Cover Systems in the Athabasca Oil Sands

A Summary of the "Green Bullet" and Ten Years of Reclamation Research at Syncrude Canada Ltd.

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Presentation Outline

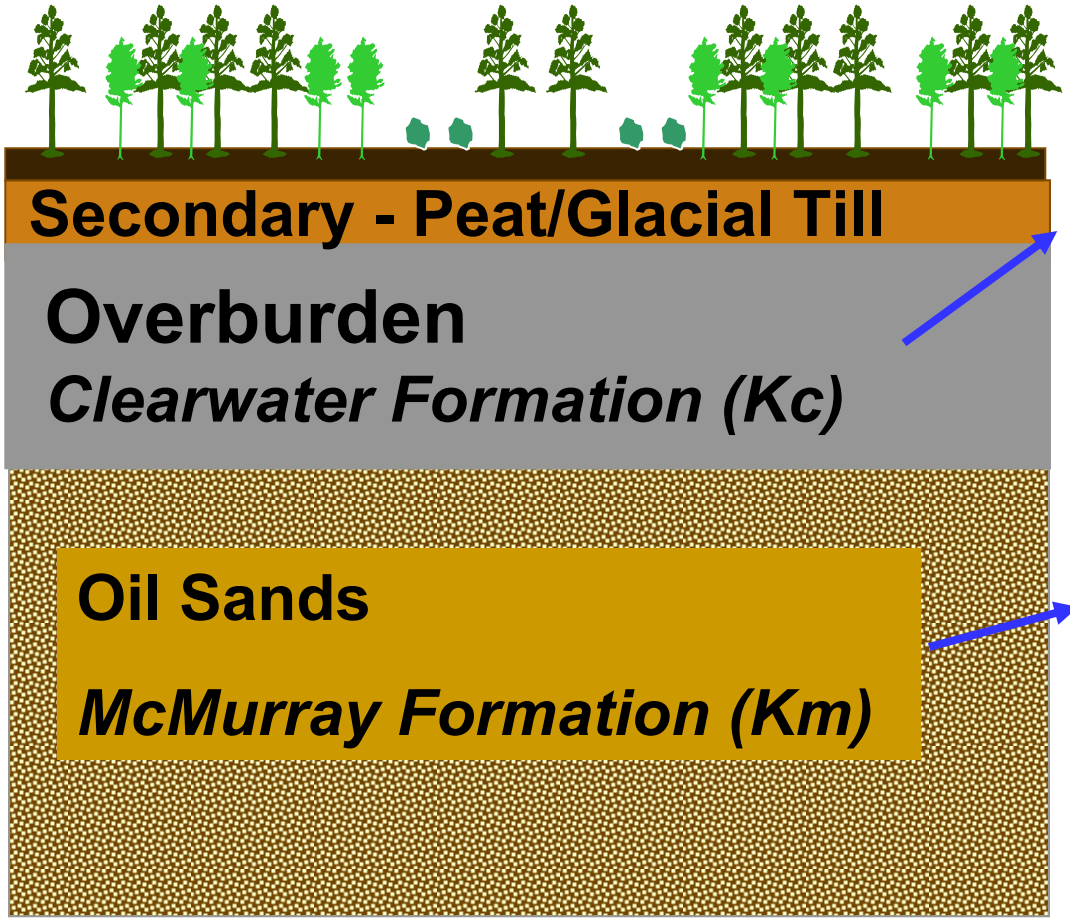
- Background:
  - Oil Sands Mining and Syncrude Canada Site
  - Site Description
- Technology Transfer Process
- Discussion and Examples of Key Lessons Learned
  - Net Percolation
  - Soil Moisture
  - Soil Salinity / Sodicity
  - Soil Nutrients and Biological Response

Site Location: Ft. McMurray, AB.

- **Opened 1978 - Mining to 2030**
- **Economics**
  - 2001 production - 81.4 million barrels (223,000 bpd)
  - Total production to 2001 ~ 1.3 bbl
  - $1billion annually / $8 billion expansion
- **Northern Alberta Reserves**
  - 1.7 to 2.5 trillion barrels of bitumen
  - >300 billion barrels recoverable with current technology
- **Significance**
  - ~ 13% of Canada's energy and 25% of Canada's light/sweet crude
  - Projected to be …
    ~25% of Canada's Energy within next 5 years
    - All oilsands mines will supply ½ of Canada's Petroleum in 10 years

Athabasca Oil Sands

- *Deposits of bituminous sands*



Saline-Sodic Clay Shale

Mature Fine Tails (MFT)

Composite Tails (CT)

Tailings Sand

Sulphur

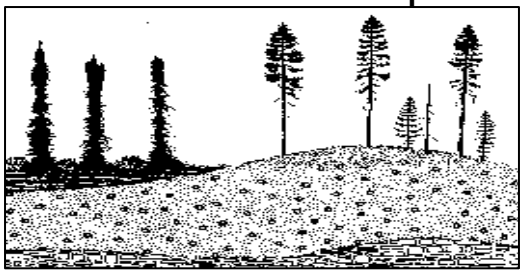
Coke

Key Waste Management Challenges

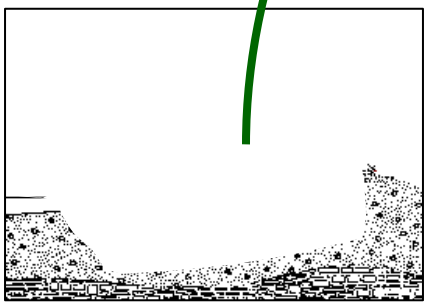
- Challenging waste materials
- Large areas and volumes to reclaim
- High expectations

NATURAL

Pre-disturbance Capability (A)

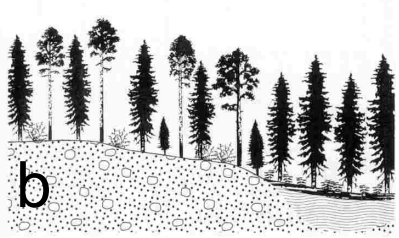


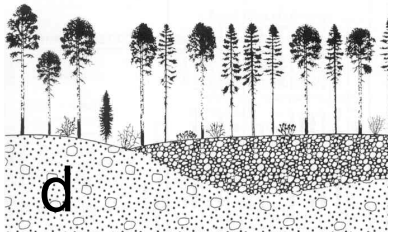
DISTURBANCE



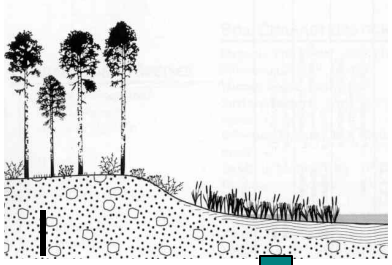
Capability = 0

Redeveloped ≠ Restore





Post-disturbance Capability (B)



Need to Characterize and Quantify the Fundamental Processes Controlling Reconstructed Landscape evolution:

BOND RELEASE and CERTIFICATION

15 yr?

