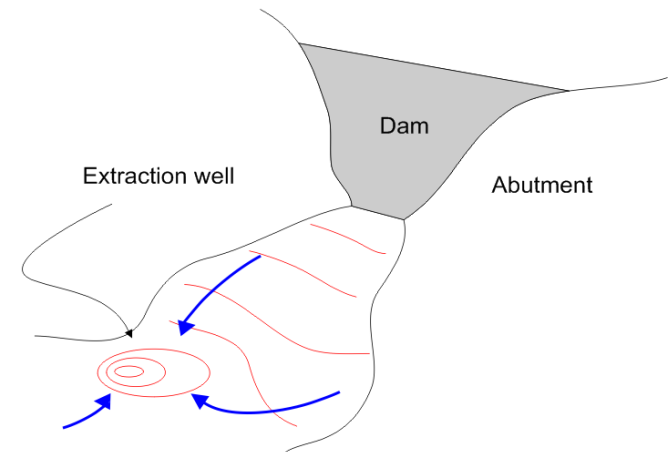
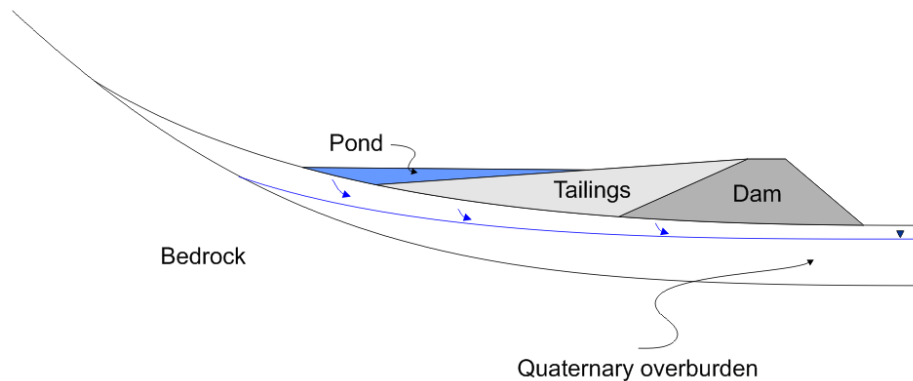


# Groundwater Issues in the Design, Operation, and Closure of Tailings, Waste Rock, and Heap Leach Facilities

Bernard Brixel, Jack Caldwell, & Christoph Wels



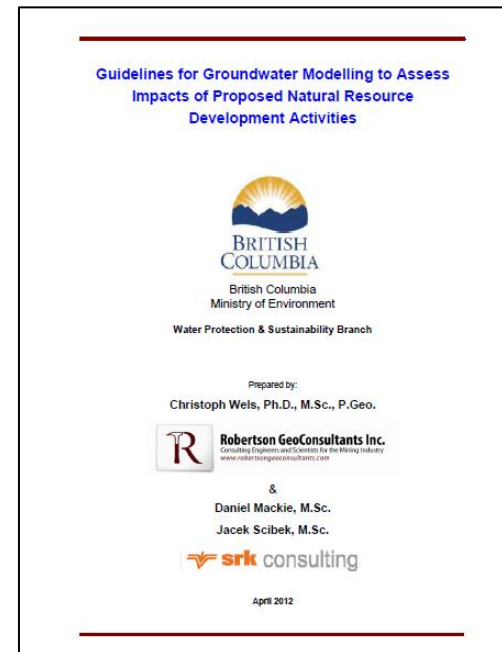
**Robertson GeoConsultants Inc.**  
Consulting Engineers and Scientists for the Mining Industry  
[www.robertsongeoconsultants.com](http://www.robertsongeoconsultants.com)

# The Paper

- A review of groundwater issues related to mine waste facilities (MWF), including:
  - Seepage from Tailings Storage Facilities, Waste Rock Dumps and Heap Leach Pads
  - Downstream seepage interception
  - Post-closure seepage rates & potential long-term environmental impacts
- An overview of commonly used approaches for groundwater modelling in the context of mine waste facilities.

# This Presentation

- Focus on the concept of groundwater modelling as a tool during design, operation and closure of mine waste facilities.
- Draws on the [Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities](#), (RGC & SRK, 2012).
- Available at: <http://www.rgc.ca/moe>



