A Summary of the INAP Report on

Evaluation of the Long-Term Performance of Dry Cover Systems

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Equity Silver
Kimberley Operations
Mt. Whaleback
Syncrude Canada
MSU Research Site

Presentation Outline

- Scope of INAP Project
- Key Processes and Properties Affecting Long-Term Cover System Performance
- Key Points

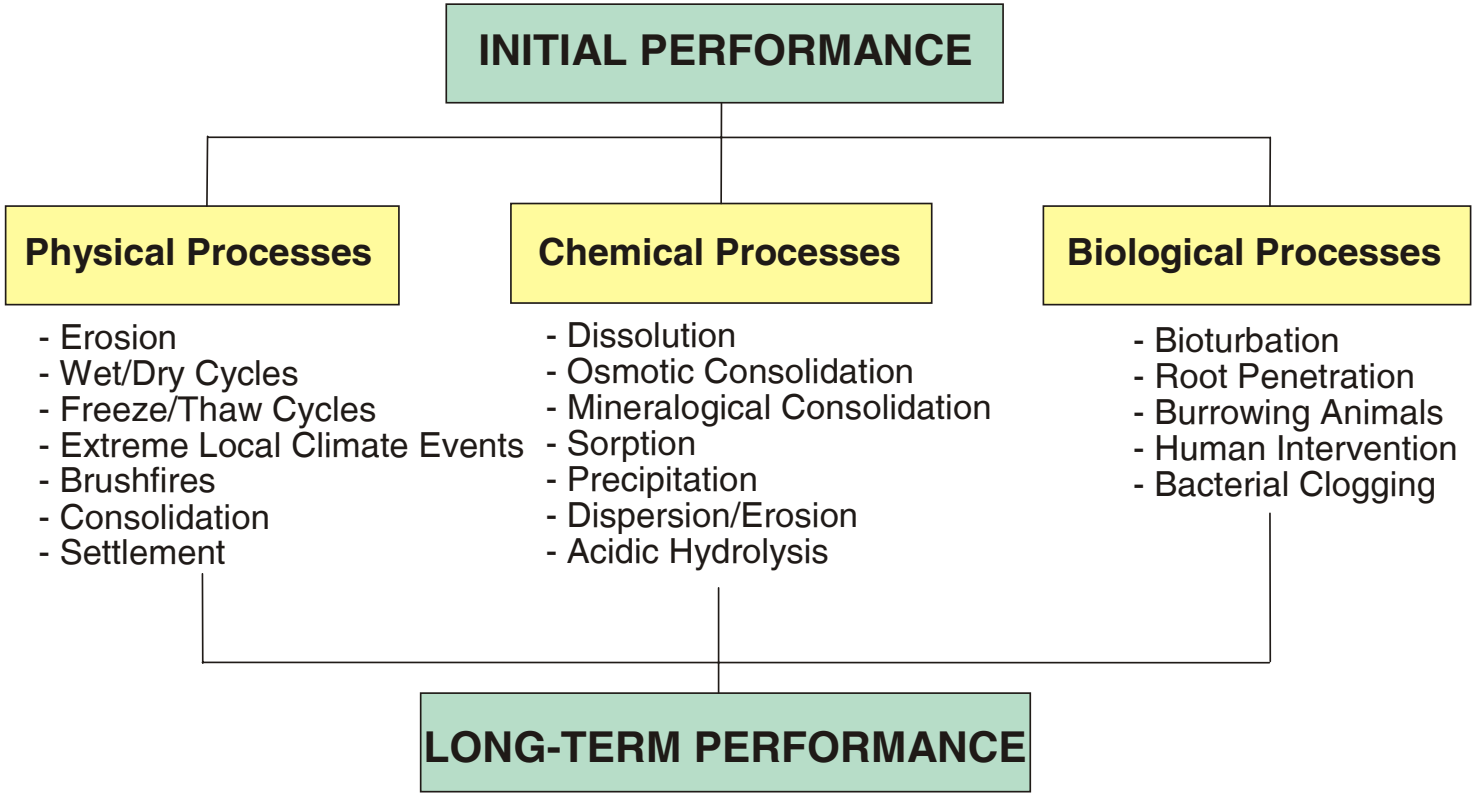
Scope of Project

- **Stage One**
  - *Identify and Define Processes Affecting Long-Term Performance*
  - *Evaluate Models / Desired Additions*
  - *Laboratory Testing*
  - *Performance Monitoring*

- **Stage Two**
  - *Obtain Field Data from Five Sites*
  - *Conduct Modelling of Two Sites*

