Waste Rock Stockpiles

Leslie Smith

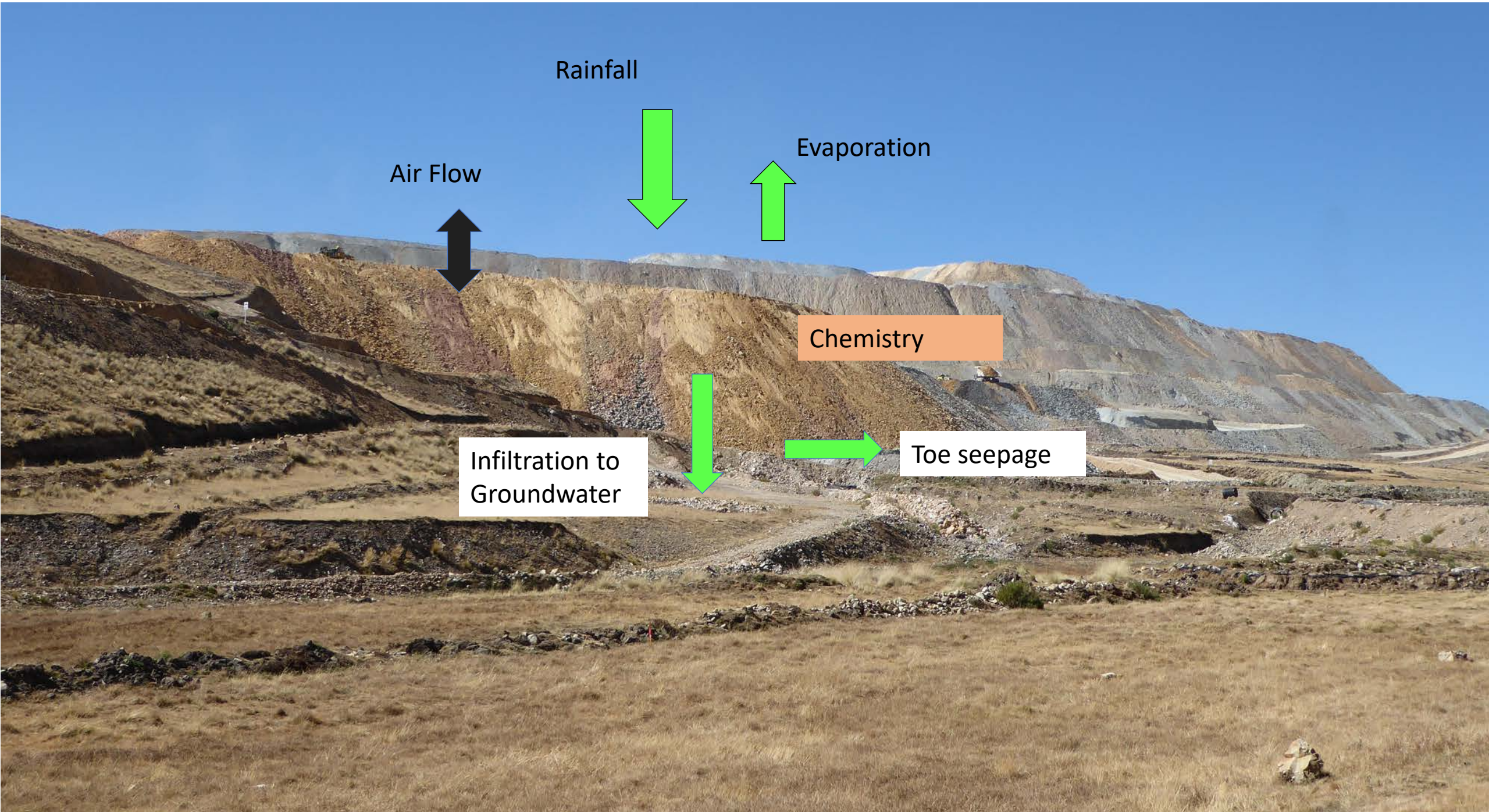
Professor Emeritus

University of British Columbia

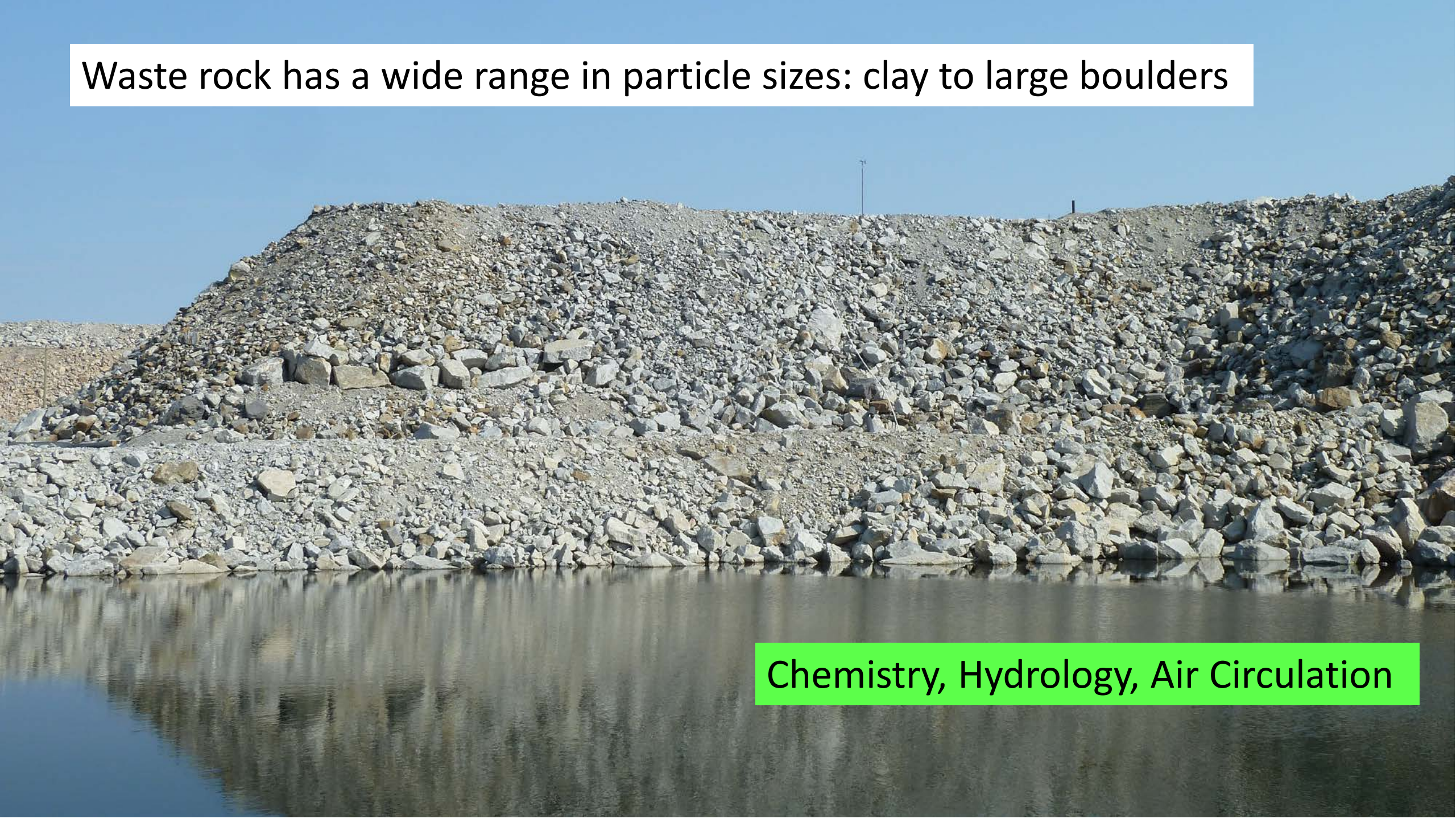
Vancouver BC

Outline for this Discussion

1. General discussion of processes that influence potential for water quality impacts from waste rock
2. Options for waste rock management
3. Waste rock stockpiles in northern Canada – unique features