# Why Model?

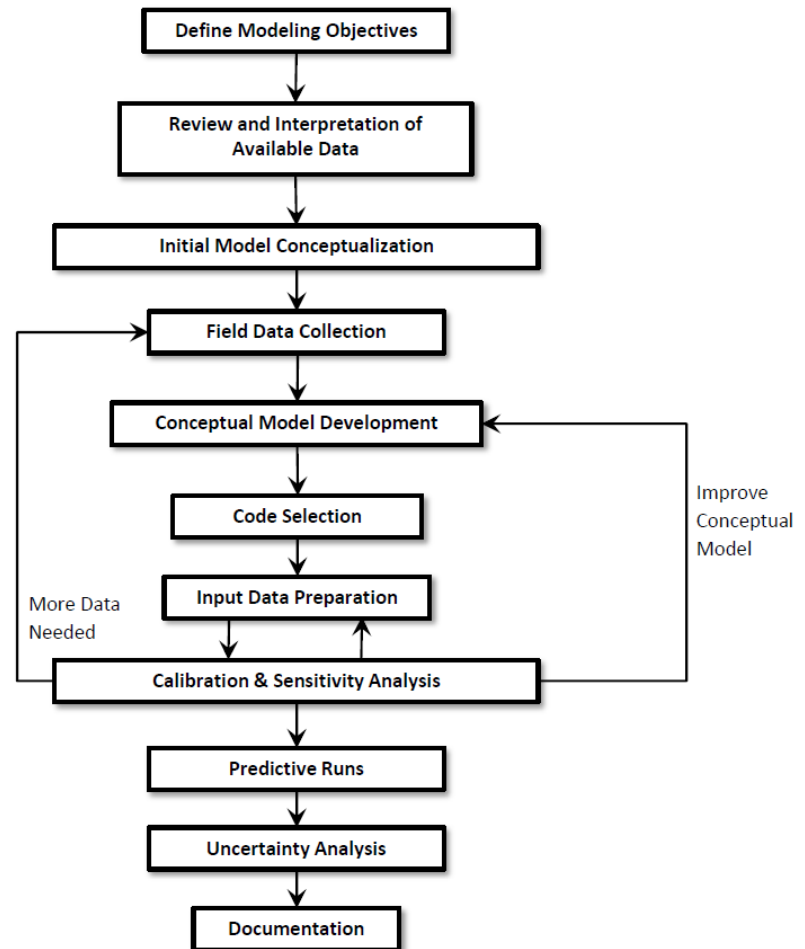
- Scientific/Engineering tool:
  - Simulate interactions between groundwater and mine waste facilities in order to:
    - Assist in the design of mine waste facilities
    - Evaluate environmental impacts
- Regulatory tool:
  - Predict plausible system response(s) in support of:
    - Permit applications
    - Regulatory reviews
- Project Management tool:
  - Use model for decision making during mining



