Natural Resources Canada's Technical Review Hydrogeology and Groundwater

Prepared for the Marathon Palladium Project

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Statement of Expert Qualifications

Research scientist with the ***Geological Survey of Canada*** since 2019

- Specializing in hydrogeological characterization and numerical modelling including groundwater and fully integrated groundwater- surface water models from site to regional scales.
- NRCan's representative on UNESCO's Intergovernmental Hydrological Programme National Committee

Consulting Hydrogeologist from 2011 to 2019

- Provided hydrogeological and modelling support for mining and other resource development projects

Scientific Disseminations

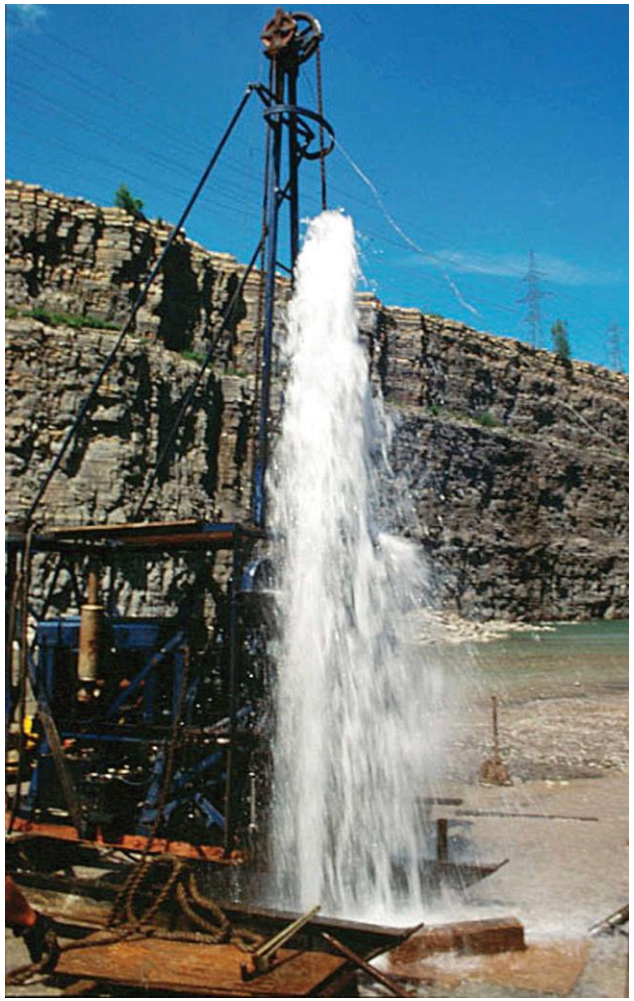
- Completed more than 30 technical groundwater modelling reports
- Published 3 first author peer-reviewed articles
- Presented research at more than 5 conferences

Role of NRCan in Hydrogeology and Groundwater

- The Geological Survey of Canada conducts research to create tools to understand, forecast changes, and protect groundwater as a freshwater resource.

- Responsibility for managing Canada's groundwater resources is shared across several federal departments, provinces and territories.