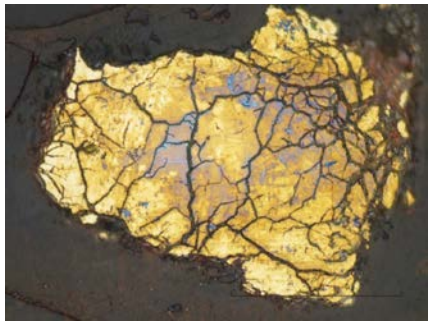

Rainfall
Evaporation
Air Flow
Chemistry
Infiltration to Groundwater
Toe seepage

Waste rock has a wide range in particle sizes: clay to large boulders



Chemistry, Hydrology, Air Circulation

Chemistry



- Sulphide content within waste rock pile, chemical reaction rates
- Presence of minerals within pile that can neutralize acidic water
- If reactive, time to onset of poor quality drainage (few months to many decades)
- Oxygen consumption and replacement
- Solutes that are mobile at neutral pH

Processes are well understood – challenges relate to site specific data interpretation and extrapolating lab tests and small scale field data to full-scale waste rock piles

Test cells to gain insight to chemistry in field conditions

Constructed in 1995 – British Columbia

Test piles to gain insight to chemistry in field conditions

Island in Tropics – South Pacific

Hydrology

- Infiltration of water into the waste rock pile
- Wet-up of the waste rock pile during / following construction
- Drainage of water out of the bottom of the pile
- LS rule of thumb estimates for downward rate of water flow in waste rock is 1 – 10 m/year

Principal challenge relates to estimating how much of the water that infiltrates a pile contacts how much surface area of reactive minerals in the waste rock pile

Air Circulation Within Waste Rock Piles

Oxygen re-supply: Controlled by bulk permeability of the pile

- Density differences between warm air and cold air
- Changes in barometric pressure (weather patterns)
- Wind-driven pressure differences

Porosity and Permeability Measurement in a Large-Scale Permeameter

4 m x 4 m x 2 m high

Waste Rock Management

- Waste rock segregation to separate non-acid generating rock from acid generating rock (“Designing for Closure”)
- Where protection of water quality requires additional measures:
    - Submergence of waste rock in water (low oxygen)
    - Reduce oxygen transfer into the interior of the waste rock pile
    - Limit infiltration of water through the waste rock pile
- Commit to long-term seepage collection and water treatment before release (perpetual care)

Waste Rock Management (Place Rock in Pit)

Saskatchewan

South Carolina

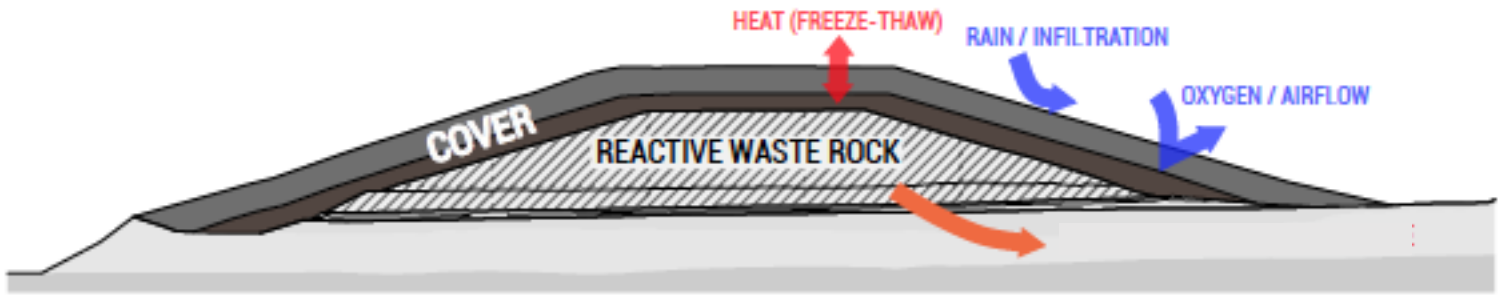
Engineered soil covers to reduce infiltration of water