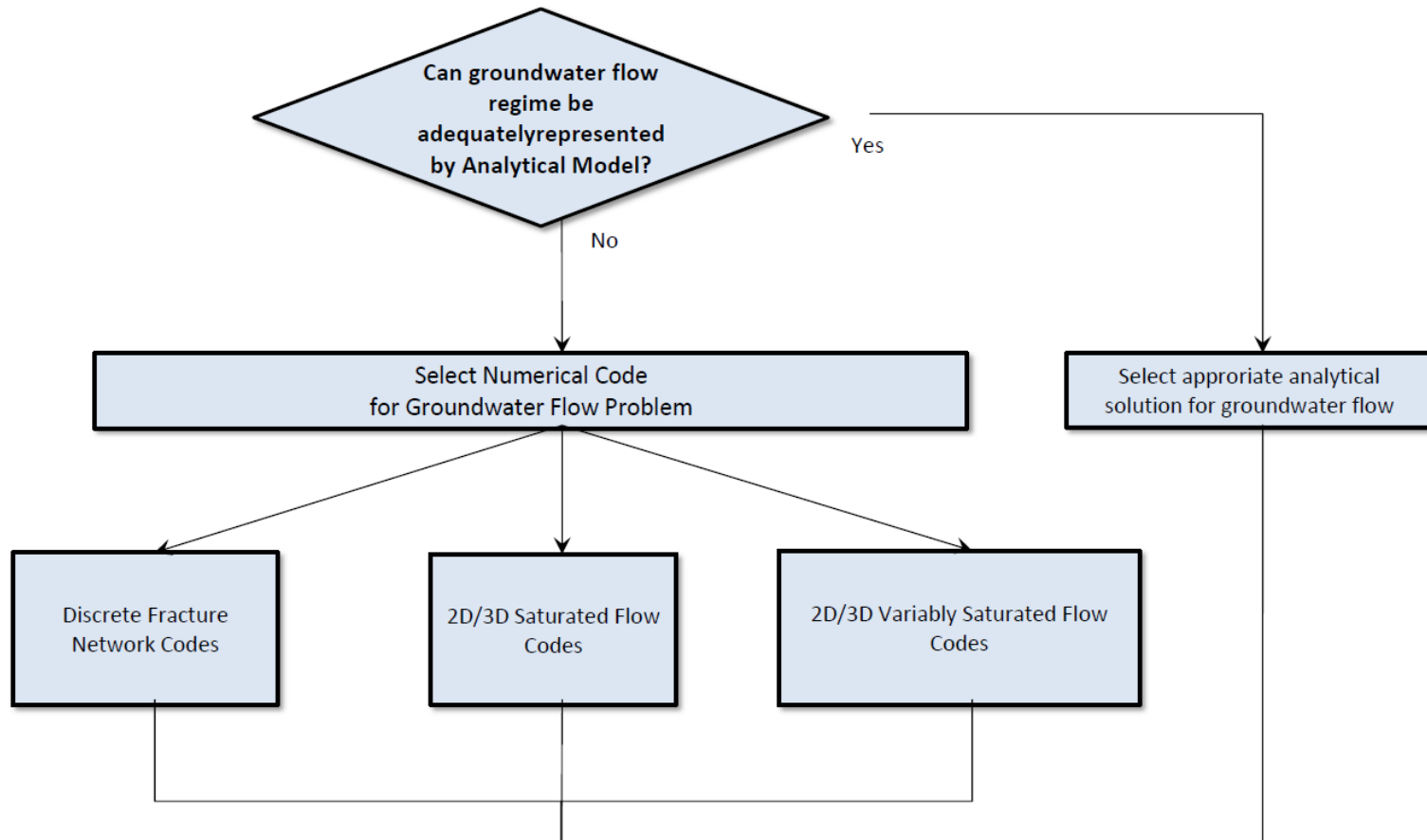
# GW Modelling Process\*

- Definition of objectives
- Data review
- Conceptualization
- Code selection
- Calibration & sensitivity analysis
- Predictions

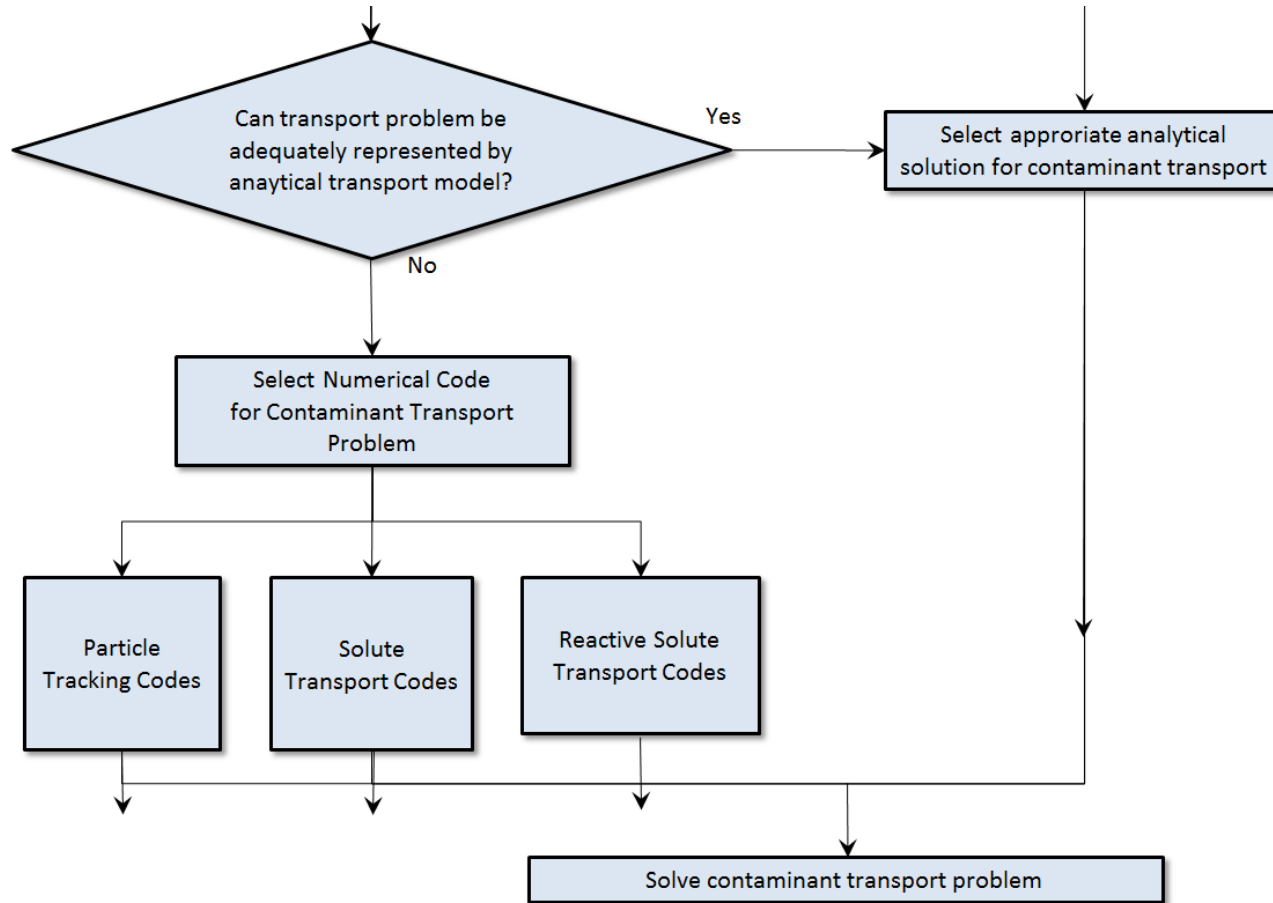
\* See BC MOE Modeling Guidelines for more details (Wels et al., 2012)



