VÉLO TUNNEL QUÉBEC · PASSIVE SAFETY

Phosphorescent Emergency Lighting

Technical and financial analysis of a photoluminescent evacuation marking system over 150 km

Prepared by Philippe Leblond — Vélo Tunnel Québec — June 2026

Total-failure mode: only the lines glow. The marking shows the direction of evacuation and the distance to the nearest exit.

~45,000 m²	~C$7.7M	C$0	~90 min
surface to mark	initial investment	electricity cost	code benchmark

In brief. The phosphorescence proposed for the Vélo Tunnel Québec network is not meant to light the tunnels, but to provide a last-resort evacuation aid in the event of a simultaneous failure of the Hydro-Québec grid, the backup generator and the emergency lighting. Charged continuously by the LEDs, the marking then releases its stored light to guide users to the exit — with no electricity at all. A proven, standardised technology, and one that is in fact mandatory in comparable buildings.

1. Summary

The phosphorescence is not intended to light the tunnels. It is a last-resort evacuation safety net, triggered only if the Hydro-Québec grid, the backup generator **and** the emergency lighting all fail at the same time. Charged continuously by the LED lighting during normal operation, the photoluminescent marking releases that light the moment all power is lost, guiding users to the nearest exit without any energy source whatsoever.

- **Function**: a passive evacuation aid, not primary lighting.
- **Duration**: a bright phase of roughly 1 hour, in line with the 90-minute benchmark of safety codes.
- **Energy**: none — passive recharge from the LEDs already installed.
- **Estimated initial investment**: about C$7.7M (range C$5–12M), already included in the network's C$180M lighting budget line.
- **Environment**: the tunnel removes the degradation drivers seen in road trials (UV, rain, heat, heavy traffic), giving superior durability.

2. Role of the system

In a total blackout, the right performance metric is not "how many lumens to ride fast," but "can a user, in the dark, find the path and the nearest exit." Photoluminescent marking is the recognised solution for that precise goal, precisely because it needs no power and no active maintenance: it works because everything else has failed.

> **Guidance, not a floodlight.** You see the lines, not the whole floor. That is enough to walk or ride slowly to an exit safely — it is not designed for riding fast while lighting every detail of the surface. That is exactly the role of evacuation lighting.

3. The physics: why the glow lasts

It is the same phenomenon as the glow-in-the-dark stars in a child's bedroom. In complete darkness the eye adapts: after twenty to thirty minutes the retina becomes thousands of times more sensitive, and the yellow-green of phosphorescence falls exactly on the colour to which night vision is most responsive. A glow that seems "weak" then becomes perfectly readable, and stays so all night — bright at first, then softer, just as ceiling stars fade towards morning without ever going out.

The pigments used (strontium aluminate doped with europium and dysprosium) store light and release it over 6 to 12 hours, along a gradual decay curve. In the tunnel the cycle is simple: during normal operation the LEDs are on, the marking is hidden by the light but recharges continuously; in a total failure the lamps go out, the eye adapts, and the lines charged all day take over.

4. Standards and precedents

Photoluminescent egress path marking is a recognised safety technology, and indeed mandatory in comparable buildings. After the September 11, 2001 attacks — where this type of marking helped evacuate the

World Trade Center towers — New York adopted **Local Law 26**, requiring photoluminescent marking in all office high-rise stairwells. The principle is now written into the **International Building Code**, the **International Fire Code** and **NFPA 101 (Life Safety Code)**, governed by dedicated standards — **ISO 17398**, **ASTM E2072** and **UL 1994**. The same passive net equips high-rise stairwells, passenger ships and airliners.

> **The code benchmark: 90 minutes.** These passive devices must remain visible for about 90 minutes after power loss. The "about 1 hour" target adopted here is in the same range — deliberately conservative, as safety requires.

5. Field experience

Phosphorescence is far from experimental. In Australia, Transport for New South Wales installed photoluminescent marking ("Glow Roads") on the Princes Highway, on the Bulli Pass descent, a hairpin bend known to be dangerous. After a six-month trial (December 2024 to July 2025) the agency measured a 67% drop in night-time near-collisions, and 83% of drivers reported greater peace of mind. For cycle paths, the **LuminoKrom** product (Eiffage Route, France), deployed since 2018, is specifically designed for unlit routes and stays luminous for around ten hours.