Closed gold mine in Nevada - 2004

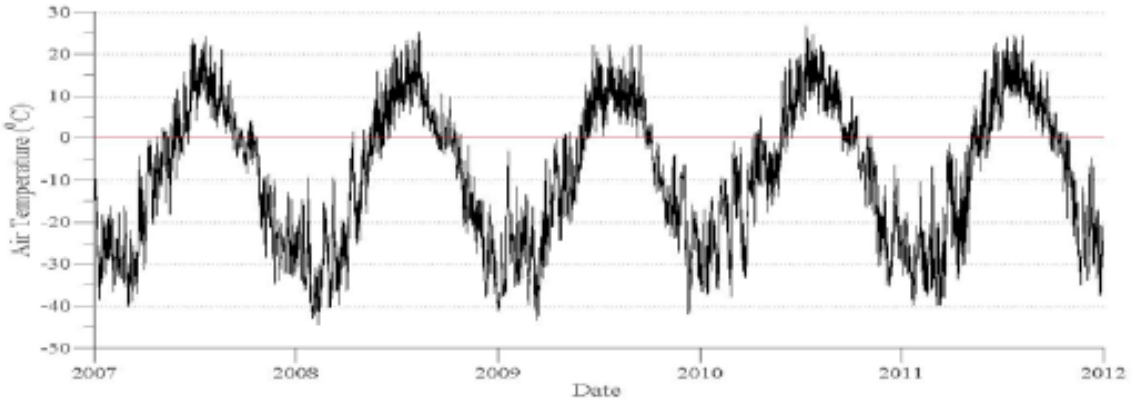
Engineered soil covers to reduce entry of oxygen