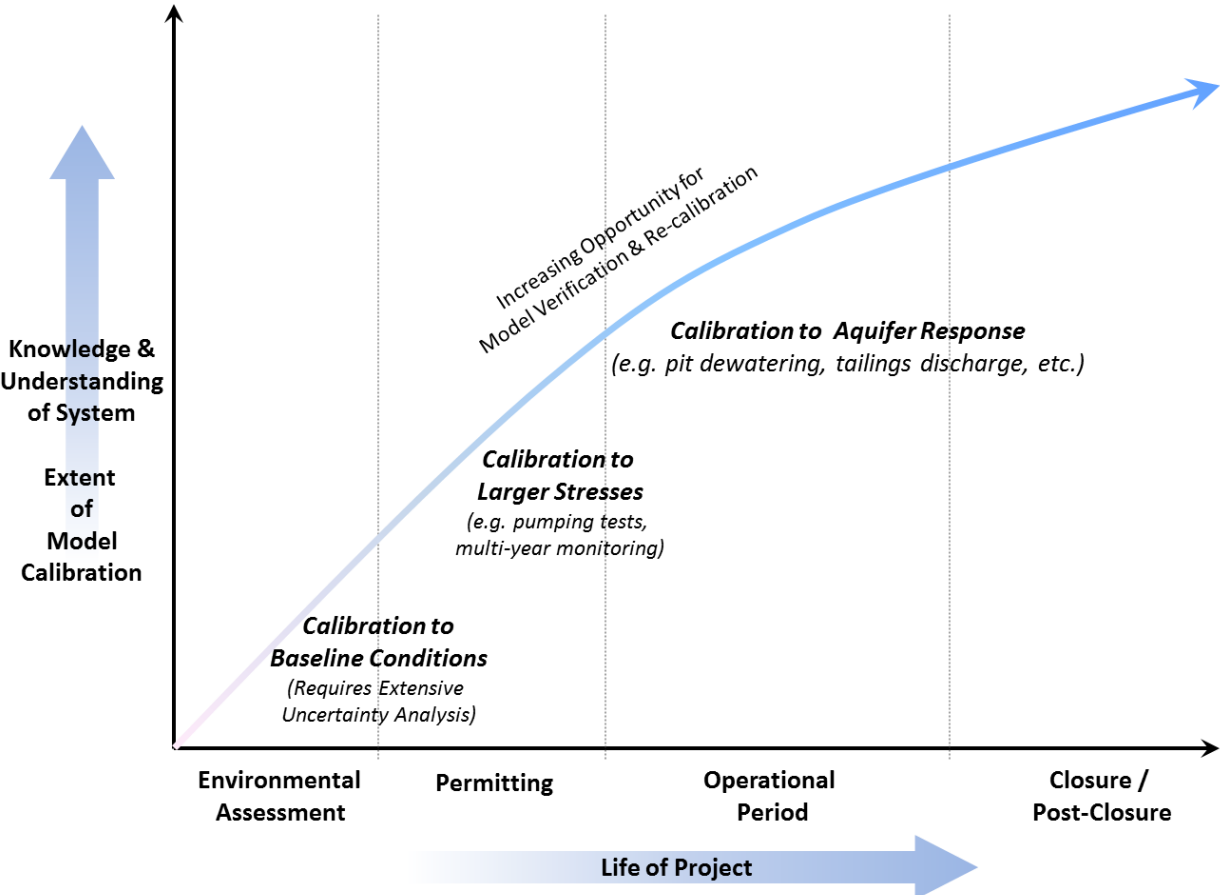
# Model Selection Process (Flow)