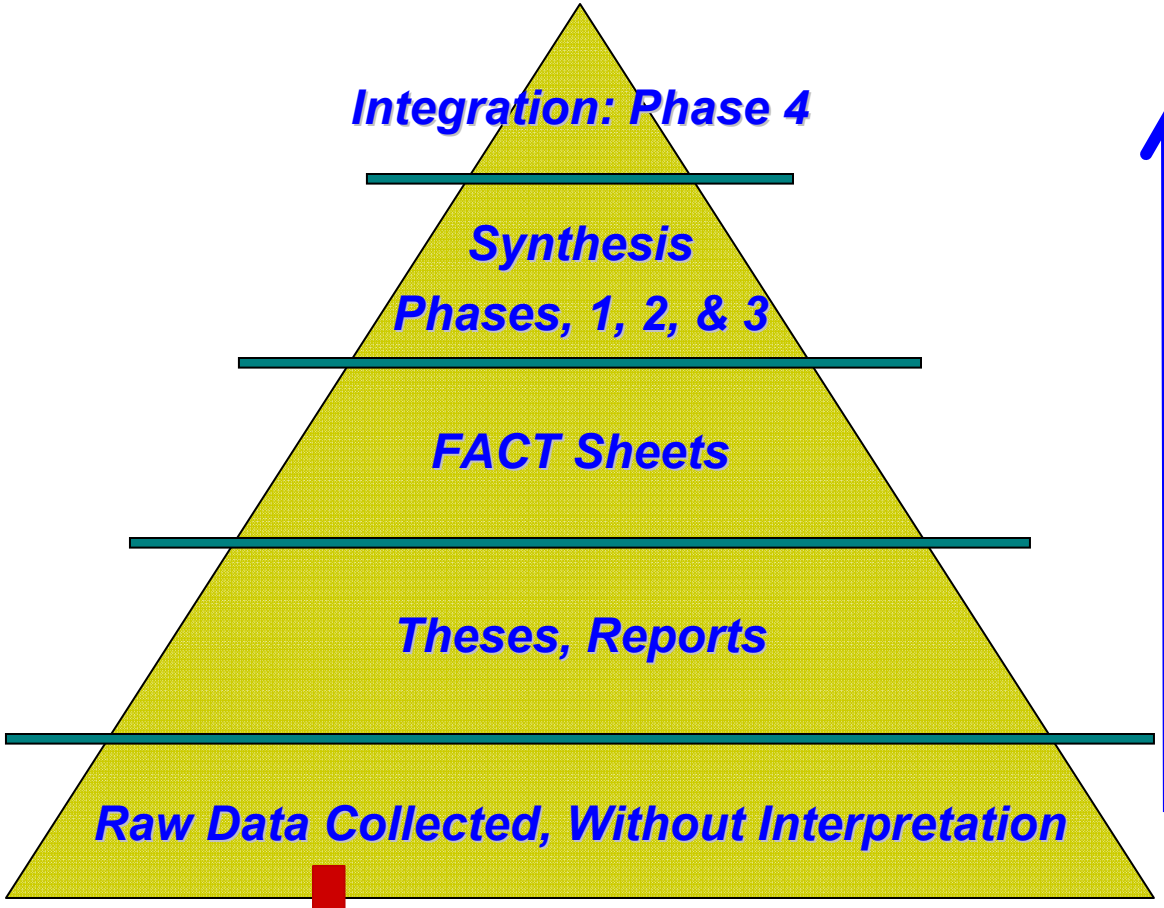
20+ yr ?

Time

Source: Clara Qualizza, Syncrude Canada Ltd.

Technology Transfer Process

A Process Developed to Interpret Data
and Establish Lessons Learned for Industry



Degree of Interpretation:

All levels necessary to provide lines of evidence for change to reclamation practice

Example of Database

Data Management

Syncrude

Site Menu

- Home
- Main Map
- Base Mine Map
- South Hills Map
- Southwest Sand Storage Map
- Mildred Lake Map
- Multi Station Charting
- Frequently Asked Questions

South Hills Map

The Team

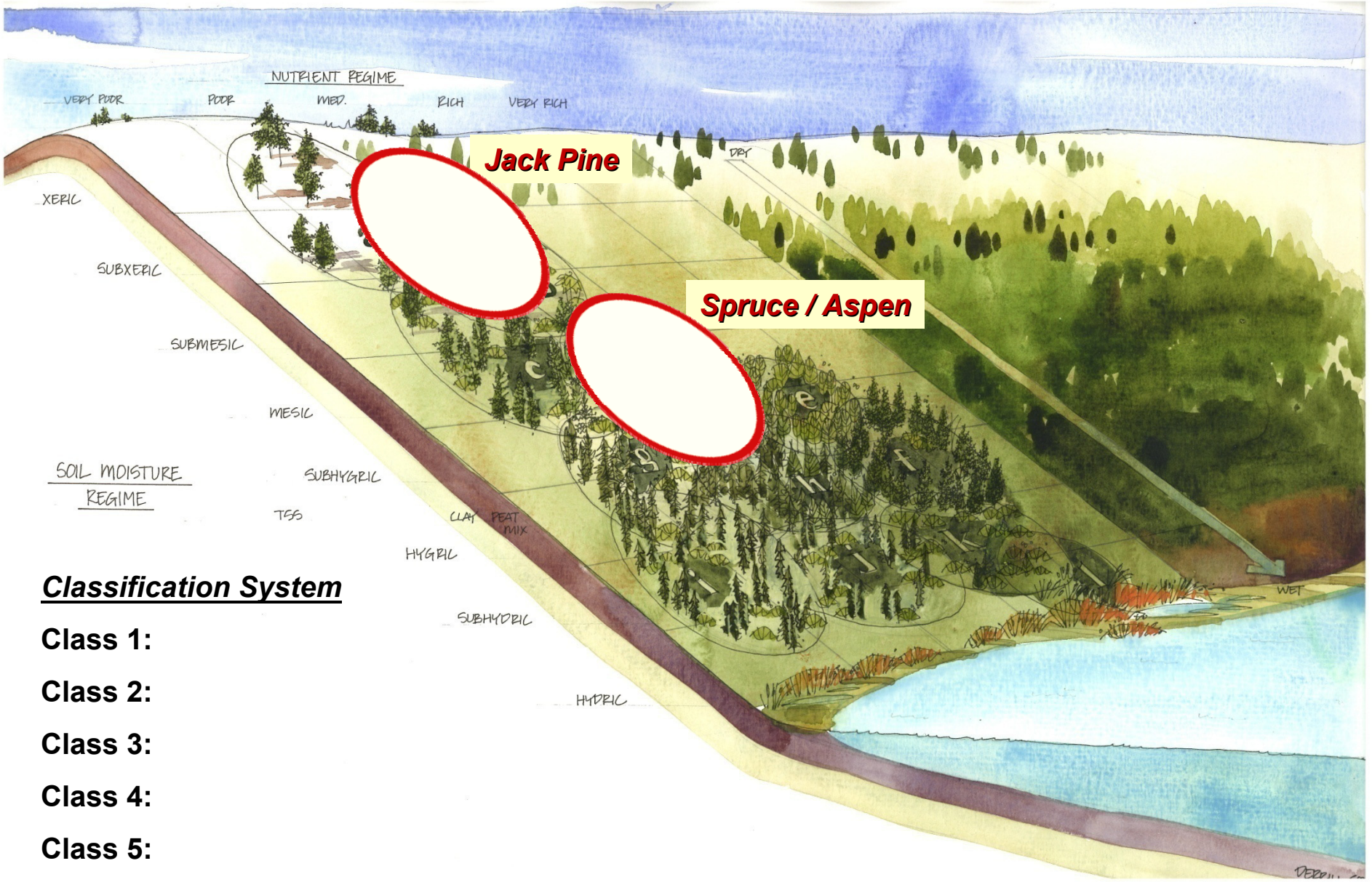
- Lee Barbour (UofS)
- David Chanasyk (UofA)
- Jim Hendry (UofS)
- Len Leskiw (Paragon Soil)
- Terry Macyk (ARC)
- Carl Mendoza (UofA)
- Craig Nichol (UBC)
- Mike O'Kane (O'Kane Consultants)
- Brett Purdy (UofA)
- Clara Qualizza (Syncrude Canada Ltd.)
- Sylvie Quideau (UofA)
- Clive Wellham (UofA)