Test pile in northern Ontario 2017

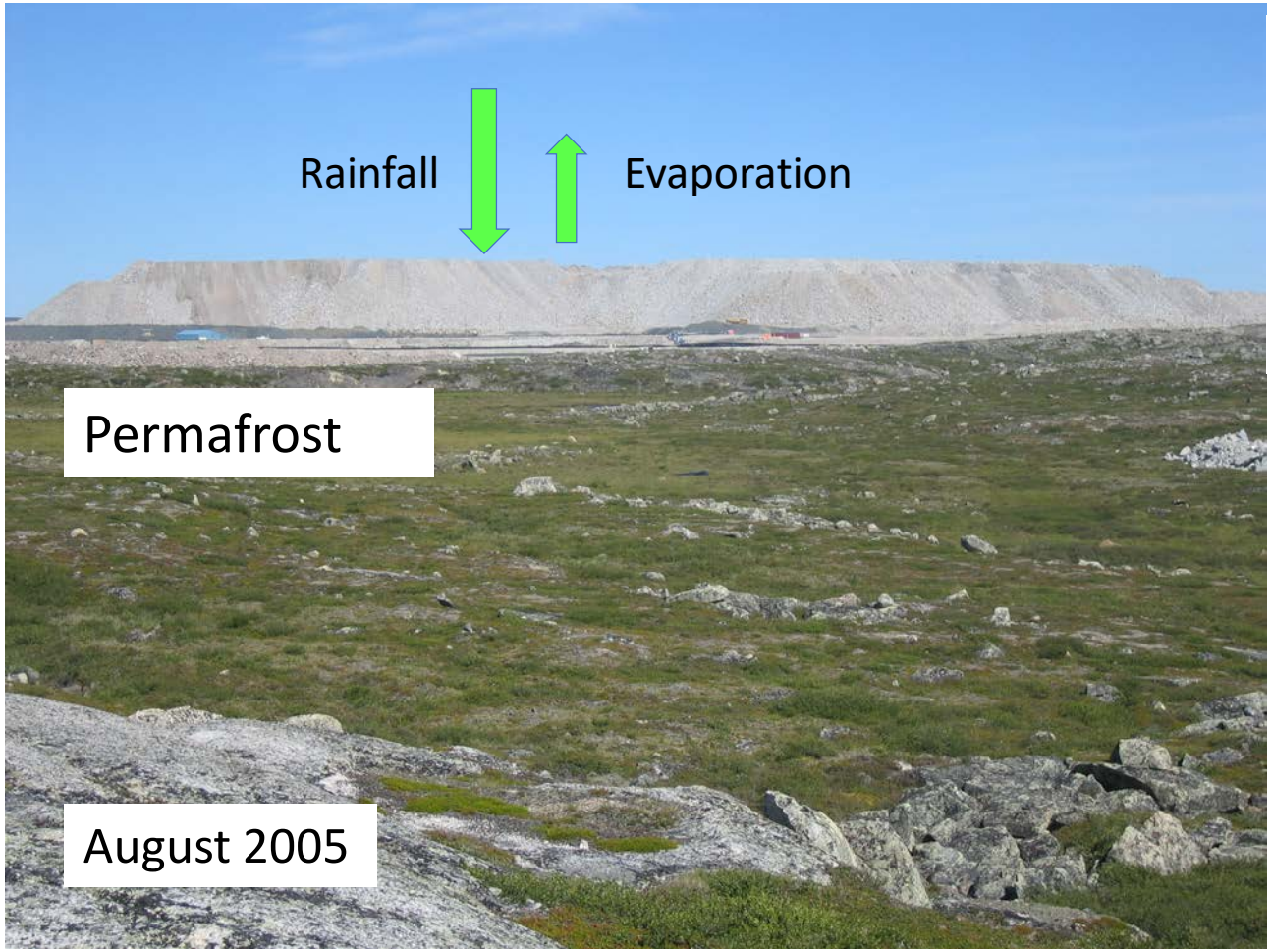
COLD REGION ACID MINE DRAINAGE

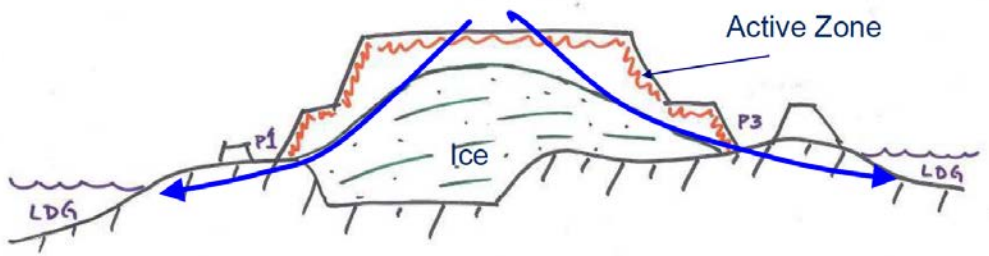


L Collette 2017



Zone of continuous permafrost
MAAT ~ -9°C

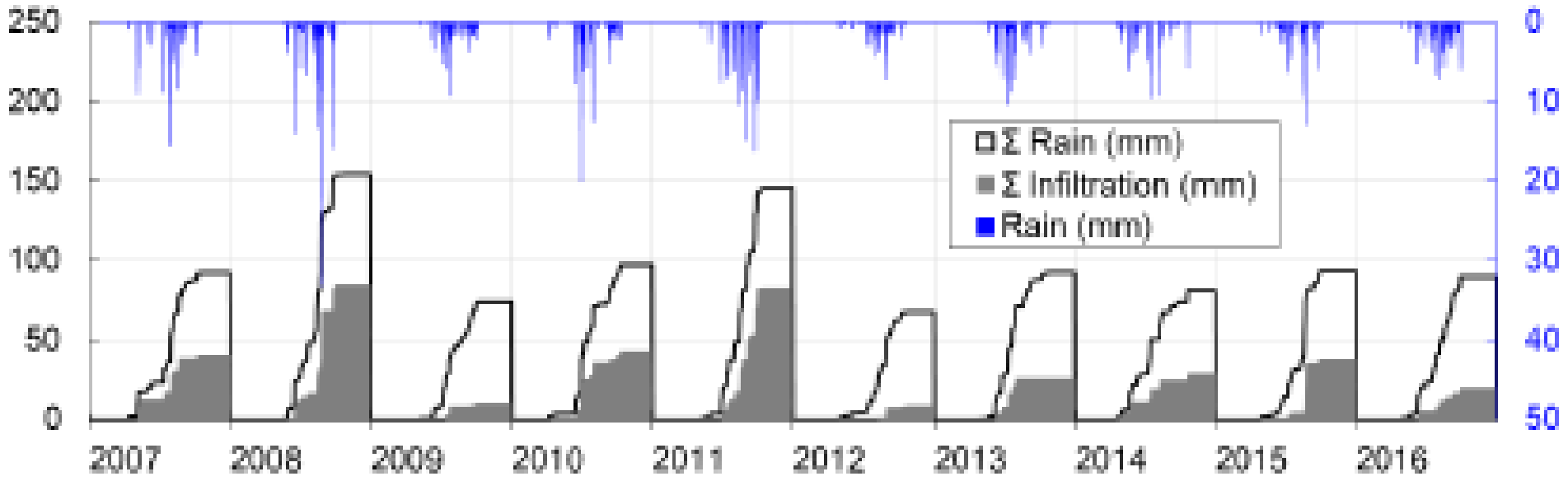




Diavik August 2005

Pods of biotite schist in a large mass of granite