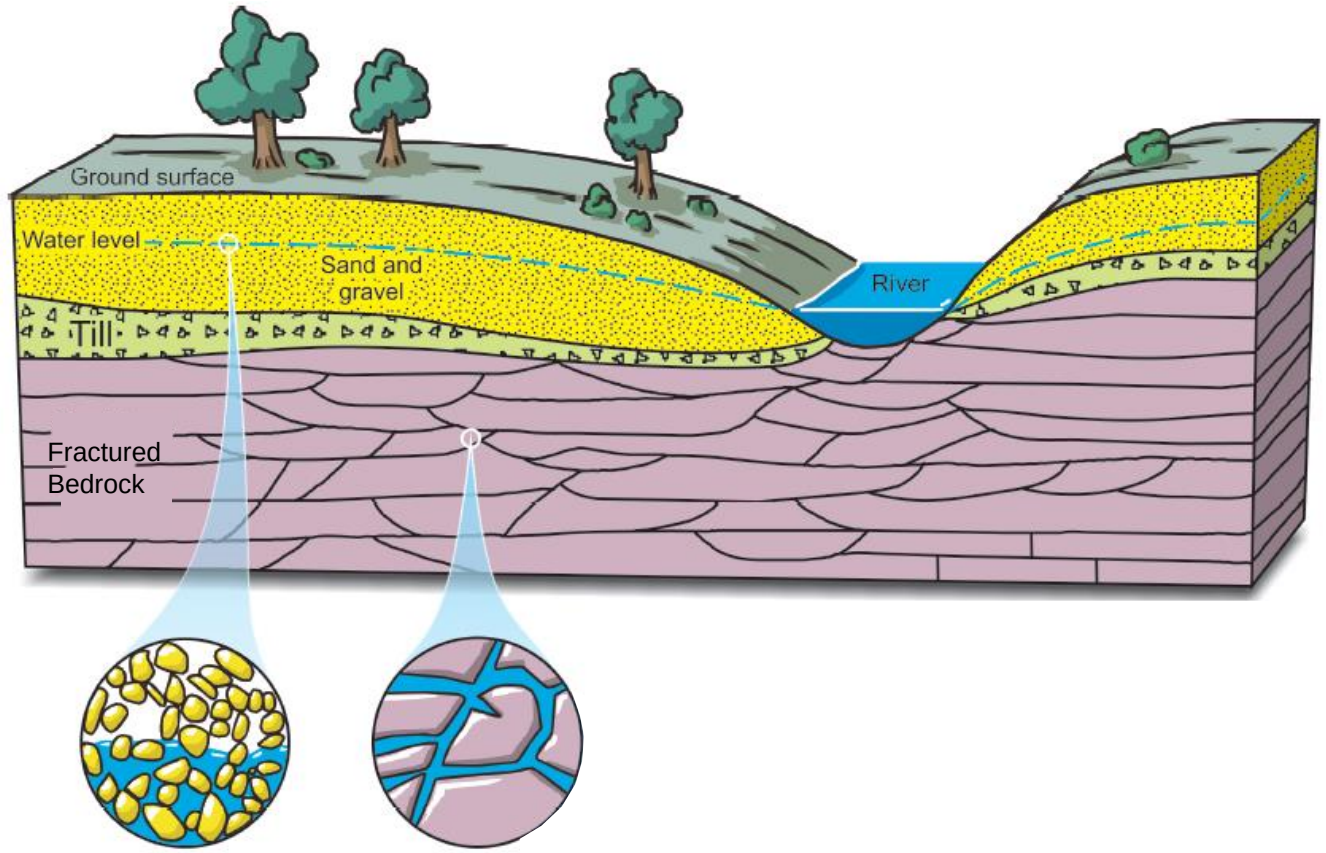
- NRCan's role in the review process is to provide technical expertise in the assessment of changes to groundwater quantity and flow, and groundwater-surface water interaction



Flowing Groundwater Well in Québec
From: Canada's Groundwater Resources (Rivera, 2014)

