, hazard datasets (e.g., flood, landslide, wildfire) remain fragmented and inconsistent. A provincial hub—backed by mandatory disclosure of risk assessments and standardized formats—would close these gaps, reduce duplication, and ensure all operators, regardless of size, have access to credible data for planning, data portals, and communities of practice*. Data improvements would unlock opportunities further spatial analysis and vulnerability modelling.

- **Provide guidance on risk assessment for critical infrastructure.** Beyond supplying hazard data, owners and operators need practical direction on how to use that information: what assumptions to apply, how to model cascading and compounding risks, and how to ensure results are comparable across sectors and regions. This guidance would reduce inconsistent methods, cut down on costly bespoke analyses, and give decision makers a common basis for understanding infrastructure vulnerabilities.

- **Develop guidance on hazard probability and risk tolerance across various hazards.** Clear thresholds for acceptable risk enable consistent, transparent decision making across sectors. Standardized methods for weighing costs and benefits prevent over-investment in low-likelihood hazards, ensure scarce resources are spent where they deliver the greatest resilience gains, and give the public confidence that infrastructure risks are being managed fairly and efficiently.

- **Develop data monitoring and evaluation systems.** Owners and operators often collect valuable information, but without common systems it stays siloed. Developing shared frameworks for monitoring and data exchange would make risk information more transparent, reduce duplication, and ensure that lessons learned in one sector or region benefit others.

- **Ensure local asset management consider climate risks.** Work with Asset Management B.C. and UBCM to build capacity through knowledge transfer and support to asset managers on how to incorporate climate risk into asset management programs. Over time, mandate asset management plans that consider climate change.

3. Improve collaboration and coordination

Key findings:

- Strong relationships and data sharing are key to effective and coordinated, cohesive critical infrastructure management and response.

- Owners and operators work in silos, divided by sector and geography. Most vulnerability data is privately held with barriers to transparency.

- Because operators operate with competitive mandates, simply asking them to collaborate will not be enough.

- Delivery of essential services is vulnerable due to interdependencies across linear infrastructure systems, but there are few forums or networks that enable proactive planning, coordinated emergency response, or joint after-action learning.

- This fragmented landscape is compounded by the lack of a dedicated body with authority over interconnected systems, leaving governance split across a patchwork of ministries, regulators, and external agencies.

* Two frameworks used in B.C. by critical infrastructure owners and operators include the Task Force for Climate Related Financial Disclosure (TCFD), now incorporated into IFRS Foundation reporting and the Carbon Disclosure Project. Governments and bond-issuing bodies in B.C. have the power to require risk disclosures.

Challenge statement:

Splintered systems breed splintered responses. With operators siloed, data locked away, and no central authority, coordination falls short and essential services are at risk.

Pathways to resilience:

B.C. needs an accountable body with the authority to coordinate across owners, operators, and regulators, ensuring resilience is treated as a shared mandate rather than a patchwork of siloed actions. This body would drive compliance, foster collaboration, and embed continuous learning into the province's critical infrastructure systems.

- **Establish a dedicated body to lead critical infrastructure system resilience.** B.C. requires a dedicated body with real authority—not just a coordinating forum. Like the Transportation Safety Board of Canada, the body should be impartial, independent, and equipped with investigative and oversight powers to cut through silos and drive accountability. Such a body would command trust from owners and operators, ensure compliance with risk assessment and emergency management requirements, and align investments across infrastructure systems. The result: stronger governance, faster response, and better value from every public dollar.

- **Build a critical infrastructure communities of practice.** Informal networks alone won't overcome economic competition and self-interests, but structured communities of practice can. By formalizing peer exchanges around shared challenges, such as asset management, water operations, or regional service delivery, government can create low-cost, trusted spaces where operators learn from one another, surface common risks, and identify efficiency gains. These groups don't replace oversight, but they strengthen capacity and trust, laying the groundwork for compliance with stronger resilience standards.