Reclamation Approach

- *It is the major building block of landscapes*
- *Majority of questions asked about landscape performance can be addressed at the watershed scale*
- *It can encompass the range of target ecosites desired for the particular reclamation material*
- *It allows for "real" measurement of balances and patterns*
- *It demands thought about interactions*
- *It is manageable*

Source: Clara Qualizza, Syncrude Canada Ltd.

Ecosystem Objectives (Edaphic Grid)



Classification System

Class 1:

Class 2:

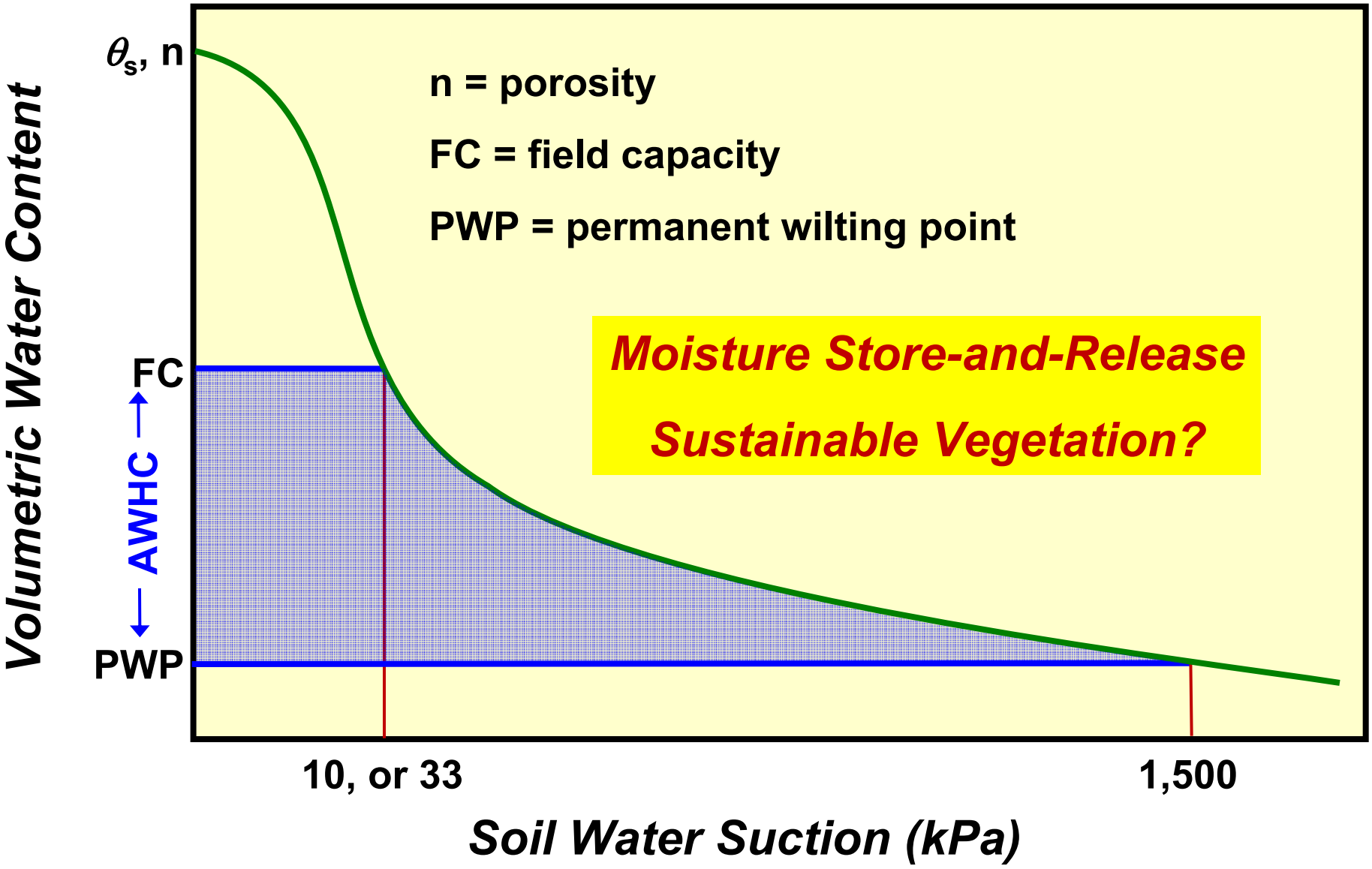
Class 3:

Class 4:

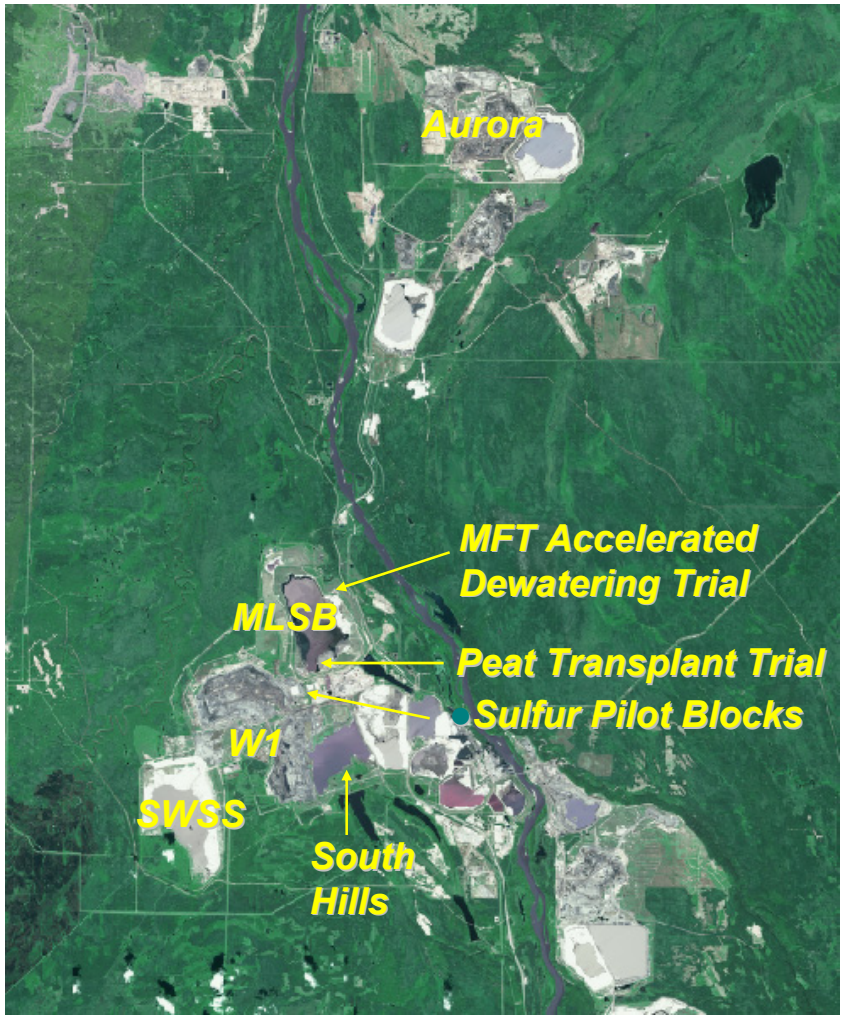
Class 5:

LCCS Manual and AWHC

Available Water Holding Capacity (AWHC)

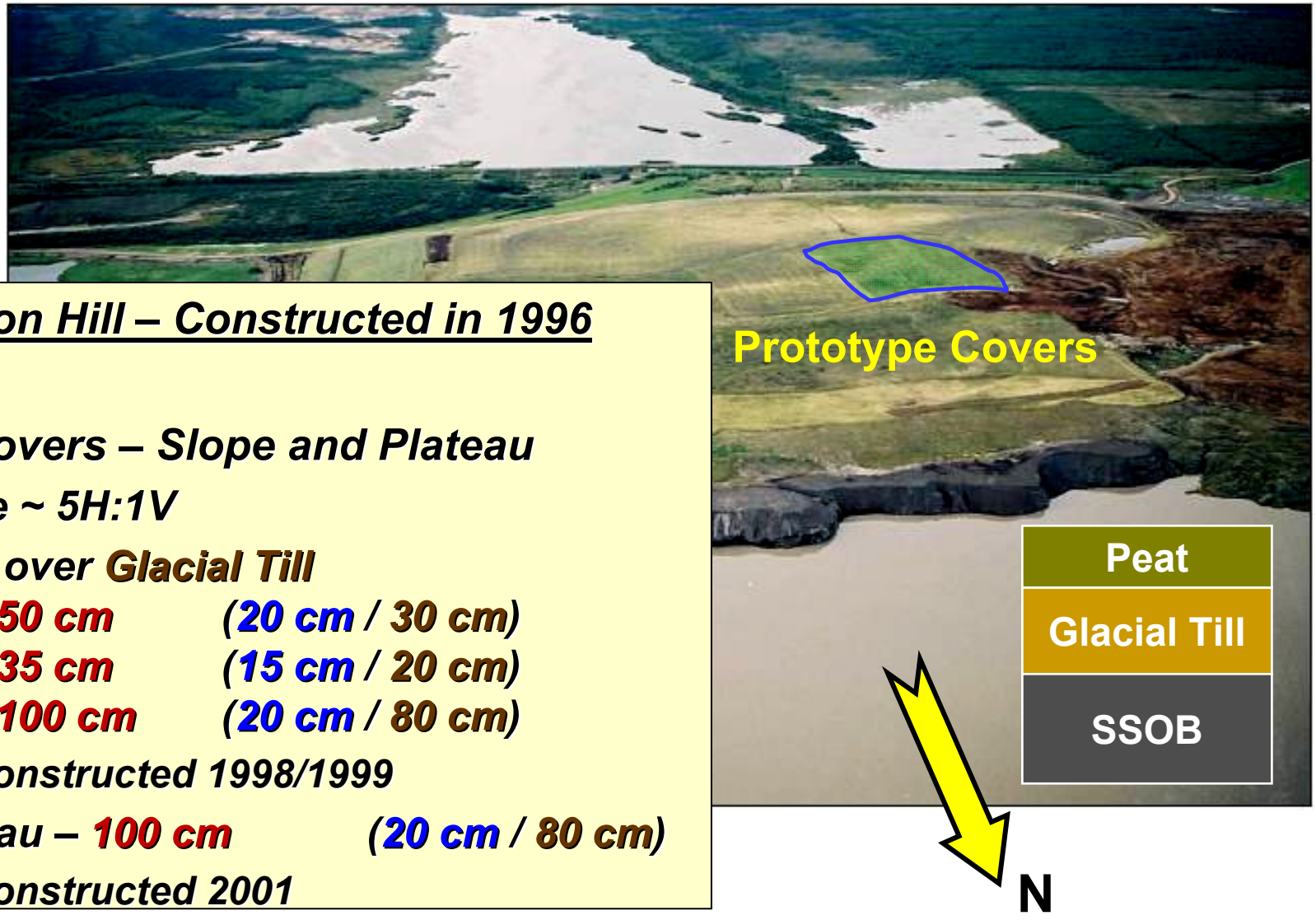


Performance Monitoring



- 26 soil moisture monitoring sites
- Nine fully instrumented meteorological stations
- Three weirs to monitor runoff at South Hills Watershed
- Reclamation areas and research projects