One counter-example deserves to be stated transparently: in Malaysia, a road trial was abandoned, with the paint costing about 20 times more than conventional marking and degrading in under 18 months in the tropical climate. But the causes of that failure — intense UV, heat, monsoon humidity and heavy-truck traffic — are precisely **absent from a Québec bike tunnel**: no sun or UV, no rain, a cool and stable temperature, and bicycle traffic that barely wears the surface. The tunnel turns the technology's main weakness into a strength.

6. Marking design

Two principles guide the layout. First, directional information comes first: in an emergency what matters is "which way, and how many metres to the exit" — hence the arrows and the markers showing the distance to the next exit. Second, accounting for smoke: an underground incident often involves fire. Because a phosphorescent marking is less intense than active lighting, a low band along the walls stays visible longer than lines at the centre of the roadway alone when smoke rises. The marking thus complements the smoke locks and evacuation niches already planned.

7. Construction costs over 150 km

The chosen marking comprises two edge lines, a centre line, arrows, pictograms and "exit in X m" markers. This represents about 0.3 m^2 of painted surface per linear metre, or close to 45,000 m^2 across the network. With two coats (about 400 g/m^2), some 18,000 kg of photoluminescent paint is required. The installed cost observed on the market ranges from C$80 to C$230/m^2; the central estimate uses about C$150/$m^2$.

Item	Detail	Amount
Surface preparation	Cleaning + reflective white primer — 45,000 m^2	C$0.7M

Item	Detail	Amount
Photoluminescent paint	Strontium aluminate, 2 coats (~400 g/m^2), ~18,000 kg	C$3.2M
Clear protective topcoat	Anti-wear varnish over 45,000 m^2	C$0.9M
Application	Labour, equipment, underground logistics — 45,000 m^2	C$1.6M
Directional signage	Arrows, pictograms, "exit in X m" markers	C$0.3M
Subtotal		**C$6.7M**
Contingency (~15%)		C$1.0M
Total — initial investment		**~C$7.7M**

Planning range: C$5–12M depending on marking density and the unit cost used (C$80–230/m^2 installed). Planning-level estimates, not a construction tender.

8. Operating costs over 150 km

Operation is remarkably light. The marking consumes no electricity: it recharges passively from the LEDs already counted in the budget. What remains is periodic photometric inspection with localised touch-ups, and a reapplication provision. Given the benign tunnel environment and bicycle traffic, a full reapplication is estimated to be needed only about every twelve years; the provision below is amortised on that basis.

Item	Annual cost
Electricity (recharge from existing LEDs)	C$0
Photometric inspection + localised touch-ups	~C$0.1M
Reapplication provision (amortised over ~12 yrs)	~C$0.5M
Total — annual operation (amortised)	**~C$0.6M**

Over a 30-year horizon, the total cost of ownership (construction plus amortised operation) is around C$25M. Against the capital budget of the entire network, that is well under 1% — and the "emergency lighting" share is already included in the C$180M lighting line. The electricity item, for its part, remains nil.

9. Conclusion

Photoluminescent evacuation marking is realistic, standardised and inexpensive for the Vélo Tunnel Québec network. It applies to a new context a safety principle already proven and mandatory in high-rises, ships and aircraft; it benefits from an ideal tunnel environment for durability; and its cost, on the order of C$7.7M, fits within the envelope already planned. It does not replace primary lighting: it guarantees that, in a total failure, everyone can reach an exit safely.

Key sources

- NFPA 101 (Life Safety Code), International Building Code and International Fire Code — egress path marking.
- Photoluminescent Safety Association — history and codes (including New York City Local Law 26 after September 11, 2001).
- Standards ISO 17398, ASTM E2072 and UL 1994 — classification and performance of photoluminescent markings.
- Transport for New South Wales — "Glow Roads" trial (Bulli Pass, Princes Highway).
- LuminoKrom / Eiffage Route — photoluminescent paint for cycle paths.
- Reporting and studies on the Malaysian trial (cost and durability in a tropical climate).