- **Conduct frequent cross-sectoral critical infrastructure exercises.** Regular, well-scoped exercises expose system vulnerabilities before disasters strike, strengthen relationships across sectors, and improve data-sharing protocols. By testing response systems under realistic conditions, operators can identify gaps, build trust, and refine coordination, leading to faster, more efficient, and less costly emergency response.

- **Support improved coordination for response.** Effective response depends on common assumptions and interoperable systems. The proposed oversight body should establish shared parameters, such as a single mapping coordinate system, standard operating procedures for exchanging critical infrastructure data, and protocols for identifying and tracking operator personnel in evacuation zones. Embedding these standards through an accountable body ensures consistency across operators, speeds up decision-making, and reduces costly delays during emergencies.

- **Coordinate structured after-action forums.** The proposed oversight body should be responsible for organizing cross-sector forums after major events to ensure lessons are captured, shared, and acted upon. By formalizing these debriefs, operators move beyond isolated reviews toward system-wide learning that strengthens future coordination. Embedding after-action processes within an accountable body turns short-term insights into long-term improvements in resilience and efficiency. A good example is the roundtable on wildfire in the northeast convened by BC Energy Regulator after the intense 2023 season.[87]

Whistler Olympic Plaza. *iStock*

Multi-organizational collaborative public safety during the 2010 Olympics

Critical infrastructure protection is always a multi-faceted problem because the asset "owners" are from all orders of government and private industry across many sectors. While information may be readily available on location and type of asset, criticality information is not readily available and interdependencies not well understood. The 2010 Olympic Games provides an example of government and industry organizations cooperating over a short period of time. However, over the long-term, there was limited support and incentive for continued information sharing.

The 2010 Olympic Games was the first time in British Columbia (and perhaps Canada) that asset owners and operators began to understand and plot their interdependencies and protection requirements. It was well understood that industry, policy, intelligence, and government agencies were working toward a common goal and a common outcome. Substantial hurdles were overcome in the lead up to the Olympics, including mutual trust levels between government and industry, as well as confidentiality agreements and procedures for the collection, use, collation, and deletion of information. The Olympic experience moved emergency management and critical infrastructure protection years ahead; however, without a sustained model and program of trusted information sharing between actors, B.C. has not continued this vital collaboration.

Lessons learned from the Olympic experience include the need for integrated planning between agencies and industry through which trusted relationship and mutual understanding can be facilitated. A coordinating governance body was essential to resolve issues between partners when required and multi-organizational working groups enhanced integrated planning. Co-location of staff from multiple organizations was effective, particularly when engaged in planning and deliberate exercises to test their relationships, protocols, and roles and responsibilities. Confusion over mandates, roles and responsibilities was important to clarify and relationship building was imperative to building trust and a willingness to share information. Integrated exercises were used as a precursor to planning rather than the reverse. Successful operations would not have been possible without exercises, especially those involving all partners across the full spectrum of an event from planning to recovery. An interesting learning was the advantage of seeking personnel capable of recognizing cultural differences and flexible to adapting to various decision-making and cultural regimes.

4. Build public appetite for critical infrastructure investment

Key findings:

- Though B.C. faces substantial infrastructure deficits, investment in built linear critical infrastructure is often given a lower priority than other capital investments.
- The public and elected officials rarely think about essential services, such as ICT, power, and sewer systems, and how these services contribute to community resilience. There is limited understanding of the potential duration of infrastructure outages in a major disaster.
- Threats to critical infrastructure systems—and the consequences of failures—are not well communicated to the public. As a result, people have limited understanding of how these systems will perform during emergencies and what level of service they can expect.
- The public can play a crucial role in improving the resilience and lifespan of infrastructure systems. Demand management is particularly important during peak times (e.g., heat waves, large events, dry summer days). Existing efforts to reduce demand can be expanded to ensure aging infrastructure systems last until replacement is feasible.
- Both public and private owners and operators generally respond to constituency concerns and priorities.