Groundwater as a resource and pathway

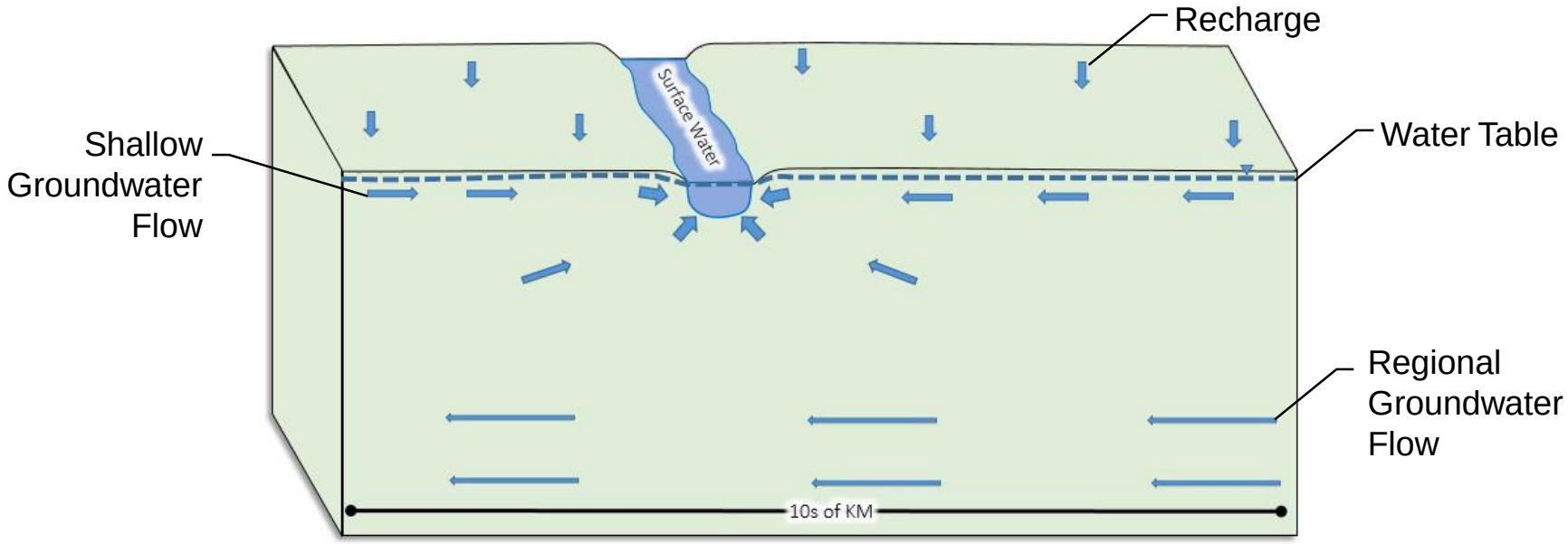
- Groundwater is the water contained in the porous spaces beneath the surface of the earth, within soil, sediment and rocks.
- Groundwater provides drinking water to about one third of all Canadians and up to 80% of the rural population.
- Groundwater sustains flow to surface water features during dry periods and provides temperature regulation for fish habitat.
- Groundwater can potentially transport nutrients and contaminates over long timescales



Cross-section schematic illustrating groundwater presence and interaction with surface water

From: Canada's Groundwater Resources (Rivera, 2014)

Mining Impacts to Groundwater
Baseline Conditions



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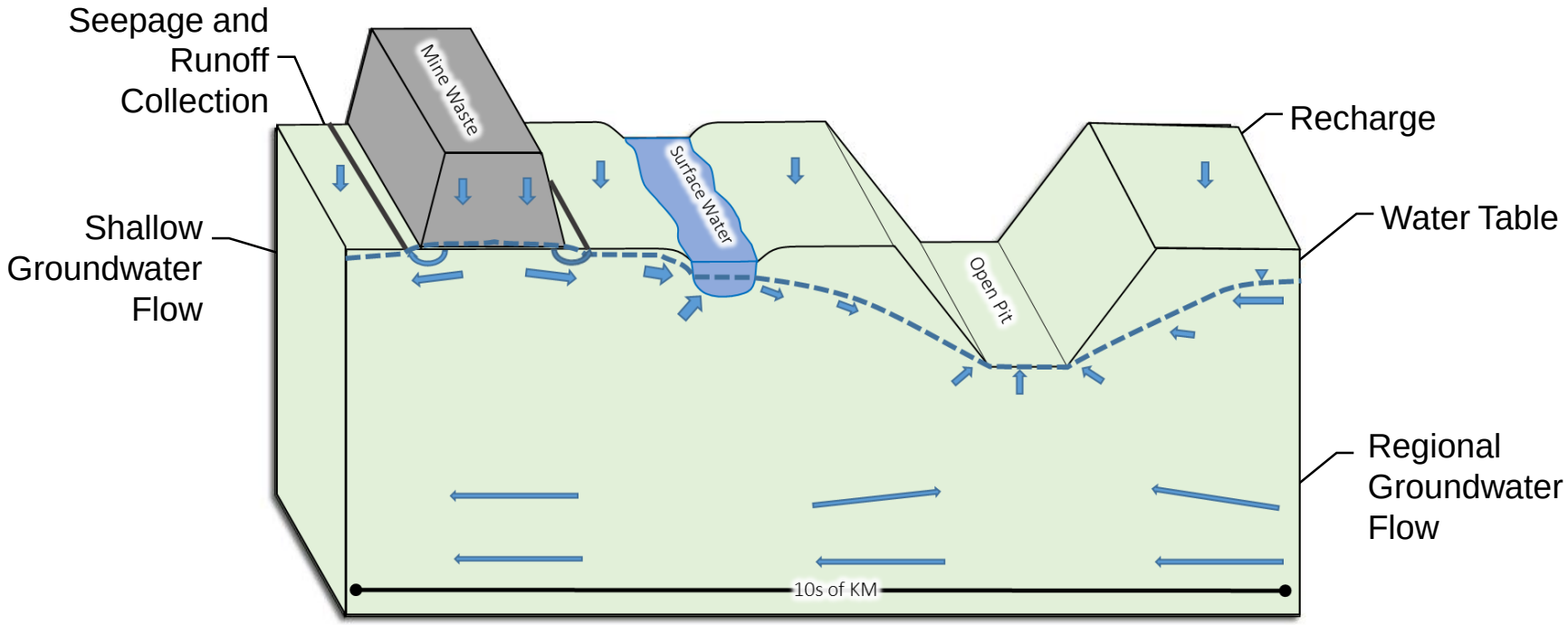
Mining Impacts to Groundwater
Operations Conditions