Ten-Year Record of Infiltration Estimates for Rainfall at Diavik Test Piles

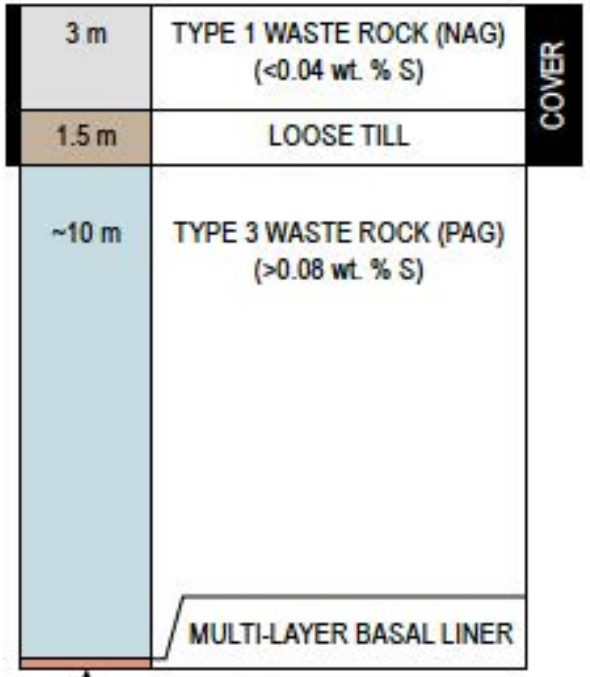


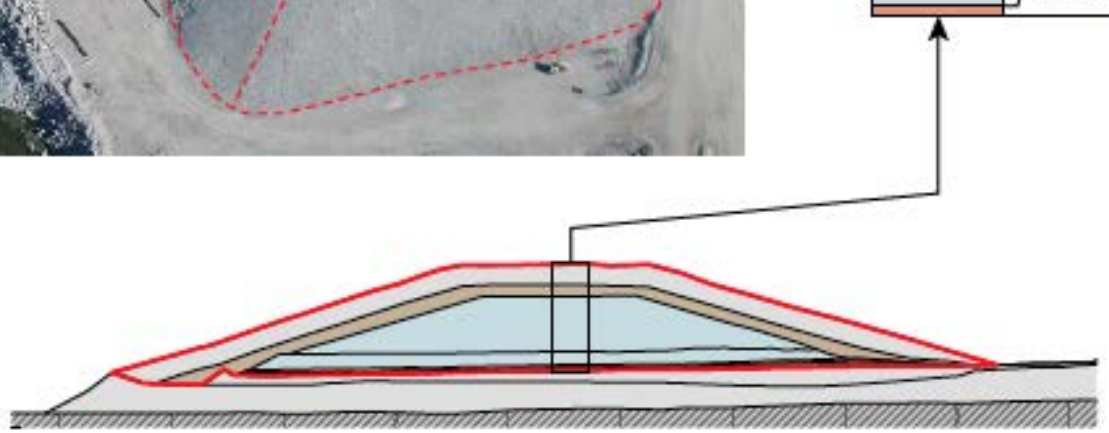
Each year is unique: long-term data is important

Snow hydrology is as important as rainfall in understanding infiltration of water to waste rock

DIAVIK TEST PILES 2004 - 2017

Adapted from Fretz (2013)