Challenge statement:

People rarely notice what keeps them safe—until it fails. The public focuses on today, but leaders must safeguard tomorrow—or communities will pay far more when disasters strike.

Pathways to resilience:

Increasing public and political support is critical to moving resilient infrastructure up the priority list. Owners, operators, and policy organizations should work together to raise awareness, strengthen trust, and equip both the public and elected leaders with the knowledge needed to support proactive investment.

- Enhance public awareness. By providing accessible information on the importance of critical infrastructure and the real costs of climate impacts, the public becomes better informed about risks and outage durations. This strengthens preparedness, builds trust, and increases support for long-term investments.
- Engage with elected officials to build awareness of risks. Educating municipal and provincial leaders on infrastructure risks and interdependencies ensures resilience is built into policy and planning. When elected officials understand the stakes, they are more likely to champion funding and prioritize upgrades.
- Invest in behavioural economics and risk communication research. Evidence-based communication strategies increase the effectiveness of outreach to both the public and decision-makers. This makes every dollar spent on engagement more impactful, ensuring awareness campaigns shift behaviour and build political will for investment.
- Build public knowledge of individual actions and steps. Teaching households how to reduce energy and water use during peak periods extends the life of aging systems, lowers operating costs, and improves reliability. Public participation in demand management also reduces the immediate burden on infrastructure, buying time for planned replacements.

Icefields Parkway in the Canadian Rockies. *iStock*

Conclusion

As climate change accelerates, the resilience of B.C.'s linear infrastructure systems will determine the reliability of the services people depend on every day. Progress is underway—operators are integrating climate projections, hardening assets, and improving forecasting—but these efforts remain uneven and disconnected.

The path forward is clear. B.C. must establish consistent ways to measure vulnerabilities and track performance. It must unlock data and set shared standards, so risks are understood across sectors. It must create a body with the authority to coordinate owners, operators, and regulators. And it must build public and political support to prioritize proactive investment over costly recovery.

Our findings and many recommendations have also been observed in other analyses of critical infrastructure vulnerabilities in B.C. and across Canada. The importance of governance and clear operational standards is widely documented.[77, 101] Further, in a 2022 report, Public Safety Canada reported most CI owners and operators thought criteria should be developed to identify and prioritize the most vital CI assets. There is also agreement that better coordination and knowledge sharing is needed.[2, 77, 102]

Closing these long-recognized gaps is not simple—if it were, they would have been fixed already. But leadership means stepping up to tackle the hard problems, not just the easy ones. Strengthening the resilience of B.C.'s critical infrastructure will require leaders to align systems around a shared vision of reliable, affordable, and sustainable service delivery—so British Columbians are protected not only today, but for decades to come.

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Appendix A:

Glossary of acronyms and terms

BCER: BC Energy Regulator

BCUC: British Columbia Utilities Commission

BNN: Business News Network

BNSF: Burlington Northern Santa Fe Railway

BRACE: Building Regional Adaptation Capacity and Expertise

CBC: Canadian Broadcasting Corporation

CCCS: Canadian Centre for Climate Services

CCME: Canadian Council of Ministers of the Environment

CDOT: Colorado Department of Transportation

CDRI: Coalition for Disaster Resilient Infrastructure

CER: Canada Energy Regulator

CI: Critical infrastructure

CN: Canadian National Railway

COVID-19: Coronavirus pandemic

CP: Canadian Pacific Railway

CPKC: Canadian Pacific Kansas City Railway

CSA: Canadian Standards Association

DMAF: Disaster Mitigation and Adaptation Fund

DRIF: Disaster Risk Information Framework

ECCC: Environment and Climate Change Canada

EDMA: Emergency Disaster Management Act

EMCR: Emergency Management and Climate Readiness (BC Ministry)