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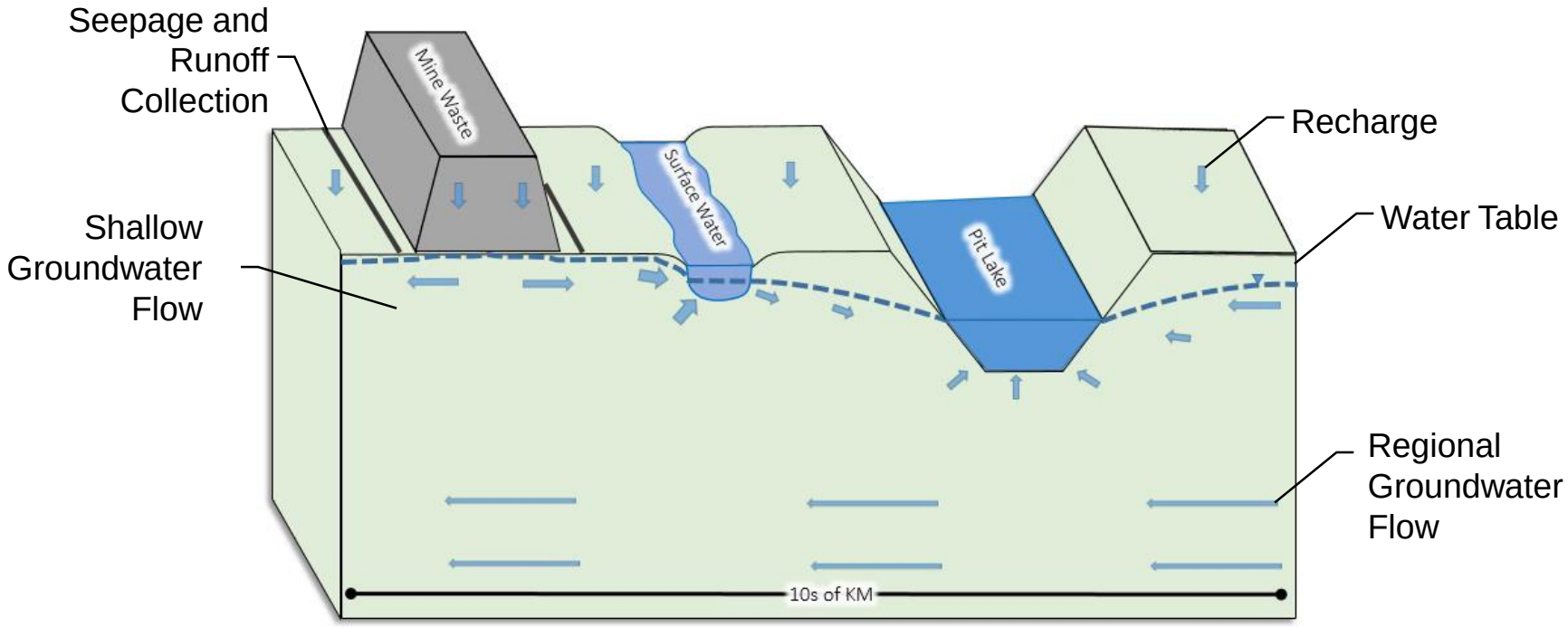
Mining Impacts to Groundwater
Post-Closure Conditions



