MEMO

Appendix H.4.C.5

To: Garry Hunter, M.A.Sc., P.Eng.

From: Hunter Folkes
Scott MacPhee, B.A.Sc., P.Eng.
Hunter and Associates

Date: May 19, 2026

File No.: 22-402

Subject: **Georgian Bay (Ontario) Pumped Storage – Open AI Query on Seismicity and Cyclical Reservoir Filling Effects on Pumped Storage Infrastructure Using Google Gemini 3 AI**

1. How will local earthquakes similar to the Oct 20, 2005 4.3 Magnitude Earthquake in Georgian Bay off of Meaford, seismicity, Niagara Escarpment Geological Formations, including Manitoulin, Queenston, Georgian Bay, Blue Mountain, Rouge River, Collingwood and Cobourg Formations, and cyclical reservoir filling with daily cyclical flow of 500 m^3/s affect the Pumped Storage Infrastructure at Meaford Department of National Defence Base?

The proposed 1,000 MW Ontario Pumped Storage Project at the 4th Canadian Division Training Centre (Meaford DND Base) involves constructing an upper reservoir atop the Niagara Escarpment and connecting it to Georgian Bay via massive underground tunnels.

Evaluating how local seismicity, the specific geological stratigraphy, and daily cyclical water movement (500 m^3/s flow, cycling up to 23 million cubic meters of water) interact requires examining several geotechnical and structural engineering factors.

---

1. Natural Seismicity & the 2005 Georgian Bay Earthquake

The October 20, 2005, magnitude 4.3 earthquake centered in Georgian Bay near Meaford is a prime example of the region's background seismicity. Western Ontario sits within the stable interior of the North American plate, but it experiences intraplate earthquakes driven by regional tectonic stresses and post-glacial rebound.

- **Ground Shaking Impacts:** A magnitude 4.3 earthquake produces light-to-moderate shaking. Modern infrastructure—especially high-consequence energy assets like a pumped storage dam—is seismically designed to withstand significantly higher peak ground accelerations (PGA) than what was generated in 2005.

2285 DUNWIN DRIVE, UNIT 18, MISSISSAUGA, ON CANADA L5L 3S3 TEL: (905) 607-4120 FAX: (905) 607-1132

- **Structural Resilience:** The main threat to the upper reservoir's 20-meter-high embankment dam is not structural collapse from a 4.3 event, but rather the potential for minor settling, cracking, or piping (internal erosion) within the dam core if a larger, low-probability event occurs.

---

2. Niagara Escarpment Geological Formations

The stratigraphy of the Niagara Escarpment at Meaford plays a critical role in how seismic waves propagate and how the infrastructure handles daily water pressures. The formations relevant to this site stack sequentially from top to bottom:

Formation	Lithology (Rock Type)	Engineering & Seismic Implications
Manitoulin	Dolostone	Strong, competent caprock. Provides a solid foundation for surface structures but is brittle and susceptible to jointing/fracturing under stress.
Queenston	Mudstone / Shale	Red shale that weathers rapidly when exposed to air and water. It has low shear strength and behaves plastically, acting as a potential plane for slumping or landslide acceleration during a seismic event.
Georgian Bay	Shale with limestone interbeds	Highly variable strength. The shale layers can act as a barrier to fluid flow, but the interbeds can concentrate stress.
Blue Mountain	Non-calcareous Shale	Weak, fissile shale. Prone to squeezing and swelling when tunneled through, requiring extensive structural lining.
Rouge River / Collingwood	Bituminous/Calcareous Shale	Organic-rich transitions. Moderate strength, but structurally complex for deep tunneling.
Cobourg	Limestone	Highly competent, dense crystalline limestone. Excellent for hosting deep underground powerhouse caverns and tunnels, providing high seismic wave velocity and minimal deformation.

The Geotechnical Risk: Differential Competency

The primary risk stems from tunneling through the **contacts between highly rigid layers** (Manitoulin Dolostone, Cobourg Limestone) and **weak, compliant layers** (Queenston and Blue Mountain Shales).

During a seismic event, these formations vibrate at different frequencies and amplitudes. This differential movement can cause high shear stress along the formation boundaries, threatening the integrity of the concrete-lined pressure shafts and tunnels connecting the upper reservoir to the bay.

3. Reservoir-Induced Seismicity (RIS) & Cyclical Loading

The project intends to shift roughly 23 million cubic meters (23×10^6 m^3) of water daily at a high flow rate of 500 m^3/s. This rapid, daily cyclical filling and emptying introduces two main mechanical phenomena:

Hydroelastic Cyclical Loading

Filling the reservoir increases the vertical stress (load) on the underlying shale and dolostone formations, while emptying it relieves that stress. This "breathing" effect applies continuous cyclical fatigue to the rock mass. Over decades, this fatigue can propagate existing fractures within brittle formations like the Manitoulin dolostone.

Pore Pressure Alteration (The Primary RIS Trigger)

As water depth changes rapidly, the hydraulic head forces water into the joints and bedding planes of the escarpment.

- **Mechanics:** According to the effective stress law:

$$\sigma' = \sigma - u$$

Where σ' is effective stress, σ is total stress, and u is pore water pressure. As water is pushed into the fractures, u increases, which directly decreases the effective normal stress holding fractures and minor fault lines closed.

- **The Result:** If the Queenston or Georgian Bay shales contain micro-faults, the reduction in friction caused by high pore pressures—coupled with the rapid 500 m^3/s flow cycles—can trigger **Reservoir-Induced Seismicity (RIS)**. While RIS events are typically minor (Magnitudes < 3.0), they increase the frequency of local micro-earthquakes.

Summary of Infrastructure Risks & Mitigation

1. **Slope Stability & Landslides:** The combination of a 4.3+ magnitude earthquake and high pore pressures from the reservoir could trigger a localized slope failure or slumping along the Escarpment face, particularly where the weak Queenston Shale is exposed.
2. **Tunnel Shear:** The deep pressure shafts passing through alternating shale and limestone formations are vulnerable to shearing at structural interfaces during a seismic tremor. Heavy steel and concrete composite linings are mandatory to mitigate this.
3. **Dam Piping:** The upper reservoir's perimeter embankment must be engineered with robust internal filters and low-permeability cores (or synthetic liners) to prevent the daily 500 m^3/s dynamic pressure cycles from eroding the foundation rock, especially if a minor tremor creates new micro-fissures.