FIFA: Fédération Internationale de Football Association

GDP: Gross domestic product

GIS: Geographic Information Systems

ICLEI: International Council for Local Environmental Initiatives

ICT: Information and Communication Technology

IDF: Intensity-duration-frequency

LNG: Liquefied natural gas

MIABC: Municipal Insurance Association of BC

MOTT: Ministry of Transportation and Transit (BC Ministry)

NRCan: Natural Resources Canada

PCIC: Pacific Climate Impacts Consortium

PICS: Pacific Institute for Climate Solutions

PIEVC: Public Infrastructure Engineering Vulnerability Committee

SCC: Standards Council of Canada

TCFD: Task Force on Climate-related Financial Disclosures

Adaptation: The ability of built systems (e.g., critical infrastructure) to adjust to climate change (including climate variability and extremes), moderate potential damages, take advantage of opportunities or cope with the consequences.

Adaptive capacity: The ability of people, organizations, institutions, communities, and systems to use their strengths, knowledge, skills, and resources to respond, manage, or adjust to adverse conditions.

Atmospheric river: Refers to long narrow streams of high-water vapour concentrations in the atmosphere that move moisture from tropical regions towards the poles across the mid-latitudes.[38]

Cascading impact: An initial hazard triggers a sequence of disruptions to human and natural systems which result in amplified impacts.

Cascading hazard: An initial hazard triggers a secondary hazard(s) which result in amplified impacts.

Compound events: Compound events occur when multiple climate drivers or hazards happen at the same time, either in one location or across several. When combined, these hazards have greater impacts than when they occur in isolation. The effects can cascade across ecosystems, water resources, public health, energy, transportation, food systems, and interconnected societal networks—often straining disaster response.

Consequence: An adverse effect on people, communities, infrastructure, services, ecosystems, and economic, social, or cultural assets that arises from the exposure of vulnerable systems to hazardous events.

Cooling demand: Refers to energy requirements for air conditioning and cooling systems due to higher-than-average temperatures or extreme heat events.

Critical infrastructure: According to Public Safety Canada, refers to processes, systems, facilities, technologies, networks, assets, and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government.[11] Critical infrastructure can stand alone or be interconnected and interdependent within and across provinces, territories, and national borders. Disruptions of critical infrastructure could result in catastrophic loss of life, adverse economic effects, and significant harm to public confidence.[2]

Debris flow and landslides: Movement of water-saturated soil, rock, and debris along slopes, often triggered by intense rainfall, snowmelt, or post-wildfire conditions.

De-rating: Refers to reducing the operational capacity of infrastructure due to stressors (e.g., climate impacts like heat or wildfire).

Disaster: Significant and widespread disruption to a community or society due to hazardous events that cause human, material, economic and environmental consequences, losses and requires immediate emergency response.

Emergency management: The process of preparing for, responding to, and recovering from disasters. In British Columbia, emergency management is guided by four pillars: Mitigation, Preparation, Response and Recovery.

Energy transition: Means using energy more efficiently, expanding the use of clean and renewable forms of energy, and relying less on fossil fuels.

Essential services: Activities considered critical to preserving life, health, basic societal functioning, and economic well-being. Canada's National Strategy for Critical Infrastructure defines essential services as those critical to the health, safety, security, or economic well-being of Canadians and the effective functioning of government.[11]

Exceedance probabilities: Describe the likelihood of a specific event—such as a rainfall amount—being equaled or exceeded in a given year. They are often expressed through return periods, which indicate how frequently an event of a particular magnitude is statistically expected to occur.

Exposure: The presence of something of value (e.g., communities, infrastructure, services, ecosystems, and economic, social, or cultural assets) in places that could be affected by a hazard.

Freshet: A seasonal increase in river flow caused by snowmelt and heavy rain, usually experienced in the spring or summer.