UBC
U Waterloo
U Alberta
Carleton U
Diavik Diamond Mine
INAP, MEND

L Collette 2017

Construction of the Covered Test Pile at Diavik

Placing Till Layer

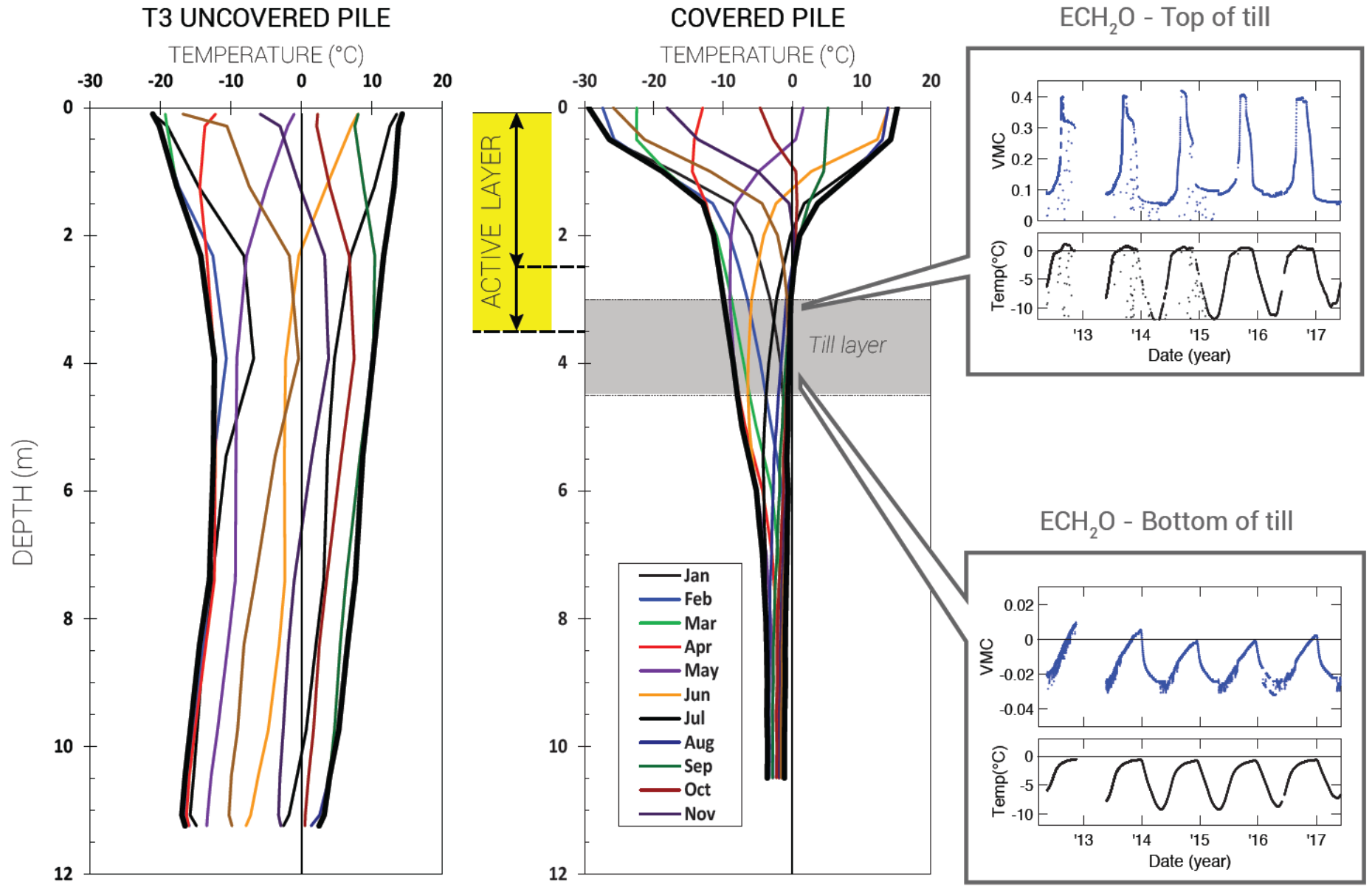
Placing Upper Waste Rock Layer

2006

Covered Test Pile – View in 2015

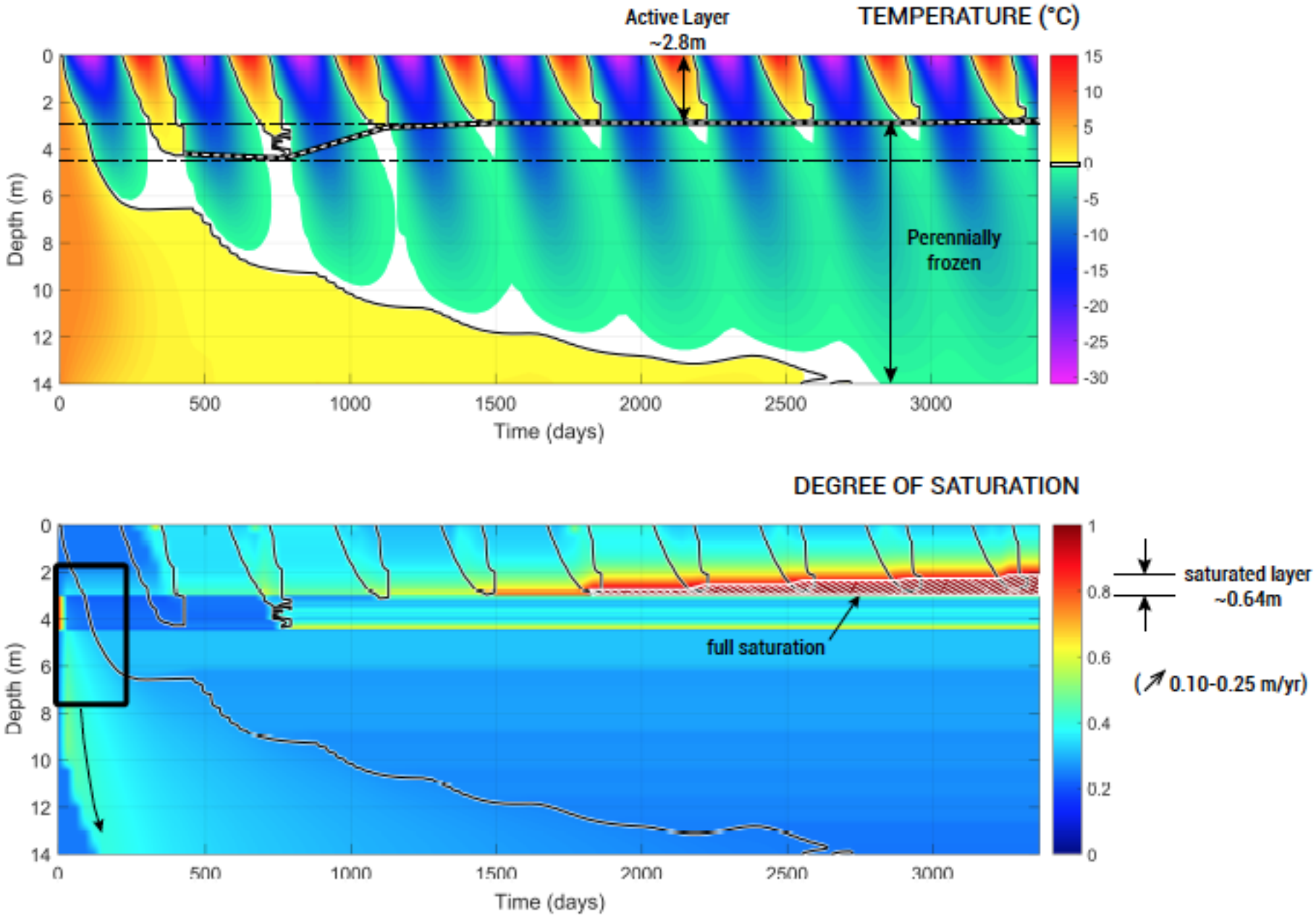
No Outflow from the Base of the Covered Pile Since 2014

Temperature & moisture below the crest



L Collette 2017

Computer simulation of the thermal and hydrologic evolution of the Covered Test Pile



L Collette 2017

Ice accumulation within open voids of a waste rock pile

2015

Blocky ice

Ice-filled pores in sand

Monitoring Data

- Thermistors for recording temperature profiles with depth
- Weather station data to estimate infiltration – can be checked with lysimeters which are designed to measure infiltration through the surface of a waste rock pile

- Seepage monitoring (quantity, quality), if possible
- Water content in active zone of waste rock pile

Effects of Climate Change

- What is the predicted extent of warming in the various regions of northern Canada?
- What is the predicted change in the amount of infiltration, if any?
- What is the internal temperature response within a waste rock pile?

Computer simulations based on sound conceptual models and reliable parameter values

Long-term monitoring programs and checking predictions