Prototype Covers

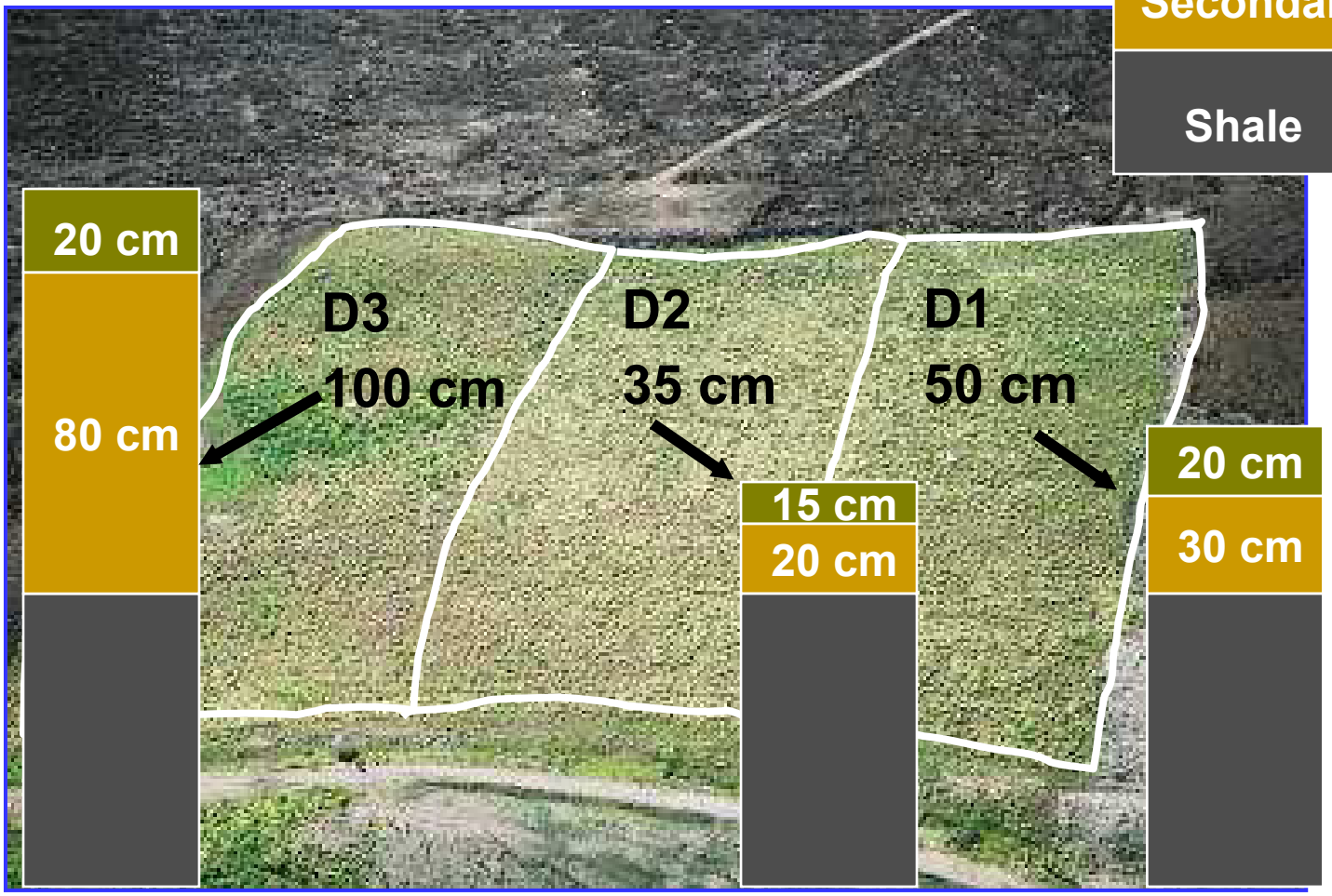


South Bison Hill – Constructed in 1996

Layered covers – Slope and Plateau

- *Slope ~ 5H:1V*
- ***PMM** over **Glacial Till***
  *D1 – **50 cm** (**20 cm** / **30 cm**)*
  *D2 – **35 cm** (**15 cm** / **20 cm**)*
  *D3 – **100 cm** (**20 cm** / **80 cm**)*
  - *Constructed 1998/1999*
- *Plateau – **100 cm** (**20 cm** / **80 cm**)*
  - *Constructed 2001*

Prototype Covers



Prototype Covers

Prototype Covers

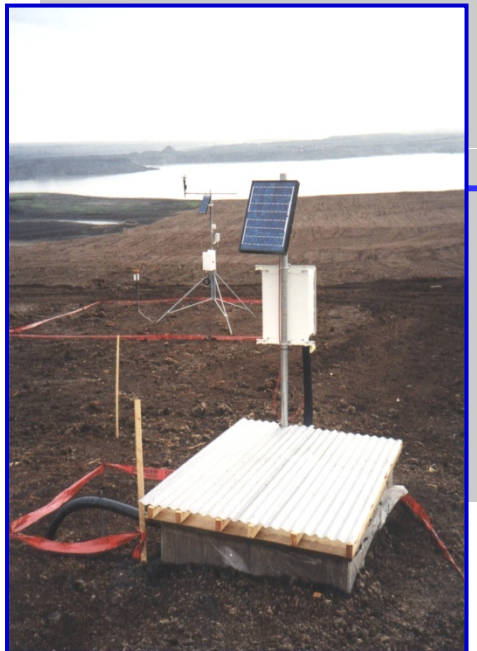
Bill's Lake

Bill's Lake

Bill's Lake

Monitoring


Runoff Weir
2. 11. 2002



N
Reclamation Material
Instrumentation Station
Neutron Access Tube
Drainage Ditch
Interflow Collection
and saturated wedge monitoring
Saline Sodic Overburden

Interflow Catchment System

Key Messages – Key Mechanisms

- *Current Placement Methodology = Excellent Soil Structure*
  - *Increasing Hydraulic Conductivity in 3-5 y (Cover and SSOB)*
- *Estimates of AHWC with LCCS are Accurate to Conservative Relative to Field Measurements*
- *Enhanced Moisture Holding Capacity due to Layering and use of Peat Mineral Mixes.*
  - *Accurately to Conservatively Estimated by 2006 LCCS*
- *'Best Practice'*
  - *35 cm covers Cannot Meet all of the Moisture Demands for Mesic Regime*
  - *50 to 100 cm Layered Covers Provided the Lowest risk of Moisture Deficits*
- *Moisture Dynamics Intimately Linked to Salt and Nutrient Dynamics*