Freeze/thaw cycles: When the air temperature fluctuates between freezing and non-freezing temperatures. Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period. Freeze/thaw cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting, and re-freezing of water can over time cause significant damage to roadways, sidewalks, and other outdoor structures. Potholes that form during the spring or during mid-winter melts are good examples of the damage caused by this process.

Gradual-onset impacts: Pervasive and slow-onset climate change impacts. These impacts can change landscapes over time, redrawing coastlines, impacting livelihoods and cultural identities.

Hazard: A natural or human-caused event that may result in adverse consequences to communities, infrastructure, services, ecosystems, and economic, social, or cultural assets that are exposed and vulnerable. Climate-related hazards are hazards influenced by climate change (e.g., wildfire, flood, extreme weather, and drought) that may become more frequent and severe over time.

Impact: An effect on people, communities, infrastructure, services, ecosystems, and economic, social, or cultural assets arising from realized risks. Impacts can be adverse or beneficial.

Infrastructure gap: Refers to the disparity between the current state of infrastructure and the level of infrastructure required to meet present and future needs effectively. It highlights an urgent need for investment to maintain the safe functioning of infrastructure.

Interdependencies: Refers to the interconnected relationships between different critical infrastructure systems, where the function or failure of one system can directly or indirectly impact others

Lateral Migrations (river): Shifting of river course across its floodplain. Movement usually occurs horizontally (laterally).

Likelihood: The probability or chance of a hazard or specific impact occurring

Linear critical infrastructure: Critical infrastructure (see above) that spans large areas or connects multiple points, such as powerlines

Redundancy: Refers to the inclusion of backup systems, duplicate components, or alternative pathways to ensure continued operation in case of failure or disruption. It enhances resilience by providing fail-safe mechanisms, such as backup power generators for hospitals, multiple internet service providers for network reliability, or redundant water supply lines for emergency situations.

Resilience: The ability for human and natural systems to cope with climate change in ways that maintain their essential function, identity, and structure. Climate resilience is positive when it promotes adaptation, learning, and transformation. Climate resilience may look different across distinct communities and for specific hazards.

Risk: The combination of the likelihood of an event occurring and its negative consequences. Risk can be expressed as a function where risk = likelihood × consequence. In this case, likelihood refers to the probability of a projected impact occurring, and consequence refers to the known or estimated outcomes of a particular climate change impact.

Risk assessment: The practice of identifying and prioritizing risks to a system by considering how likely an event is (likelihood) and the consequences of the event

Risk management: The process of identifying, assessing, and reducing risks to a human system.

Sensitivity: Refers to the degree to which critical infrastructure will be affected when it is exposed to a climate impact.

Vulnerability: The degree to which something of value (e.g., communities, infrastructure, services, ecosystems, and economic, social, or cultural assets) is susceptible to experiencing harm when exposed to a hazard

Appendix B:

A brief summary of the anticipated climate change trends in B.C.

Extreme heat and temperature shifts

Summers in B.C. are projected to get hotter and drier over time. Global climate models project rising temperatures across all regions of B.C. in all seasons through the 21st century[104]. By mid-century, what is now a one-in-20-year extreme warm temperature event will occur every five years, while extreme cold events will decrease.[3] Areas such as the southern and Central Interior, low-lying valleys, and urban regions (due to the urban heat island effect) will be particularly affected by heatwaves.[104] The average hottest summer days will be about 3°C to 6°C hotter by mid-century, depending on geography.[105] In addition, nighttime temperatures will stay above 20°C more often, resulting in sustained periods without substantial temperature drops overnight.[106] The number of days with temperatures above 25°C will likely more than double in the South Coast, West Coast, Omineca, and northeast regions.[107] Days above 30°C may triple in the Thompson-Okanagan, Boundary, and Cariboo regions.