# Model Selection Process (Transport)

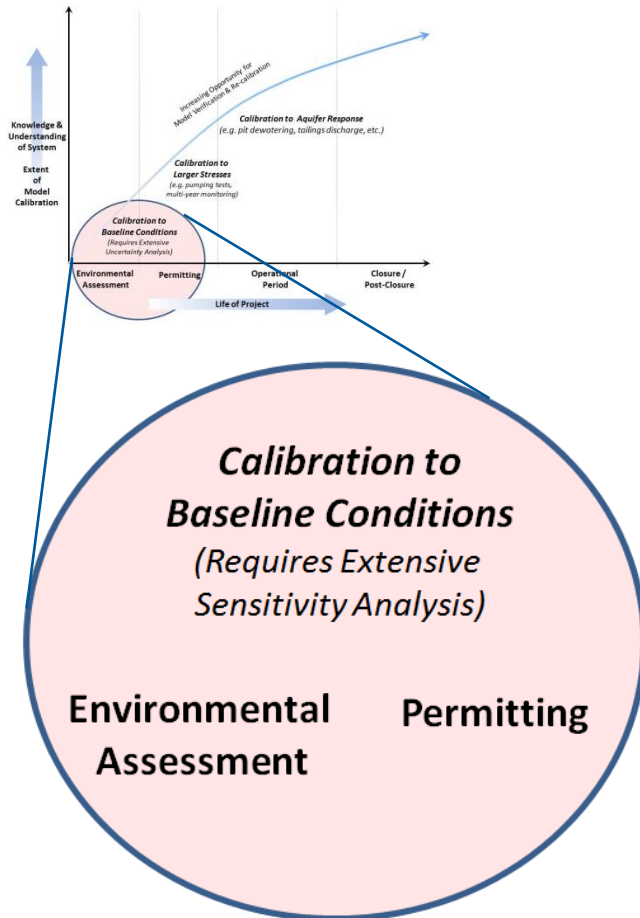


# Modeling through the Life of a Project





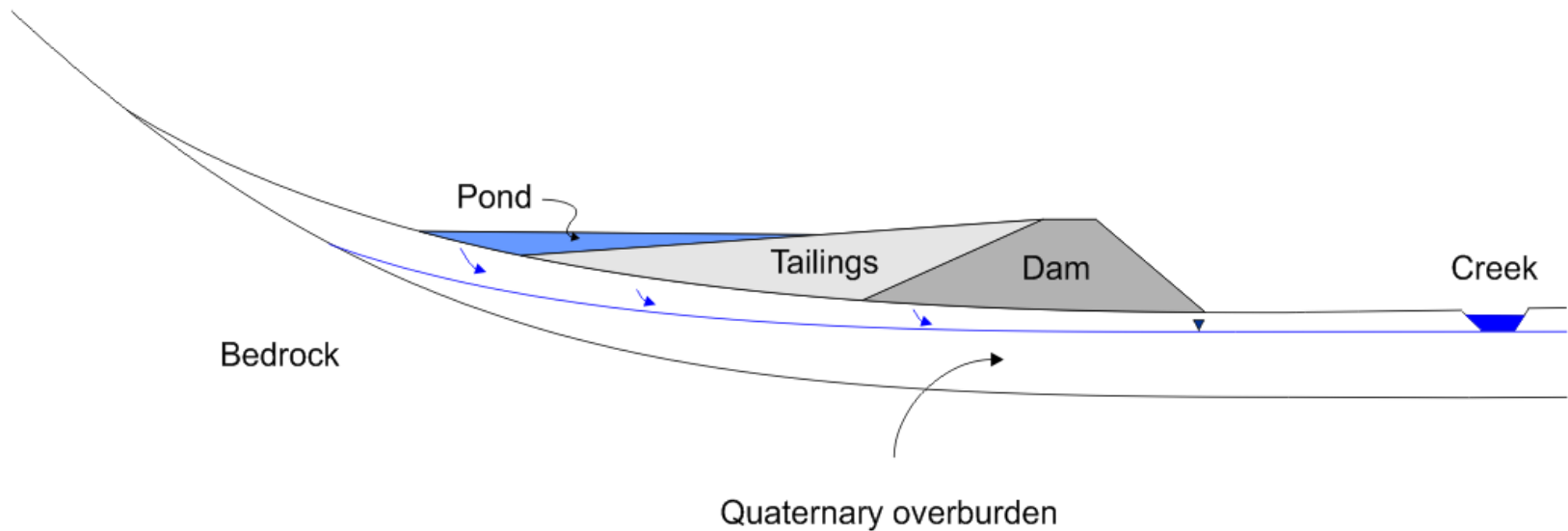
# Design/Permitting



- Establish the baseline hydrogeological regime in the proposed area of waste disposal (**baseline model**)
- Predict the future hydrogeological regime:
  - Mine waste seepage (recharge to aquifer)
  - Contaminant transport
  - associated impacts on downstream receptors
- Assist in the design of systems/structures:
  - water management
  - Tailings dam
  - toe cutoff/drainage systems
  - groundwater monitoring networks