Change in Scope:
In Situ
Hydraulic Conductivity Testing

Long-Term Performance



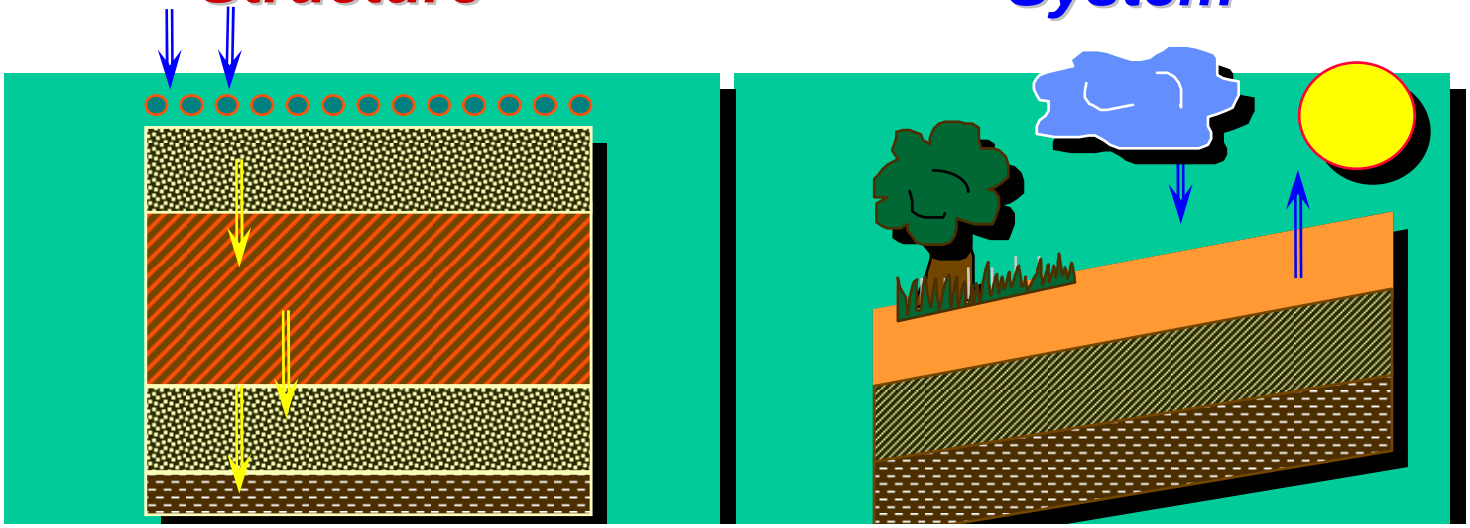
Resulting In:

- ***Change in Field Hydraulic Conductivity***
- ***Change in Moisture Retention Characteristics***
- ***Change in Oxygen Diffusion Characteristics***
- ***Change in Physical Integrity of Cover System***

Choosing a Model

Engineered Structure

Engineered System



Example: Two-Dimensional Effects

- Static
- Capillary Barrier
- Steady State
- Engineered Integrity
- Isolation

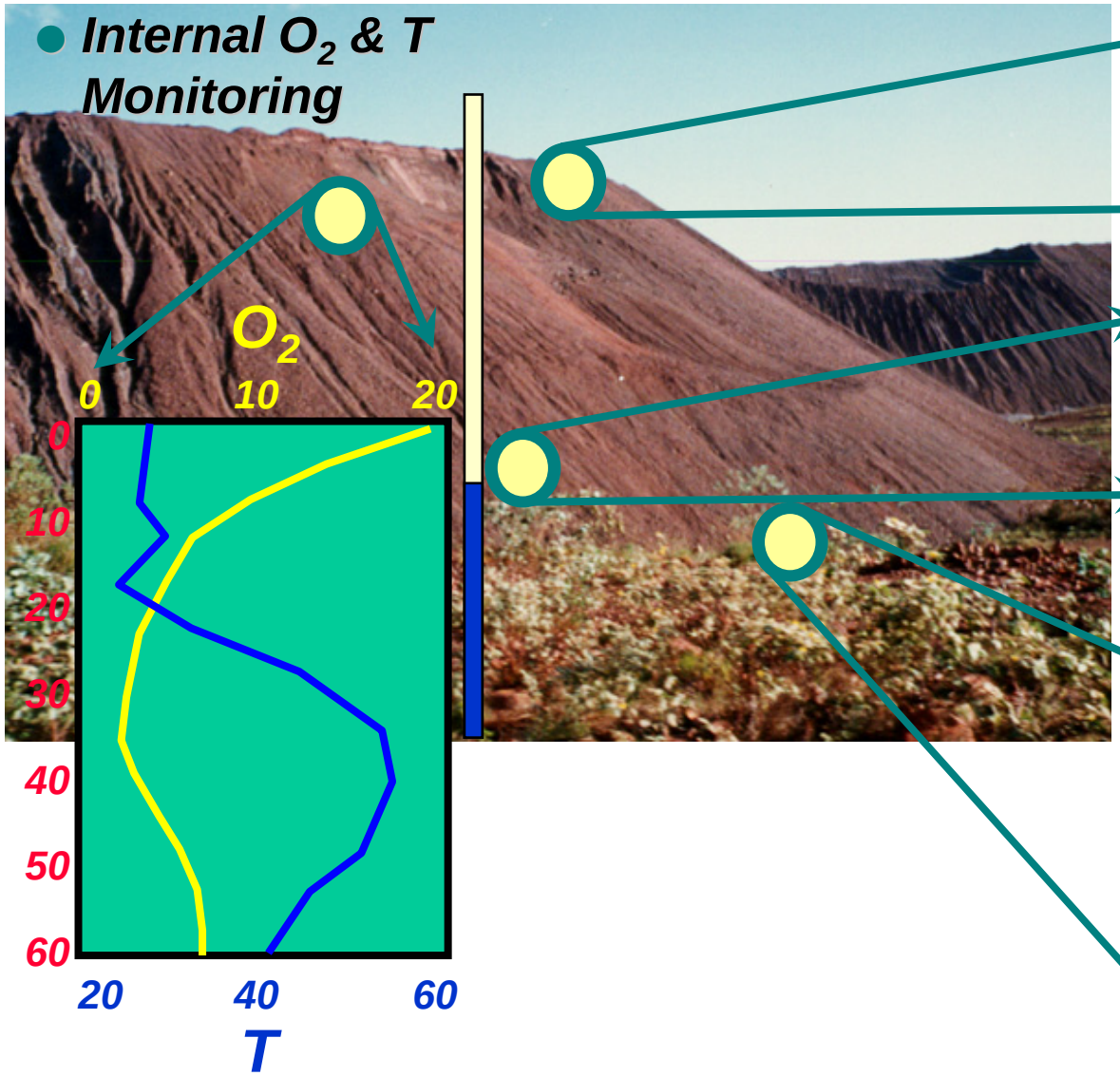
- Dynamic
- Soil / Ecosystem
- Coupled Transient
- Ecological Stability
- Integration

Improving the Models?

