ANALYSI

Winter Weather Risk for High-Speed Rail

Snowfall, Freezing Rain, and the Infrastructure - considerations necessary for informed decision-making in Eastern Ontario

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PURPOSE

We presents a comparative analysis of winter weather conditions along the two principal alignment options under consideration for the Alto corridor between Peterborough and Ottawa. It is prepared for municipal elected officials, regional planning staff, and citizen stakeholders who require a clear account of climate risk differences between the routes — particularly as they relate to long-term infrastructure costs, operational reliability, and service resilience over the expected century-long life of the railway.

The analysis draws on Environment Canada climate normals (1981–2010), peer-reviewed research on freezing rain occurrence in eastern Ontario, and published engineering guidance on winter weather impacts on high-speed rail infrastructure.

KEY FINDINGS AT A GLANCE

Climate Metric	Southern Route	Northern Route
Annual snowfall	Peterborough 138 cm; Belleville 141 cm, Kingston 159 cm, Brockville 175 cm [1]	Lanark 211 cm, Sharbot Lake 197 cm, Bancroft 175 cm, Renfrew 195 cm [1]
Snow days/year	34–52 days (Peterborough to Kingston stations) [1]	50–70+ days (Lanark to Renfrew stations) [1]
Freezing rain hours/year	22–37 hrs/yr at Kingston. The St. Lawrence Valley freezing rain zone extends across the full southern corridor [2]	Lower: consistently cold baseline means precipitation falls as snow, not ice [2]
Dominant precipitation type	Mixed: oscillates around 0°C	Predominantly snow (colder baseline)
Ice storm exposure	High: the Kingston–Brockville–Cornwall segment of the St. Lawrence Valley is Canada's most active ice storm zone [2]	Lower: Shield terrain colder; precipitation falls as snow [2]
Projected trend (to 2050)	+25–34% increase in freezing rain weather types across the St. Lawrence Valley and eastern Ontario by 2050 [3]	Smaller projected increases in freezing rain frequency [3]

Climate Metric	Southern Route	Northern Route
Freeze-thaw cycles/year	35–50 typical oscillation events; 131 cycles measured on a 48-km VIA Rail track section between Kingston and Brockville in a single mild winter [4]	Fewer oscillation events; colder Shield baseline means subgrade stabilises for bulk of winter [1,2]
Subgrade frost risk	High: Frontenac Arch creates abrupt transitions between non-heaving Precambrian granite and frost-susceptible Champlain Sea clay [4]	Lower: more uniform sedimentary and Shield subgrade; fewer stiffness transition zones

[1] ECCC Climate Normals 1981–2010; Current Results Publishing. [2] Auld & Klaassen (2004), Severe Ice Storm Risks in Ontario, ICLR. Data: Environment Canada 1953–2001. [3] Thériault et al. (2023), Changes in Freezing Rain Occurrence over Eastern Canada, PMC. [4] Roghani (2021), Quantifying the effect of freeze-thaw cycles on track degradation, Transportation Geotechnics / NRC Canada.

THE CRITICAL DISTINCTION: SNOW VS. ICE

Both corridors under study experience significant winter precipitation. The decisive difference for a high-speed railway is not the quantity of precipitation but its form.

Heavy snowfall, as experienced in the northern corridor, is a manageable railway hazard. Track heating, snowploughs, and blower systems address it routinely. High-speed operations in Japan and Scandinavia experience far heavier snowfall than either route would face.

Freezing rain is a categorically different problem. When supercooled rain contacts surfaces at or below 0°C, it coats overhead catenary wire, pantographs (the current-collecting arms on HSR trains), signalling equipment, and switch gear with a layer of ice that cannot be cleared by a plough. Ice on catenary causes arcing and power interruption. Ice on pantographs causes contact loss and equipment damage. Ice on switch machines causes misalignment failures. These are not inconveniences — they are service-halting events.

> *"Freezing rain and ice pellets are usually formed when there is a melting layer above a sub-freezing layer. The accumulation of ice on surfaces can cause major power outages, ground and air transport disruptions, and injury. These types of events are very common in Eastern Canada and in particular within the St. Lawrence River Valley."*
>
> PMC / Changes in Freezing Rain Occurrence over Eastern Canada, 2023

The southern corridor close to the St. Lawrence Valley — the region that makes up Canada's most active freezing rain zone. Environment Canada data from the Kingston monitoring station recorded 22–37 hours of freezing rain annually — the highest of any Ontario station studied (Auld & Klaassen 2004, ICLR). The 1998 ice storm, the 2013 storm, the April 2023 event, and the December 2025 event all struck this corridor with peak intensity. Climate projections indicate a 25–34% increase in freezing rain weather types across eastern Ontario by 2050 (Thériault et al. 2023).

FIVE FINDINGS FOR DECISION-MAKERS

01 The southern corridor passes through Canada’s highest-frequency freezing rain zone

The eastern Ontario segment of Alto’s southern alignment passes near the St. Lawrence Valley — the most documented ice storm geography in the province. Environment Canada data (1953–2001) recorded 22–37 freezing rain hours per year at the Kingston station — among the highest of all Ontario stations (Auld & Klaassen 2004, ICLR). This region is characterised by temperatures that oscillate around 0°C during winter precipitation events, creating conditions ideal for freezing rain rather than snow.

02 The northern corridor crosses colder Shield terrain with more predictable winter precipitation

Alto’s northern option crosses the Canadian Shield through counties such as Lanark, Frontenac, and Hastings. Baseline temperatures in this terrain are colder on average: when precipitation arrives during winter systems, it is consistently below freezing and falls as snow, not supercooled rain. Snow is a managed railway hazard; ice is a service-stopping one.