# Design/Permitting (Example)

## Seepage Losses & Environmental Impact



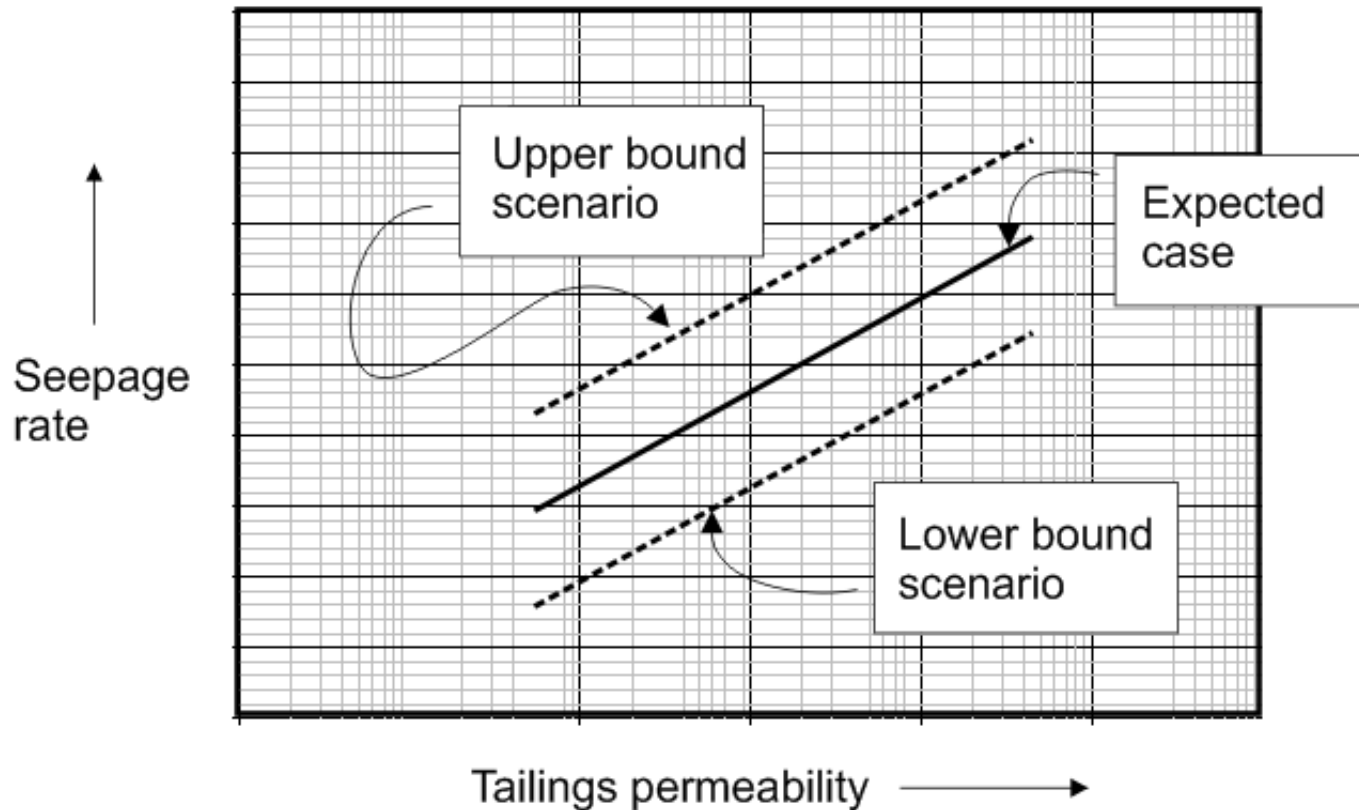
# Design/Permitting (Example)

## Seepage Losses & Environmental Impact

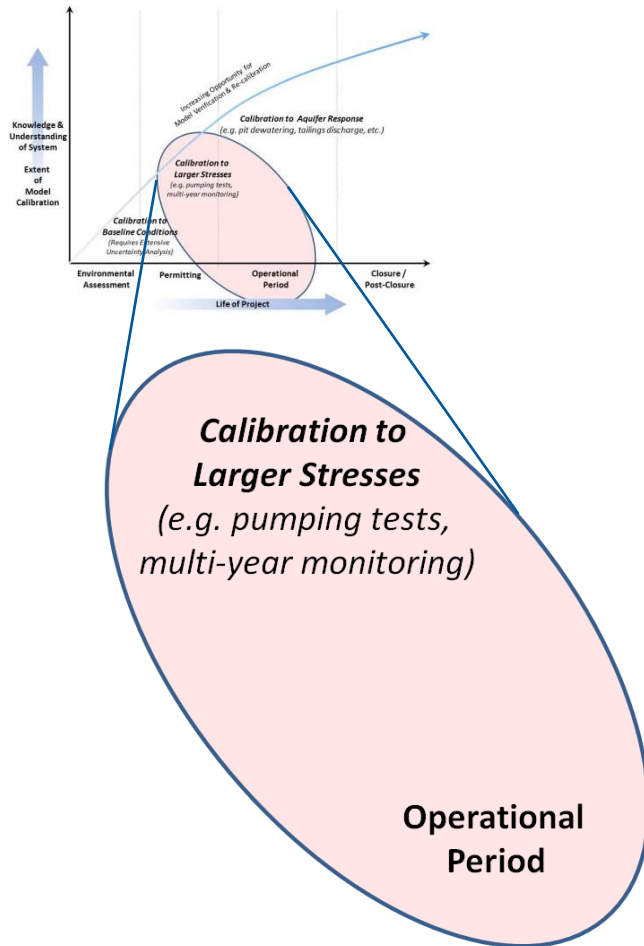
- Important for:
  - Quantifying make-up requirements
  - Predicting contaminant loading to aquifer
- Requires knowledge of:
  - Deposition method
  - Process water discharge
  - Tailings/aquifer properties
  - Containment strategy
  - Drainage strategy