Vegetation

- *Current Methodology*
  - *Leaf Area Indices (LAI)*
  - *User Defined Root Characteristics*
  - *User Defined Transpiration Limiting Function*
- *Improve Ability to Link Biological and Physical Aspects of Cover Performance*
  - *Vegetation Requires Oxygen, Nutrients, and Water*
  - *Root Development Dependent on In Situ Conditions* ***not User Defined***

Cover Performance Monitoring

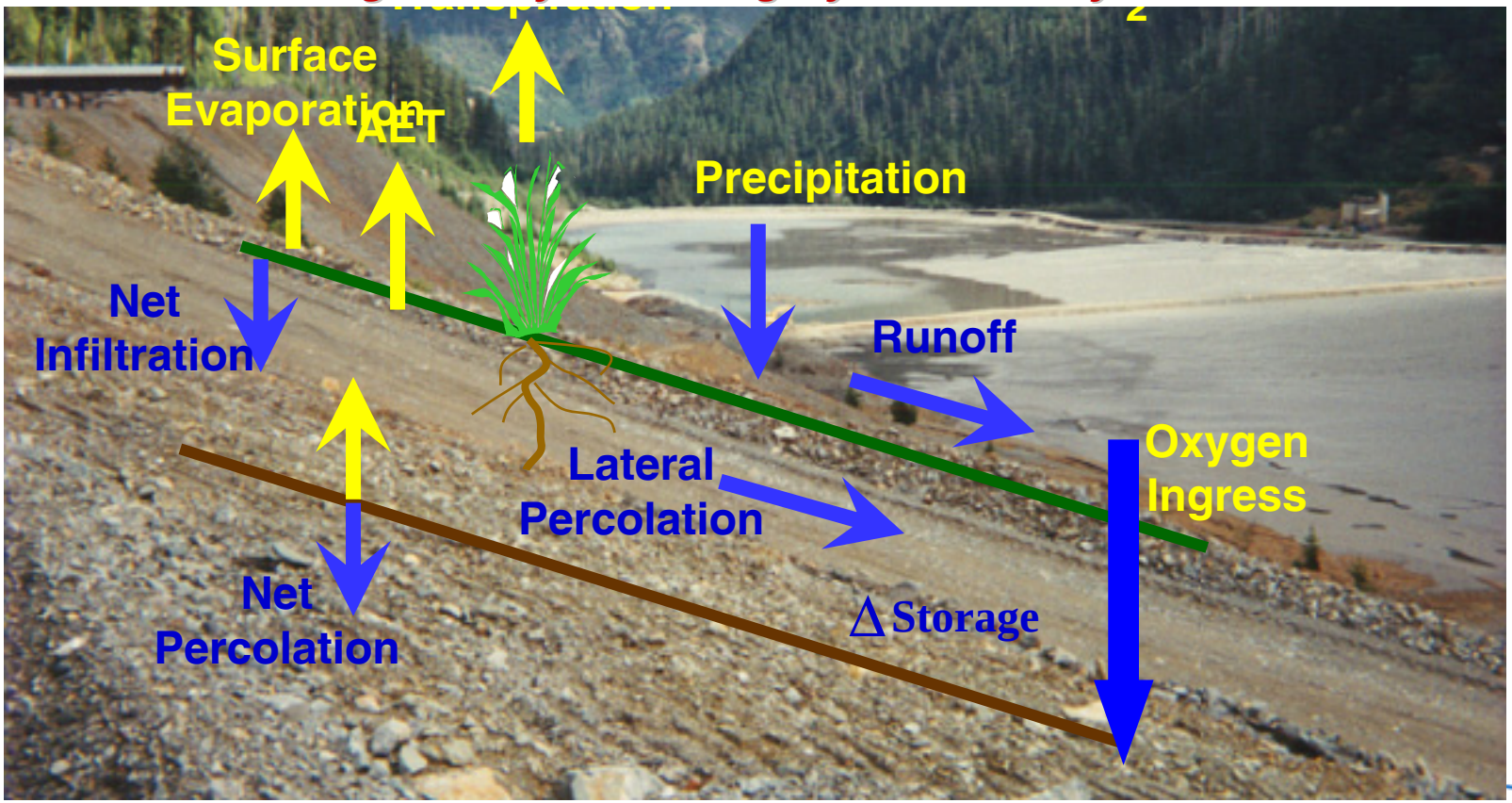


- Direct In Situ Monitoring
- Basal Flow?
- Water Quality Monitoring

In Situ Direct Cover Monitoring

- *Change in Field Hydraulic Conductivity*
- *Change in Moisture Retention Characteristics*
- *Change in Oxygen Diffusion Characteristics*
- *Change in Physical Integrity of Cover System*