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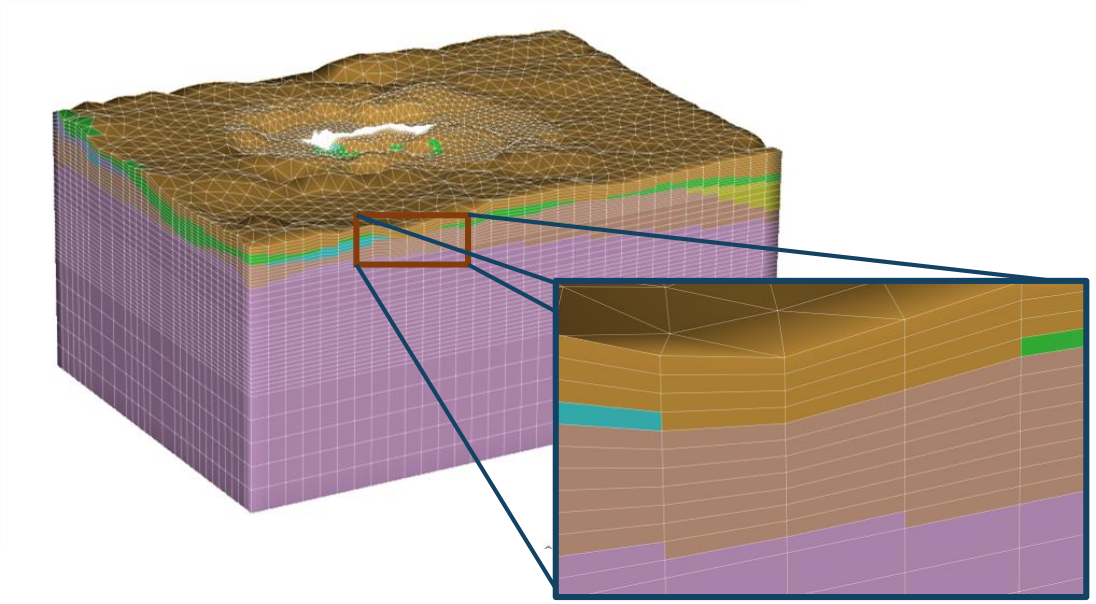
Assessment of Impacts to Groundwater

- Baseline data is used to develop a conceptual (qualitative) model of groundwater flow.
- Conceptual model and mine plan drive the selection of methods to quantify changes. Typically numerical models are used.
- Baseline data and conceptual model are used in the calibration process for validation
- Forecasting results rely on model calibration and accuracy of conceptual model