# Design/Permitting (Example)

## Seepage Losses & Environmental Impact (Sensitivity Analysis)



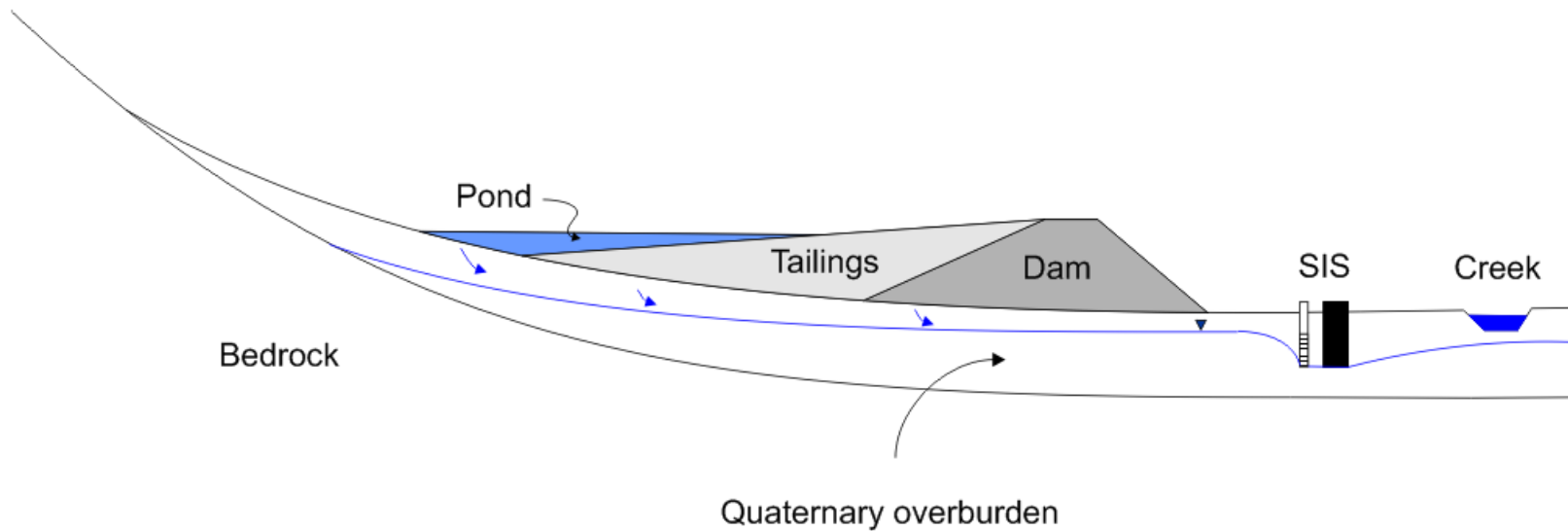
# Mine Operation



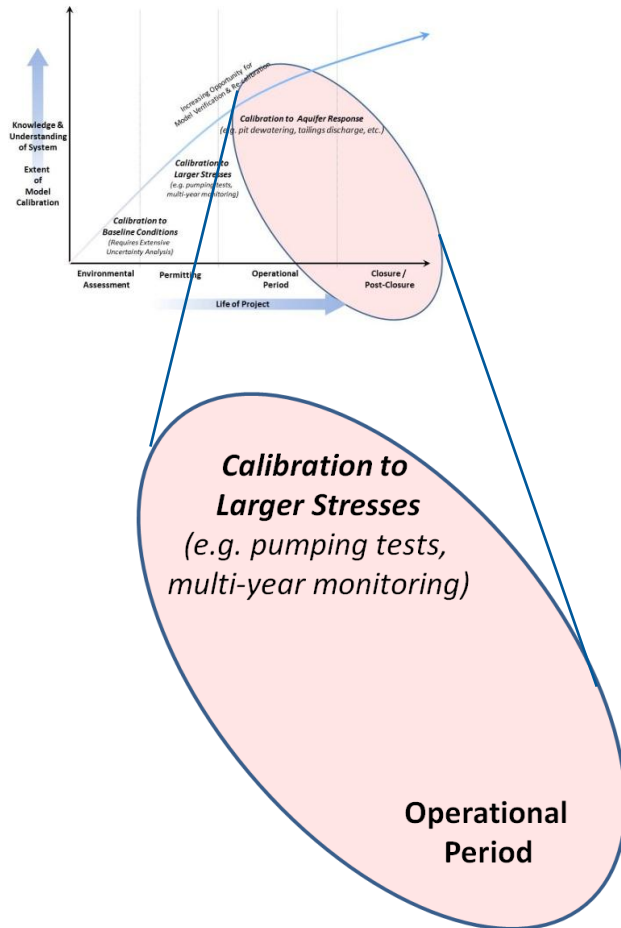
- Describe observed groundwater impacts resulting from waste disposal activities (**calibrated baseline model**)
- Evaluate alternative seepage mitigation scenarios:
  - cutoff-wall
  - interceptor trench
  - pump & treat
- Performance assessments:
  - dam seepage
  - seepage mitigations options

# Mine Operation (Example)

## Seepage Interception



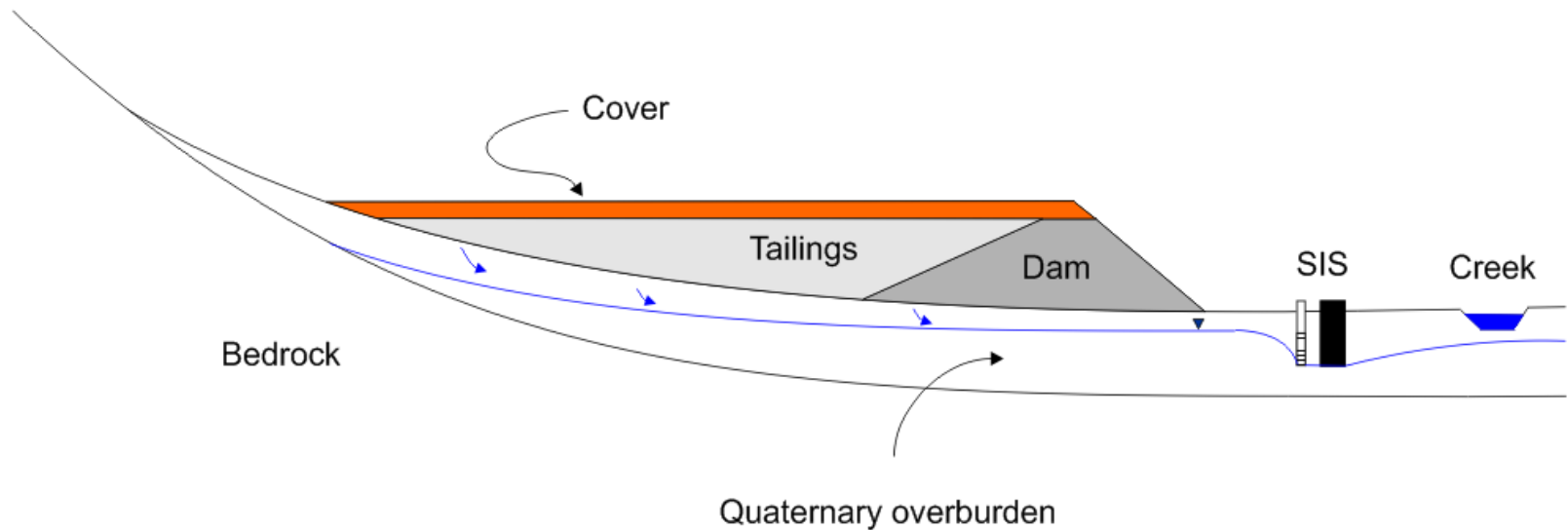
# Closure



- Predict the post-closure hydrogeological regime (groundwater rebound, seepage rates, water quality)
- Assist in the design of alternative closure options:
  - Cover design
  - Waste relocation (e.g. pit backfill)
  - Seepage interception
- Trade-Off Studies

# Closure (Example)

## Cover Design & Long-term Impacts





# Concluding comments

- Groundwater modelling is an important tool throughout the design, operation and closure of mine waste facilities
- The scope and objectives of models should always be tailored to the needs dictated by the stage of the project
- The BC MoE groundwater guidelines provide a framework to facilitate the application of groundwater modelling to mine waste disposal