Long-Term Performance

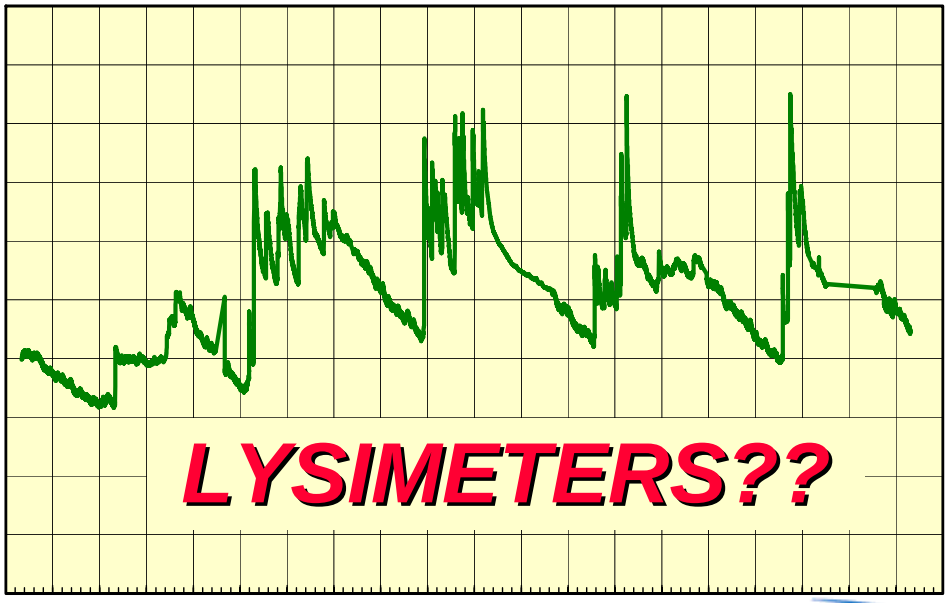


Full-Scale? / Minimum?