03 Freezing rain imposes specific HSR infrastructure costs that snowfall does not

High-speed electrified rail requires catenary de-icing systems, heated pantographs, ice-protected switch machines, and hardened signalling in freezing rain zones. These systems add capital cost and require maintenance over the life of the asset. The southern route's exposure to 22–37 hours of freezing rain annually means these systems will be activated frequently. No published Alto cost estimate has accounted for this differential.

04 Climate projections worsen the southern route's freezing rain exposure

ECCC climate modelling projects a 25–34% increase in freezing rain weather patterns across eastern Ontario by 2050, with greater increases in eastern and northern Ontario than in southern Ontario. A railway with a design life of 80–100 years will operate well into a period when freezing rain events in the southern corridor are more frequent. The projected change strengthens, not weakens, the case for taking this risk seriously at the planning stage.

05 Winter weather analysis for the two corridors has not been disclosed to the public

Alto’s publicly available consultation materials contain no comparative winter weather analysis, no account of freezing rain risk to catenary infrastructure, and no disclosure of whether engineering assessments addressing this have been conducted. Decision-makers and citizens are being asked to evaluate route options without the climate risk data necessary to do so.

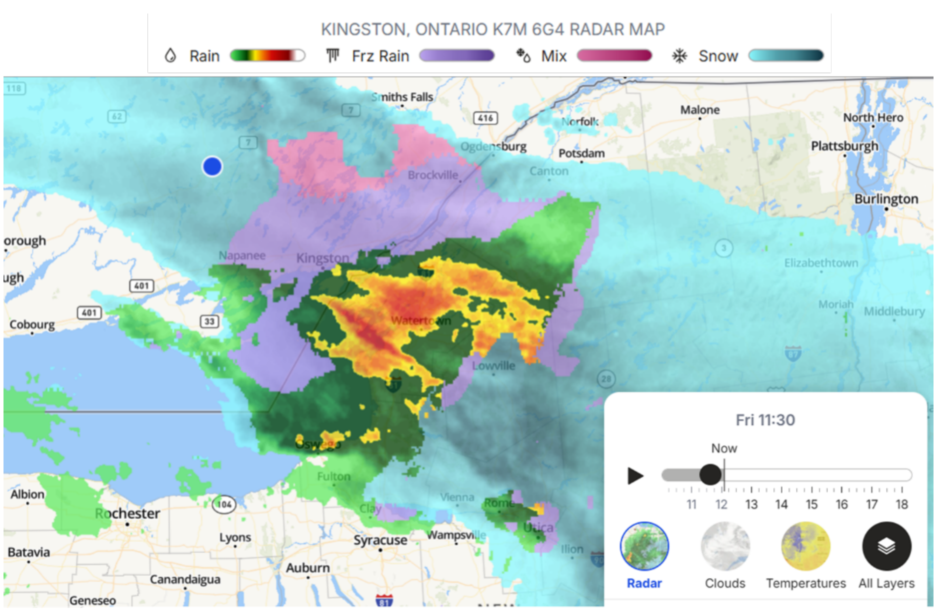
06 Freeze-thaw cycling and subgrade geology create a second, independent maintenance cost asymmetry

The southern corridor's mild, transitional winters produce more frequent freeze-thaw cycles than the consistently colder Shield terrain to the north. A National Research Council Canada field study of 48 km of VIA Rail track in eastern Ontario (Roghani, 2021) measured this directly: a warmer winter produced 131 air freeze-thaw cycles and only 0.5 m of frost penetration — yet track profile roughness was 46–55% higher the following spring than after the colder winter, and alignment roughness was 66–86% higher. Near culverts and drainage structures, roughness increased by over 120%. The mechanism is counterintuitive: shallower, repeated frost cycles produce larger differential heave at transition points than a single deep freeze. Any route chosen through the southern corridor must additionally cross the Frontenac Arch — a ridge of exposed Precambrian granite where shallow, variable overburden alternates abruptly with deep frost-susceptible Champlain Sea clays. These transitions multiply differential deformation across the full alignment. Alto has disclosed no geotechnical assessment of this subgrade or its implications for track form selection.

QUESTIONS DECISION-MAKERS SHOULD PUT TO ALTO

- Has Alto commissioned a comparative freezing rain risk assessment for the eastern Ontario segment of possible southern routes? If so, what did it find and why has it not been disclosed?
- What catenary de-icing and pantograph heating specifications are being used for route costing? Are these applied equally to both route options?
- How are projected climate changes — specifically the projected 25–34% increase in eastern Ontario freezing rain frequency — incorporated into long-term maintenance cost modelling?
- What is Alto's planned service reliability target under freezing rain conditions, and what infrastructure investment underwrites that commitment on the southern route?
- Will Alto commission and publicly release a full comparative winter weather cost analysis before the consultation period closes?
- Has Alto commissioned a geotechnical assessment of the Frontenac Arch subgrade and the freeze-thaw transition zone conditions a southern alignment would encounter? What are the implications for track form selection and frost protection layer design?
- National Research Council Canada's field study of eastern Ontario track found that a mild winter with 131 freeze-thaw cycles produced 46–86% worse track geometry than a cold winter with 101 cycles. What is Alto's maintenance cost model for this differential on a dedicated high-speed corridor?

20th Feb 2026: Significant freezing rain event - 6mm in Sydenham Ontario.



This Is Not an Argument Against Improved Rail Service

Improved rail service (High Speed or High Frequency on dedicated tracks) between Toronto and Ottawa is a legitimate and important infrastructure goal. This analysis argues only that the route decision must be made with complete information — including a rigorous, publicly disclosed comparison of winter weather risk and its implications for capital cost, operational reliability, and long-term maintenance. Decisions made without that analysis will be more expensive and less reliable than they need to be.

SOURCES

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