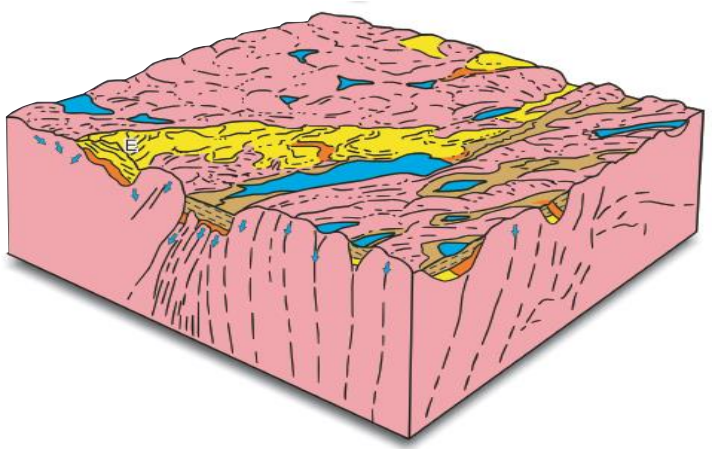


Example 3D Numerical model using a finite element method

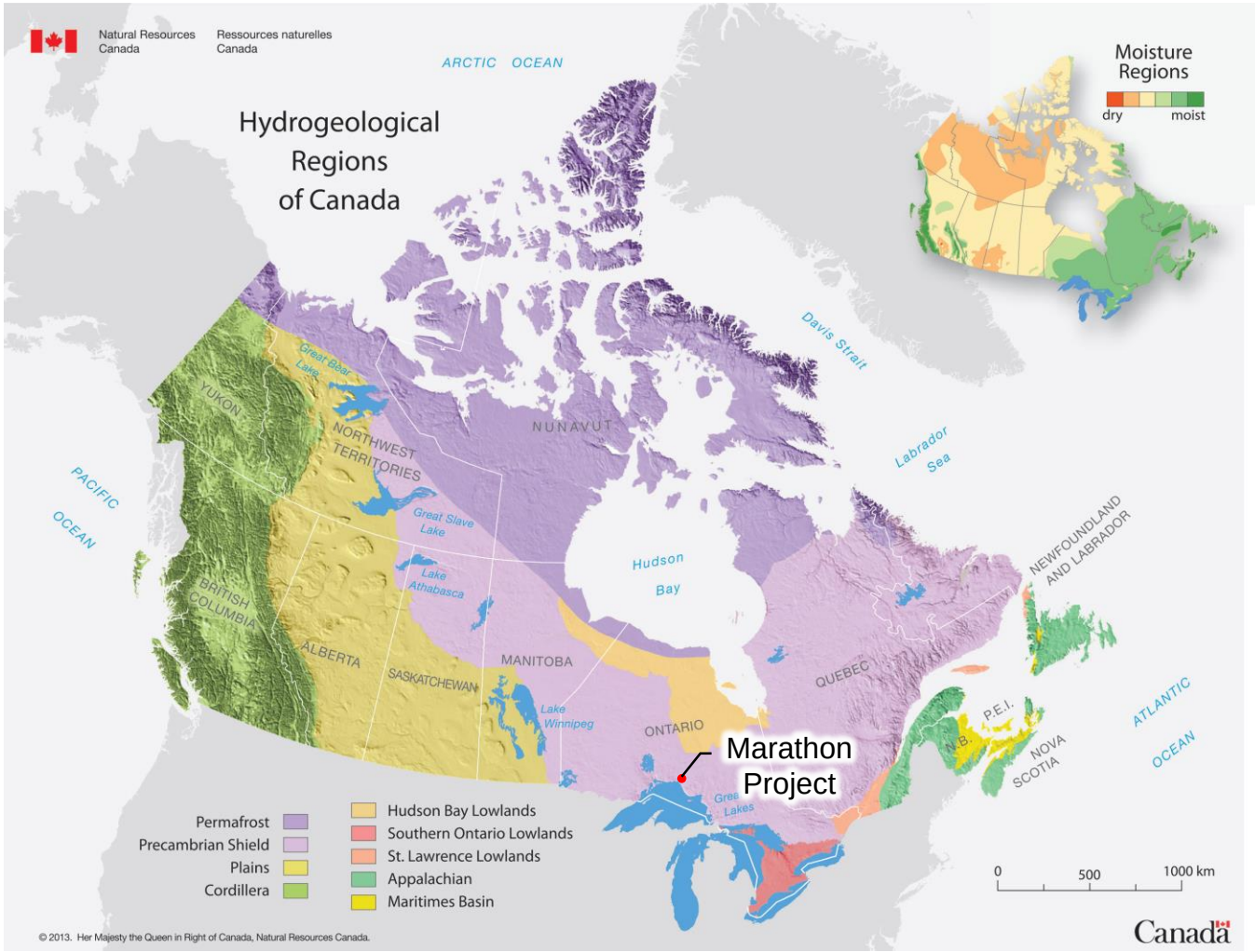
Unpublished Figure (Bunn, 2019)

Groundwater flow in Canada's Precambrian Shield Hydrogeological Region

- Groundwater flow pathways are short and shallow.
- Flow is slow due to low driving gradients
- Sediment cover is thin and water storage is low.