Moisture Storage Changes

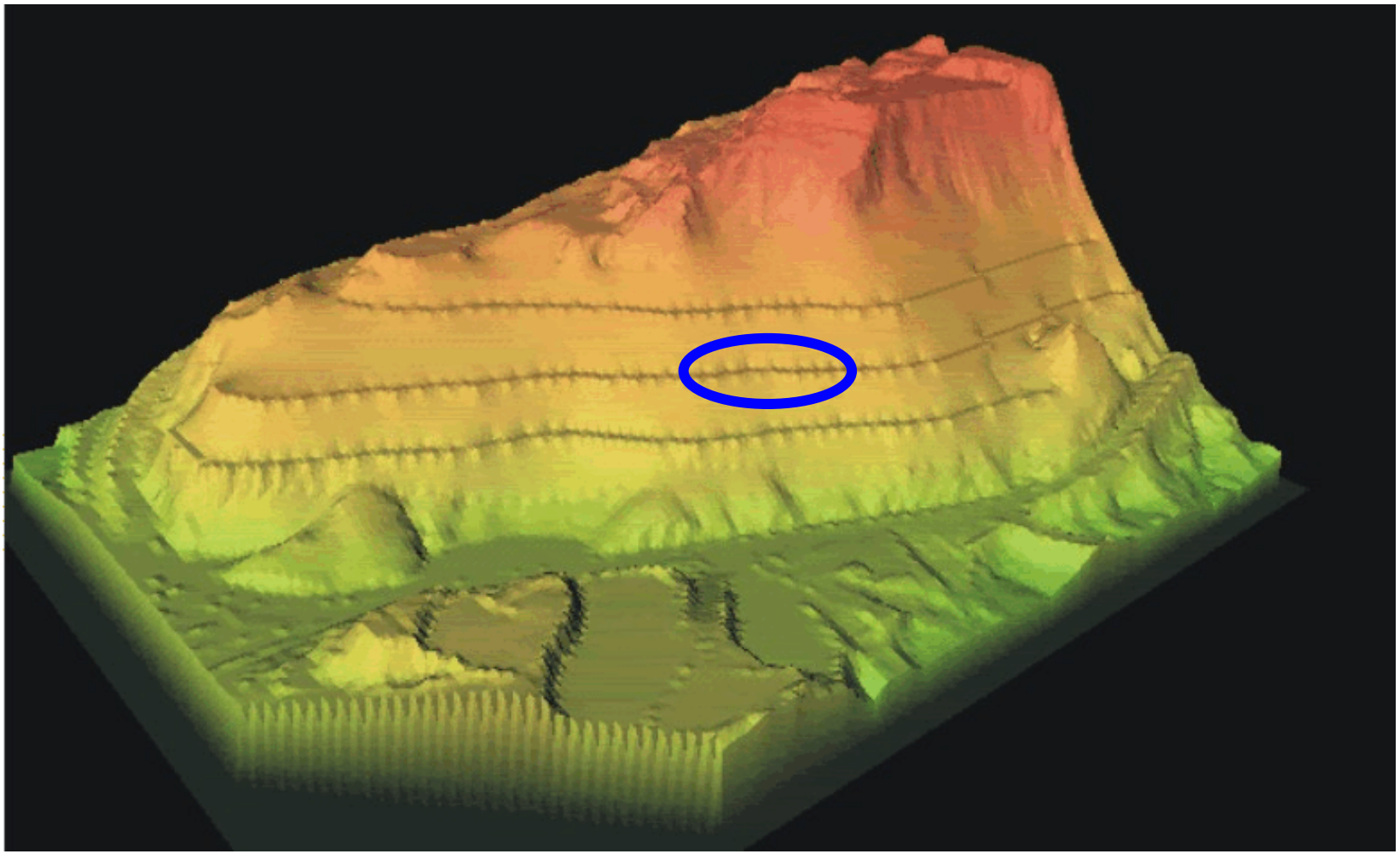
Site Specific Rainfall & SWE

Watershed Surface Runoff



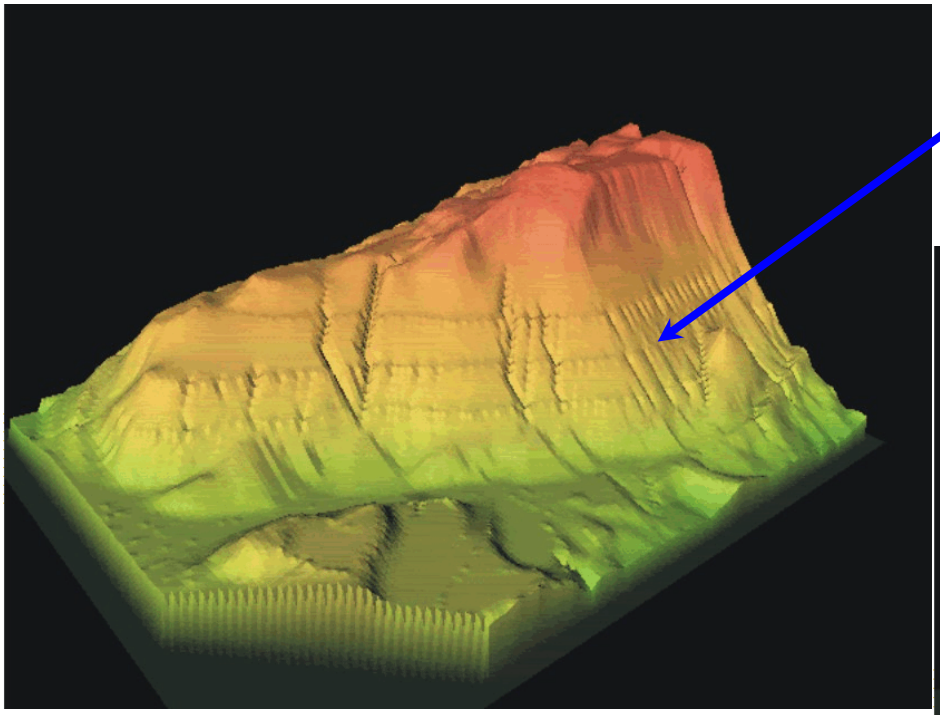
Landform Evolution

After Construction: Contour Banks Installed



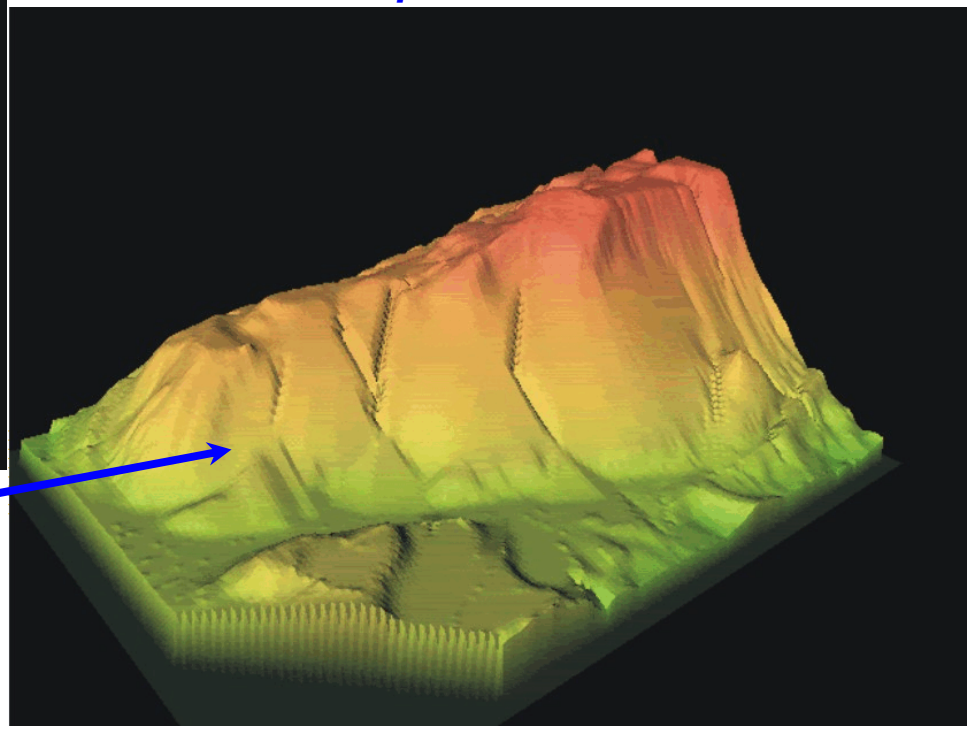
Source: Rob Loch and Greg Hancock

Landform Evolution



Forty Years: with contour banks

High rates of erosion develop once the contour banks fill with sediment and overtop



Forty Years: without contour banks:

Over the long- term the model predicts lower rates of erosion as there are no structures to concentrate flow