Wildfire and smoke

Recent wildfire seasons—2021 through 2023 in particular—saw historic levels of wildfire activity. Wildfires are becoming larger, hotter, and more frequent with substantial impacts on air quality during the summer months. Hotter, drier summers in B.C. are one of the drivers of increased wildfire and smoke events.[108] Each year, B.C. experiences approximately 1,600 wildfires on average. With increased storms and longer periods with dry fuel, a higher rate of ignition and increase in wildfire activity is likely. Research predicts that western Canada, where the fire potential is already high, will see a 50 per cent increase this century in the number of dry, windy days that let fires start and spread.[109] The annual area burned is projected to increase by up to four per cent by 2050, exceeding nine million hectares across Canada.

Inland and coastal flooding (fluvial, coastal, and pluvial)

The West Coast receives 20 to 25 per cent of its annual precipitation in heavy-rainfall events resulting from atmospheric rivers.[110] An analysis of the 2021 atmospheric river event in southwestern British Columbia found that the probability of such extreme streamflow events has increased over time and will continue to do so into the future. The 2019 B.C. Climate Risk Assessment projections show that today's moderate floods (51 to 100-year events) can be expected to occur once every 11 to 50 years by 2050.[111] The same assessment indicated that today's 500-year Fraser River flood may become five times more likely by 2050. Riverine flood risk is rising due to earlier snowmelt, more rapid runoff, and increased rainfall, particularly during the spring.

Sea level rise is contributing to an increase in coastal flooding over time.[111] When winter storm patterns that cause storm surge occur simultaneous to annual high tides such as king tides, coastal flooding can occur.

Across the province, the single wettest days are becoming wetter as are the consecutive five-day wettest periods. Atmospheric rivers are projected to increase substantially in frequency and intensity, with a doubling of days with these conditions by the 2080s.[112] More intense and frequent rainfall is leading to increased pluvial flooding. Pluvial flooding depends on the amount and timing of rainfall, soil conditions (whether the ground is dry, wet, absorbent, or frozen), and the condition of natural and engineered drainage systems.

Drought

In British Columbia, rising temperatures and changes in precipitation patterns are leading to increased risk of drought and water supply shortages. Prolonged and more intense dry periods are anticipated, especially in Southern B.C.[112] Snowpack, which serves as a natural reservoir for the dry summer months in snow dominated watersheds, is decreasing and melting earlier in the year, triggering lower streamflow in summer. Warmer temperatures will increase evaporation and transpiration and contribute to soil water loss. This may contribute to greater landslide risk, and greater incidence of falling trees. Groundwater recharge will likely be affected as well in areas where soils cannot take in water at a normal pace.

Debris flow and landslide

Diverse phenomenon influence slope stability, including changes in precipitation and temperature. There is high confidence that changes in heavy precipitation will affect the occurrence of landslides; areas that expect an increase in the frequency and intensity of rainstorms (like B.C.) will experience an increase in shallow landslides, debris flows, and rock falls.[113] The B.C .Ministry of Forests anticipates an increased risk of landslides and debris flows in areas with unstable slopes due to the increase of extreme rainfall and snowmelt events.[114, 115] Steep slopes that have been affected by wildfire have fewer roots providing stability and may have hydrophobic soils that increase runoff, both leading to increased risk of landslide.[116]

Extreme weather (tornado, wind, heavy snowfall, ice storm)

The intensity and frequency of storms, including heavy precipitation events such as atmospheric rivers, are expected to increase.[31] These storms are already affecting critical infrastructure, for instance, by causing power outages, blocked roads, cancellation, or disruptions of transportation due to high winds, and more. The impacts of storms are expected to grow in both the fall and spring seasons.[54] For example, projections suggest that precipitation associated with storms could increase by 40 to 60 per cent in southern coastal regions and by up to 150 per cent in the northern areas.[104] The number of storm events responded to by BC Hydro has tripled in the past five years, reflecting the increasing intensity of these extreme weather events.[117]

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We acknowledge and respect the lək̓ʷəŋən Peoples on whose traditional territory the University of Victoria stands and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.