Groundwater Flow in The Precambrian Shield Hydrogeological Region
From: Canada's Groundwater Resources (Rivera, 2014)

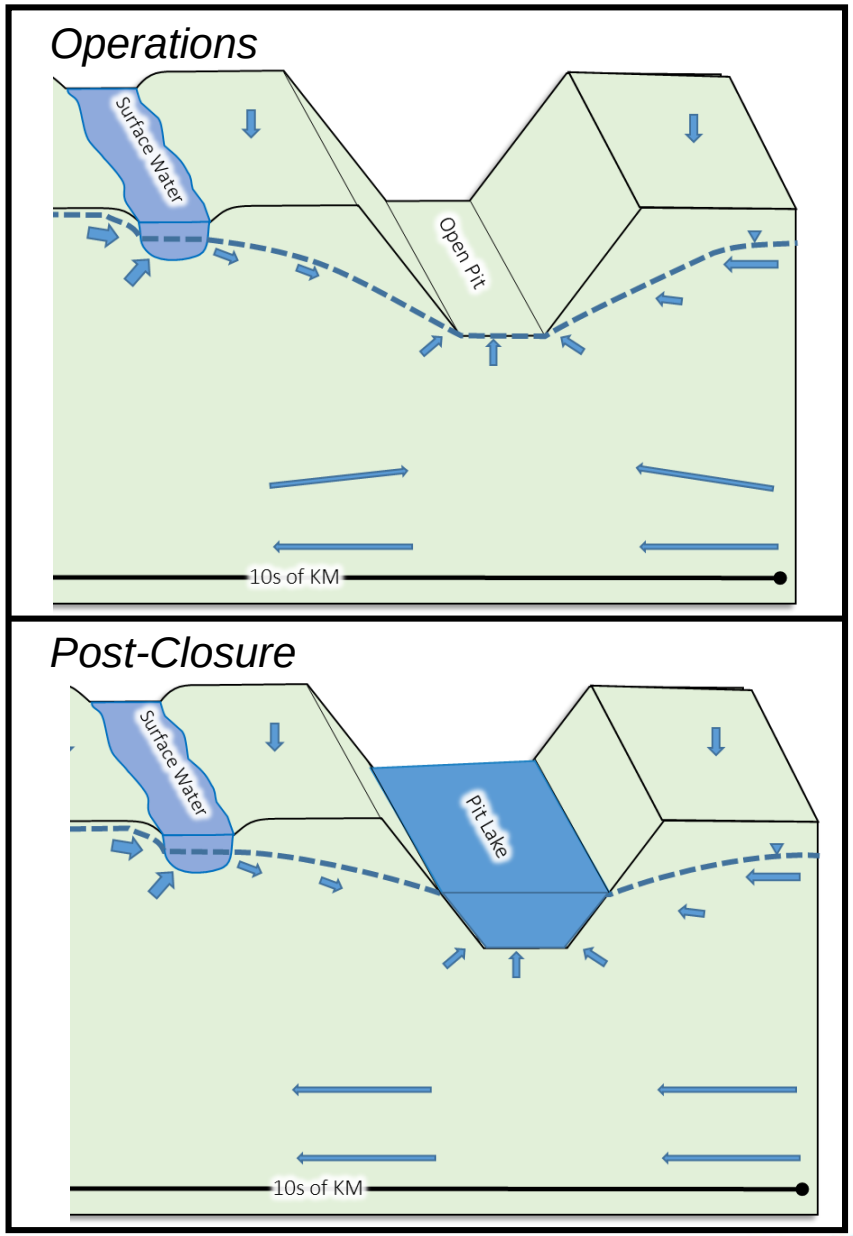


Canada's Hydrogeological Regions
From: Canada's Groundwater Resources (Rivera, 2014)

Marathon Project Groundwater

- At the end of operations pits are dewatered to depth of >100 m with drawdown extent of >1 km.

- When flooded the pit recovers, groundwater elevations remain drawn down by > 50 m with similar extent.