Long-term stability can be very different to short-term stability

Source: Rob Loch and Greg Hancock

In Situ Hydraulic Conductivity

Direct Measurement

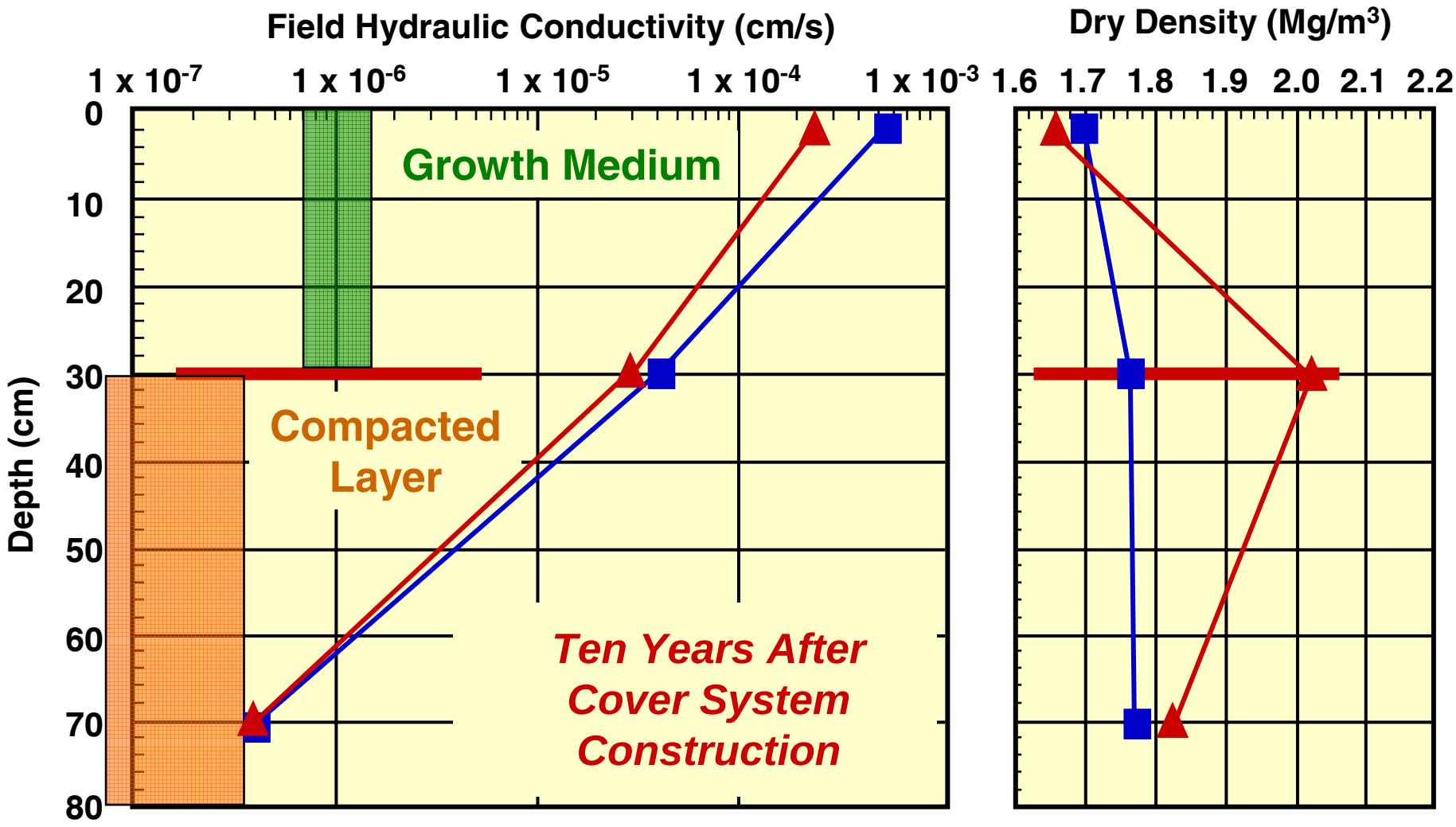
Syncrude Canada Ltd.
(Alberta)