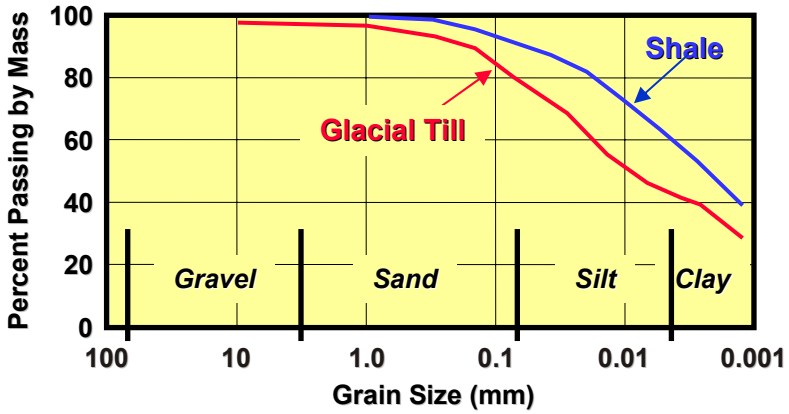
In Situ Hydraulic Conductivity

Direct Measurement

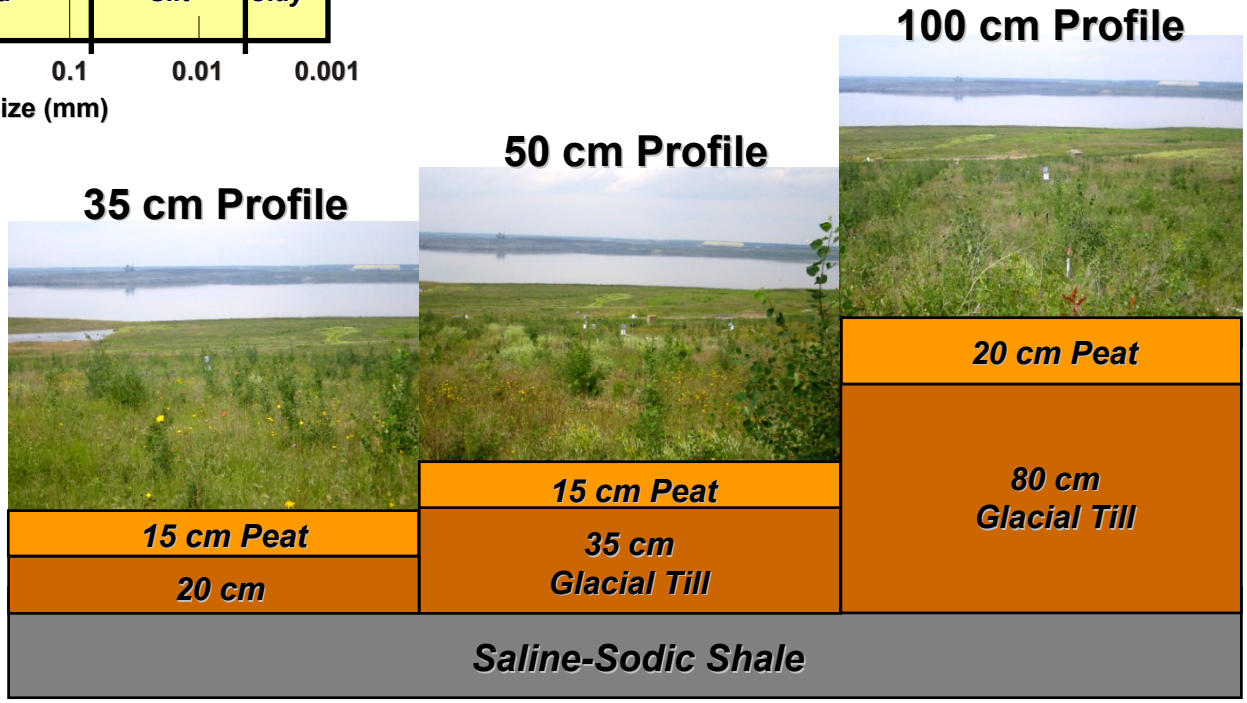
Guelph Permeameter and Tension Infiltrometer