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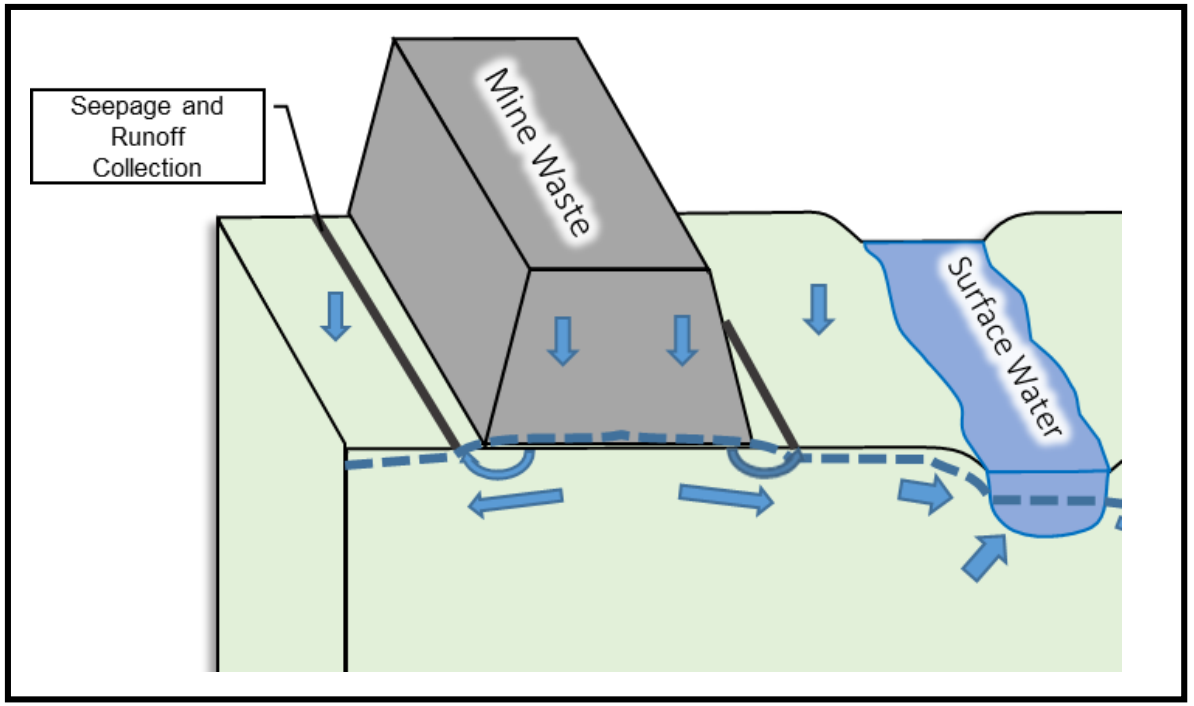
Marathon Project Groundwater

- Mounding below the MRSA and PSMF reaches >10 m above baseline conditions at the end of operations and through post closure.
- Seepage from these facilities is simulated to occur within the bedrock of the upper model layer (up to 75 m bgs).
- Seepage discharge to major river systems, not projected to occur until centuries post-closure.



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NRCan's Review

- Following the Proponent's presentations on the new project design and operations plan, NRCan requested information on:

  - Model recharge
  - Details on modelled MRSA (Mine Rock Storage Area) and PSMF (Process Solids Management Facility)
  - Additional details on drawdown and water table maps and additional maps
  - Updated Particle Tracking Results

NRCan's Review 2021

Following review of the EIS, Supporting Documents and Addendum, NRCan submitted Information Requests (IRs) to the JRP for details on the numerical groundwater model as follows:

- **Groundwater discharge to surface water**
- **MRSA Water Balance**
- **PSMF Water Balance**
- **Groundwater Model Particle Tracking**

Recommendations

NRCan offers the following recommendations to address the reporting of seepage and groundwater discharge to surface water to guide the development of the monitoring plan:

1. The Proponent should report forecasted changes to groundwater- surface water interaction for the individual surface waterbodies represented in the numerical model, and that reported flux changes are consistent with reported changes in groundwater elevations.

Recommendations (Continued)

2. The Proponent should provide detailed reporting of model results relating to the PSMF and MRSA to ensure clarity on reported seepage quantities and flow pathways.

Recommendations (Continued)

3. The Proponent should account for long travel times, consistent with groundwater model results in development of the monitoring plan.

THANK YOU