Placer Dome
Equity Silver Mine

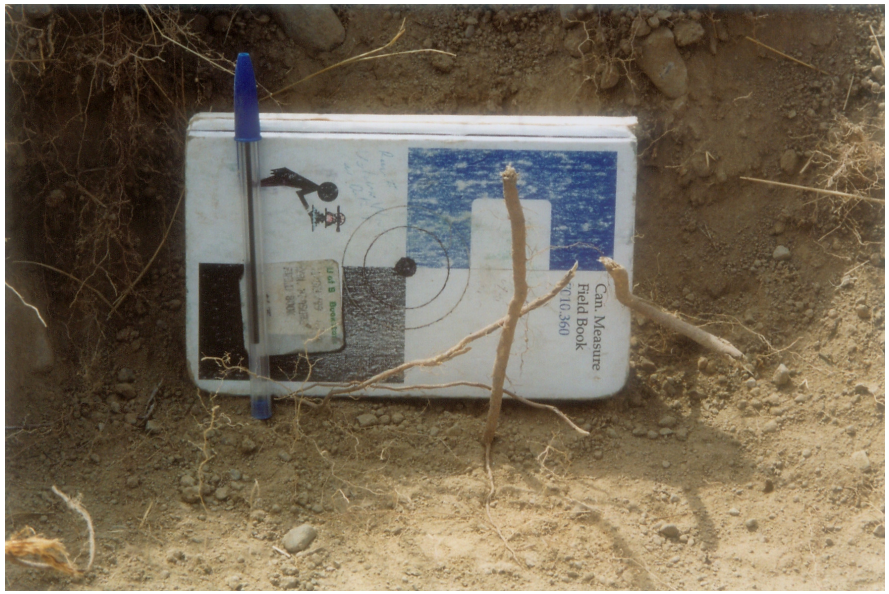
TeckCominco
Kimberley Operations

Montana
Reclaimed Coal Spoil

Field K_{fs} – Equity Silver Mine



Kimberley Operations



Effect of Wet / Dry Cycles

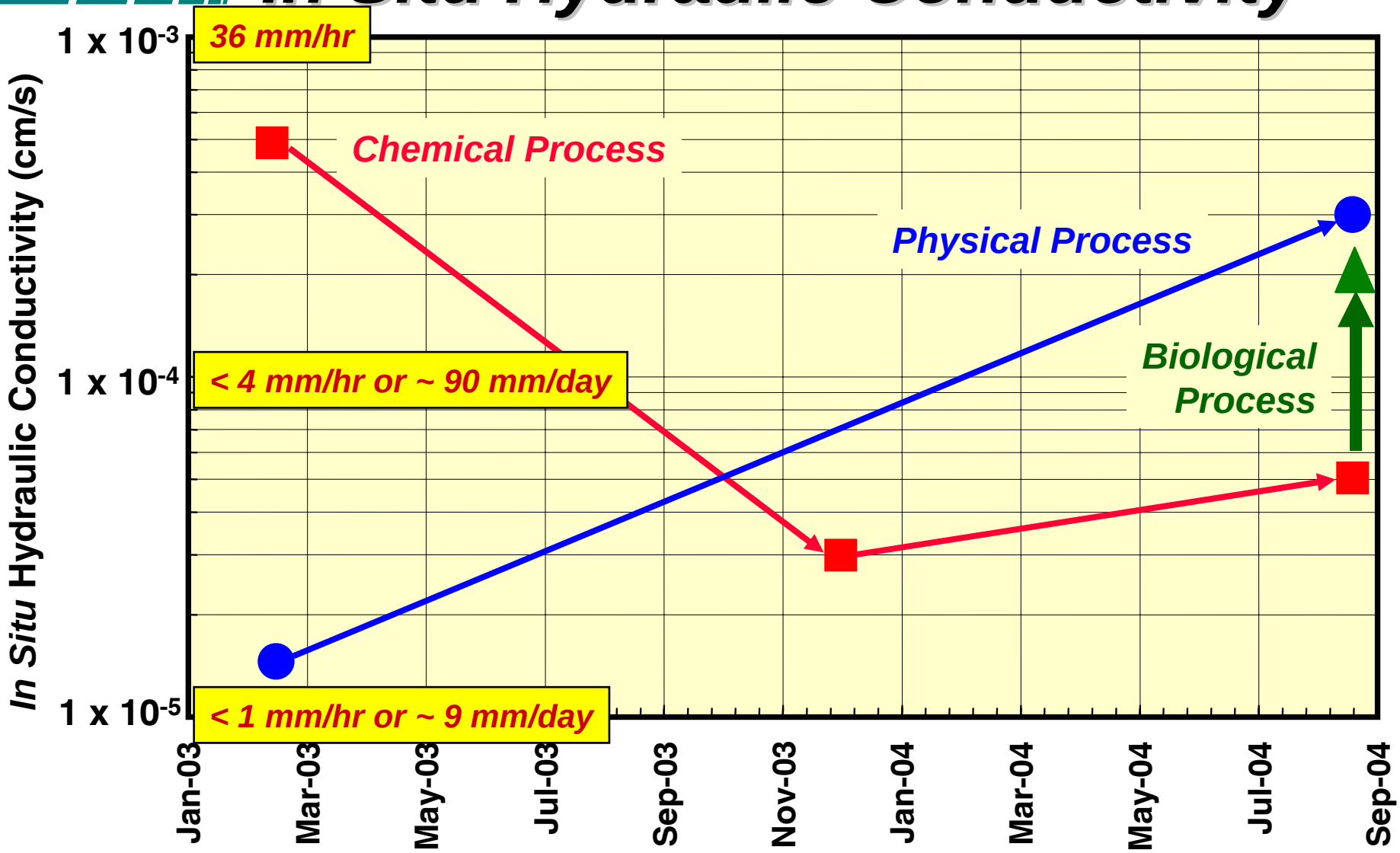
and

Root Development

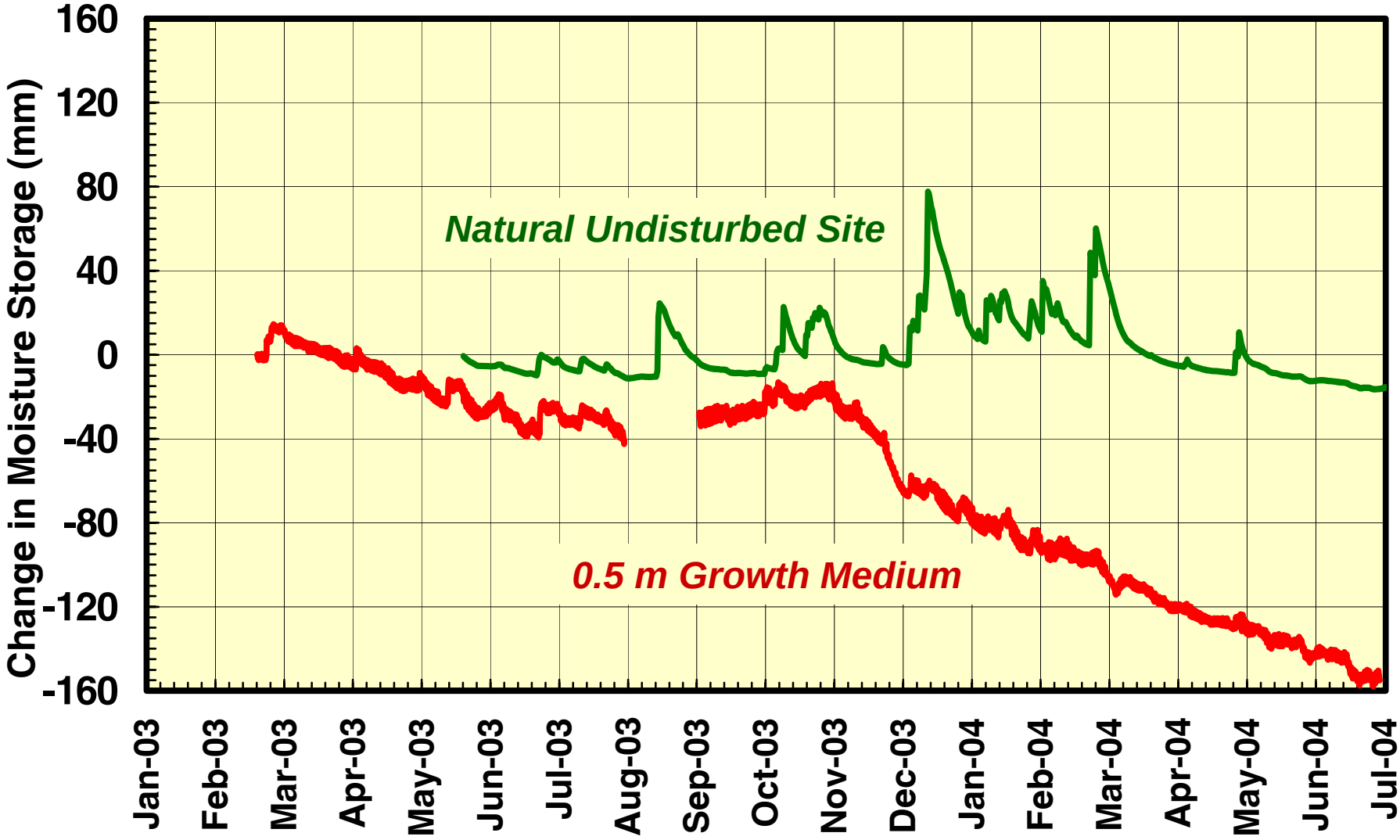
In Situ Hydraulic Conductivity

- Chemical Process
  - Sodic material
- Physical Process
  - Wet/Dry Cycles
- Biological Process
  - Grass and Root Development