Example: Change in k_{fs}

Moisture Store-and-Release Covers

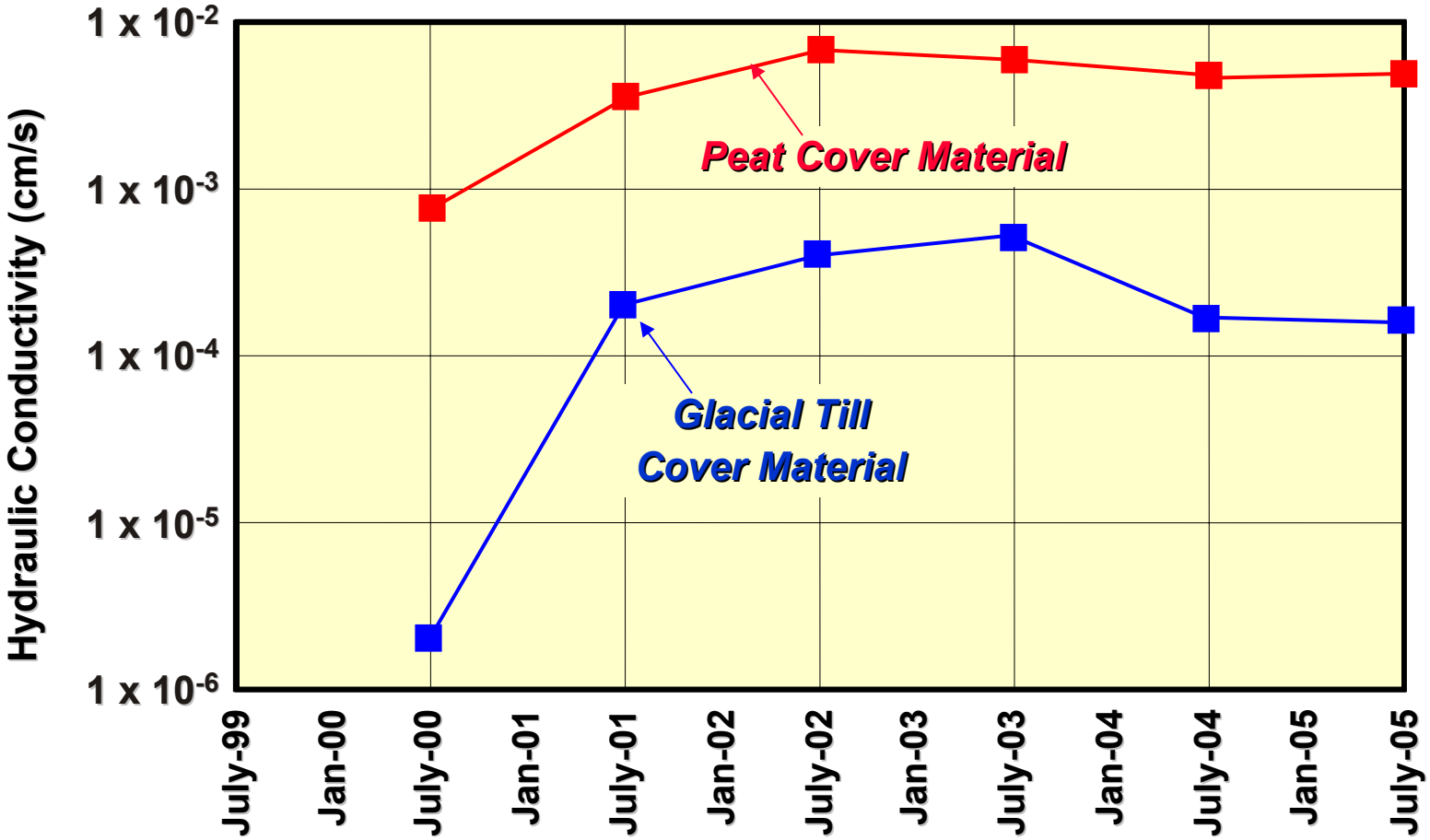


Fine grained materials
> 80% silt and clay sized particles



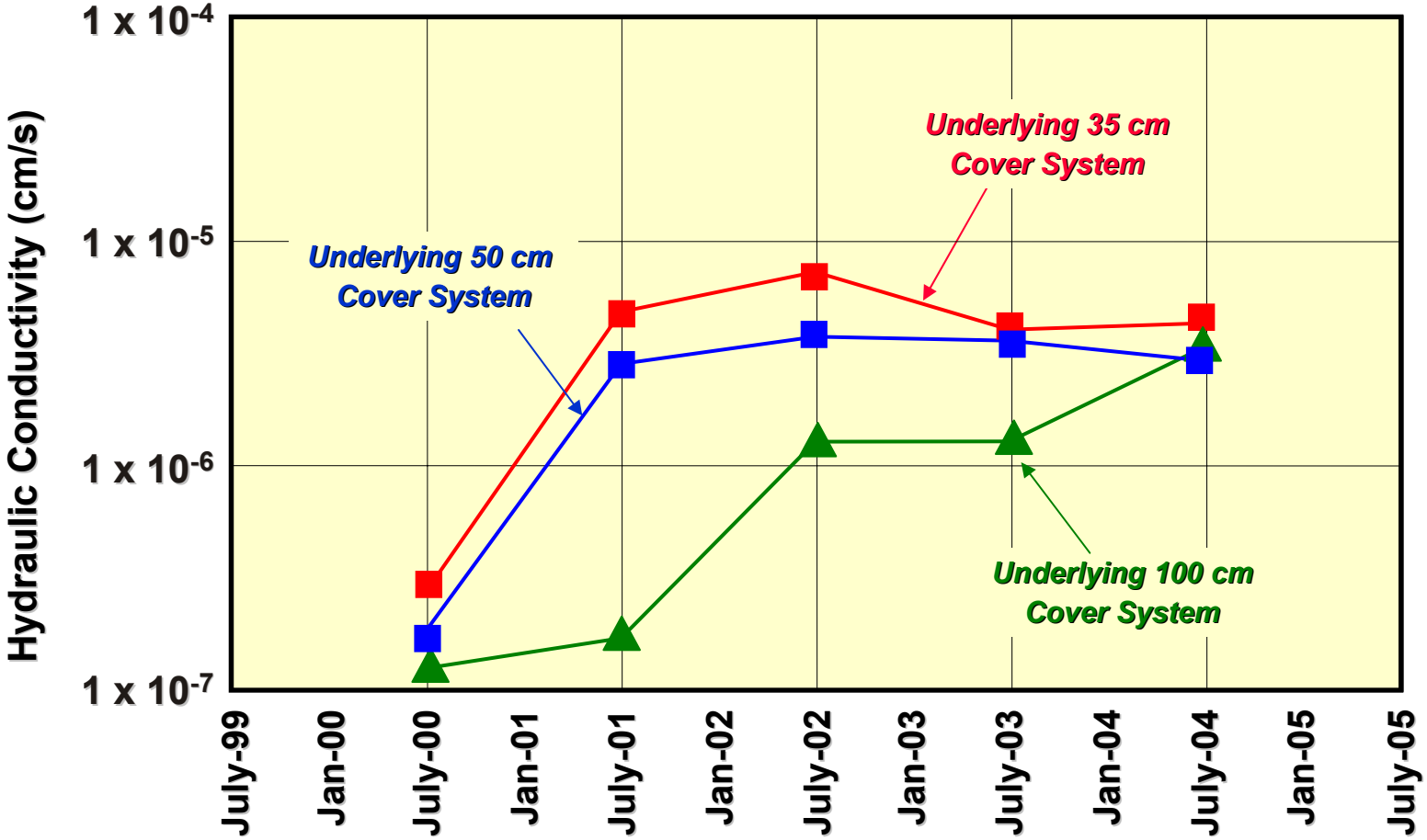
Example: Change in k_{fs}

Hydraulic Conductivity – Cover Material



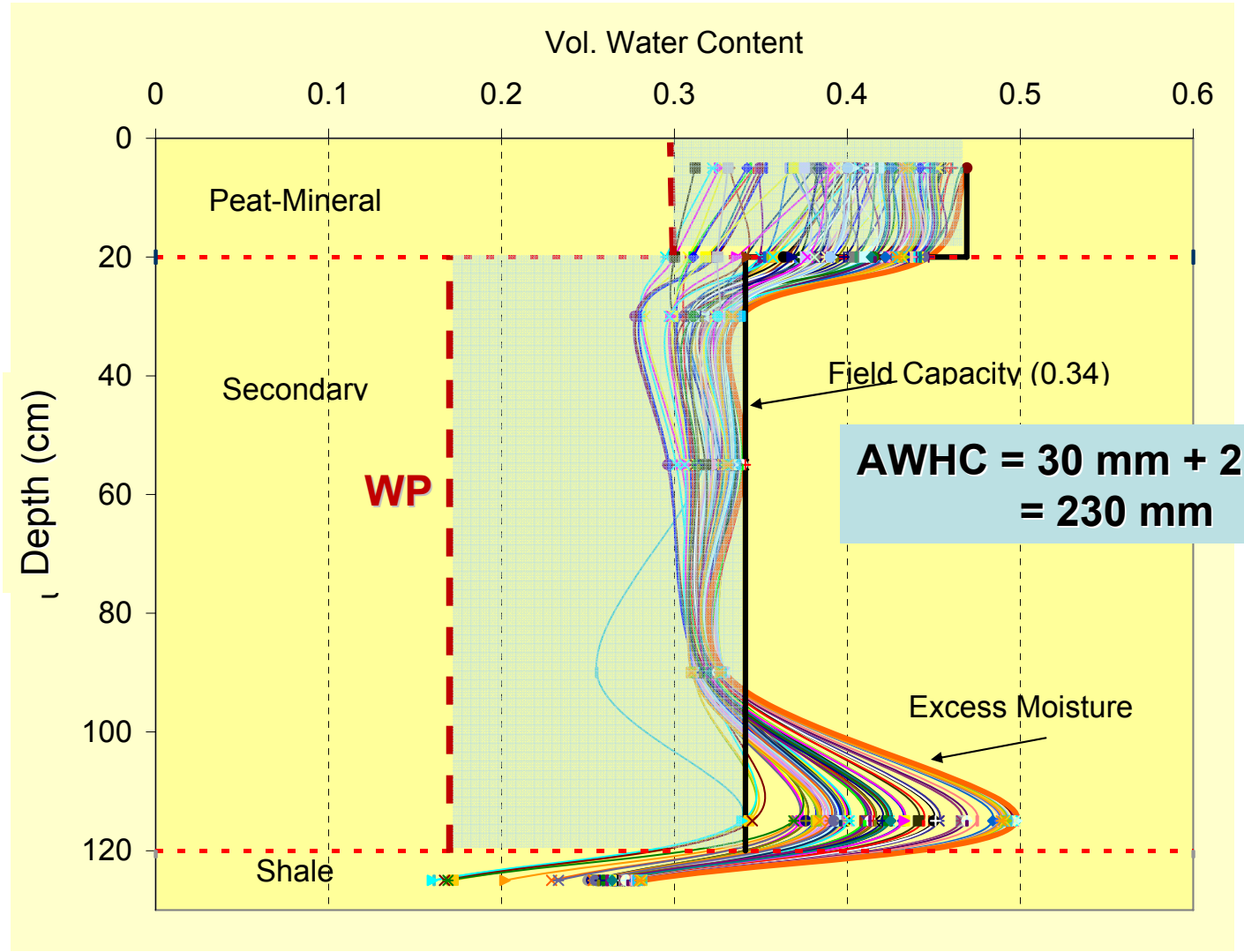
Example: Change in k_{fs}