In Situ Hydraulic Conductivity



In Situ Hydraulic Conductivity



Plant Available Moisture

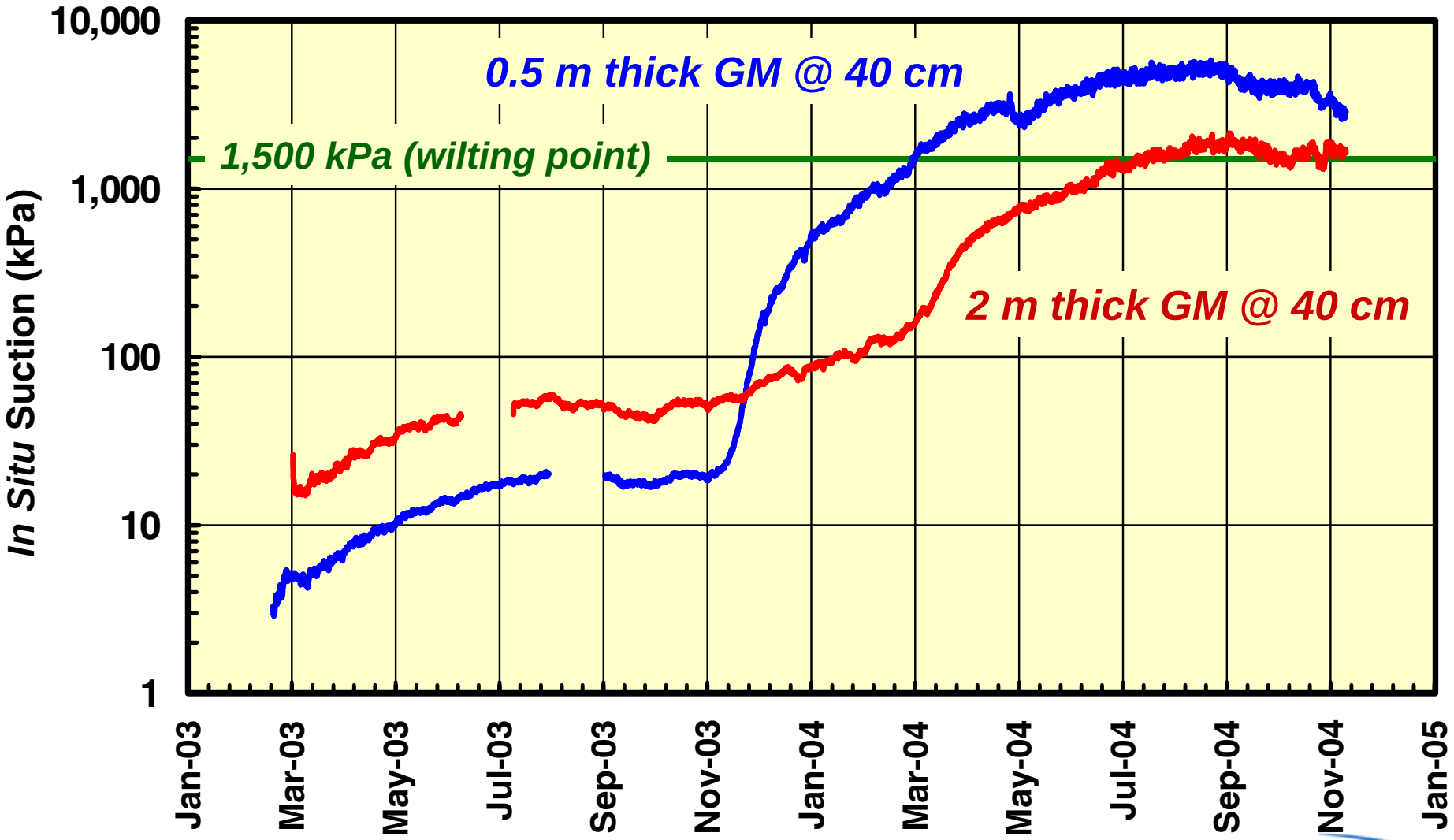
2 m thick Growth Medium

0.5 m thick Growth Medium

Artificial Drought Condition??

Plant Available Moisture

Influence of Growth Medium Thickness



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Thickness of Growth Medium

Bioturbation

Low-level radioactive tailings exposed by biological activity approximately 5 years after cover placement

Source: Mike Fawcett

Key Points

- *Unsaturated* System Where Performance is Intimately *Coupled to Atmosphere*
  - *Dynamic* not Static
- *In Situ Performance Monitoring*
  - Paramount for *Understanding* the *Processes* Controlling *Long-Term* Performance
  - *In Situ K-tests* as a Surrogate for Evaluating *Impact of Processes*
- *Thickness of Growth Medium?*
  - Typically Focus on Compacted Layer
  - *As Much Design Required for GM*
  - Site Specific Physical, Chemical, Biological Processes?
    - *Evolution of Cover Material*
  - Climax Vegetation?
    - *If Build It…..It Will Come!*