Hydraulic Conductivity – Saline-Sodic Shale



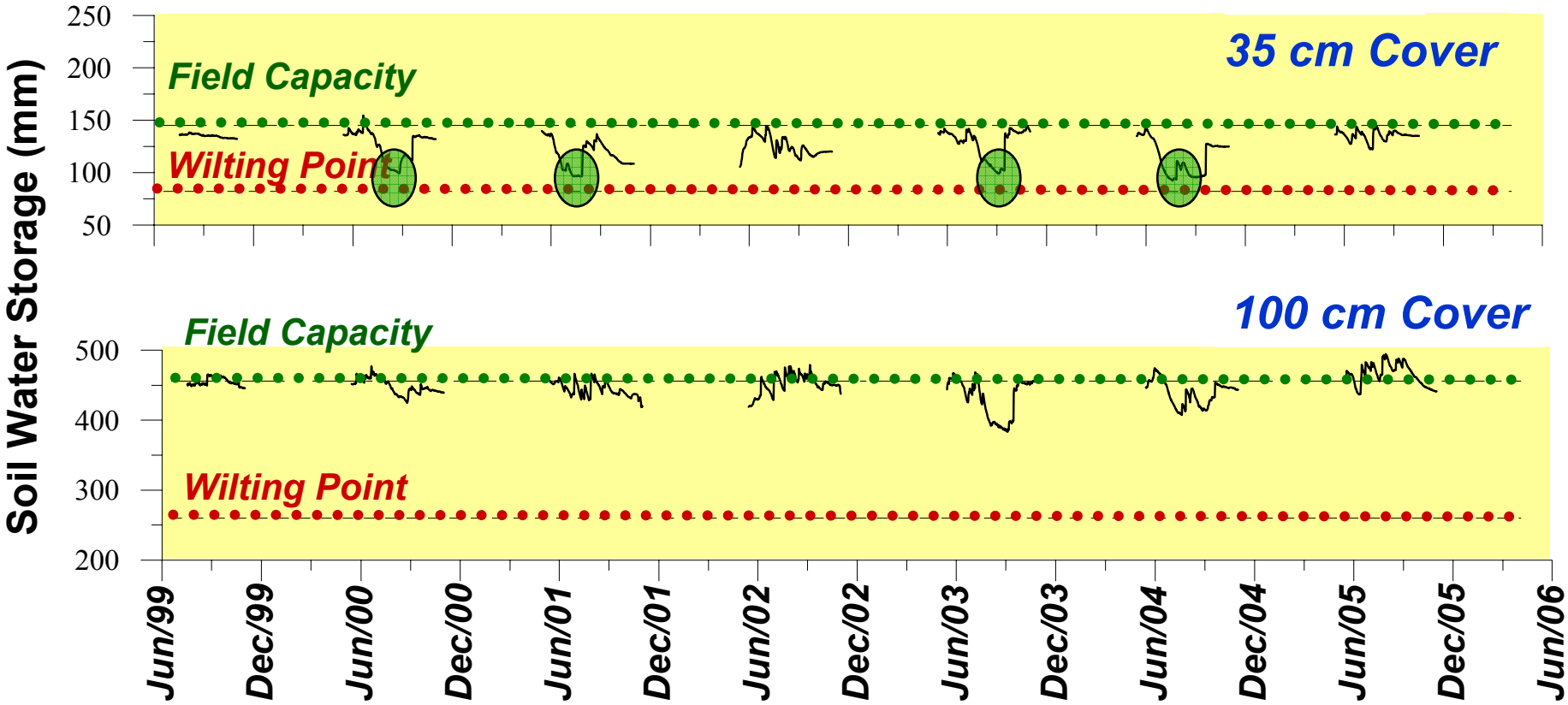
Available Water Holding Capacity

- *Available Water Holding Capacity*
  - ***AWHC = ∑(FC-WP)* Δz***



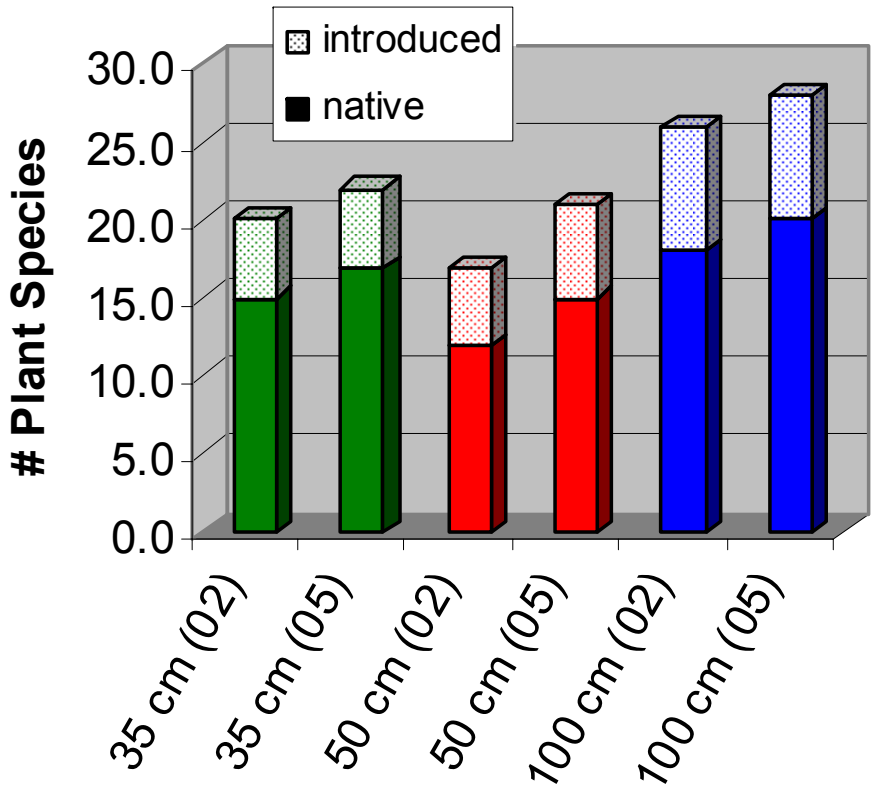
Illustrative Case Study

Measured Long Term Moisture Storage



Plant Community Composition

Measured Long Term Moisture Storage

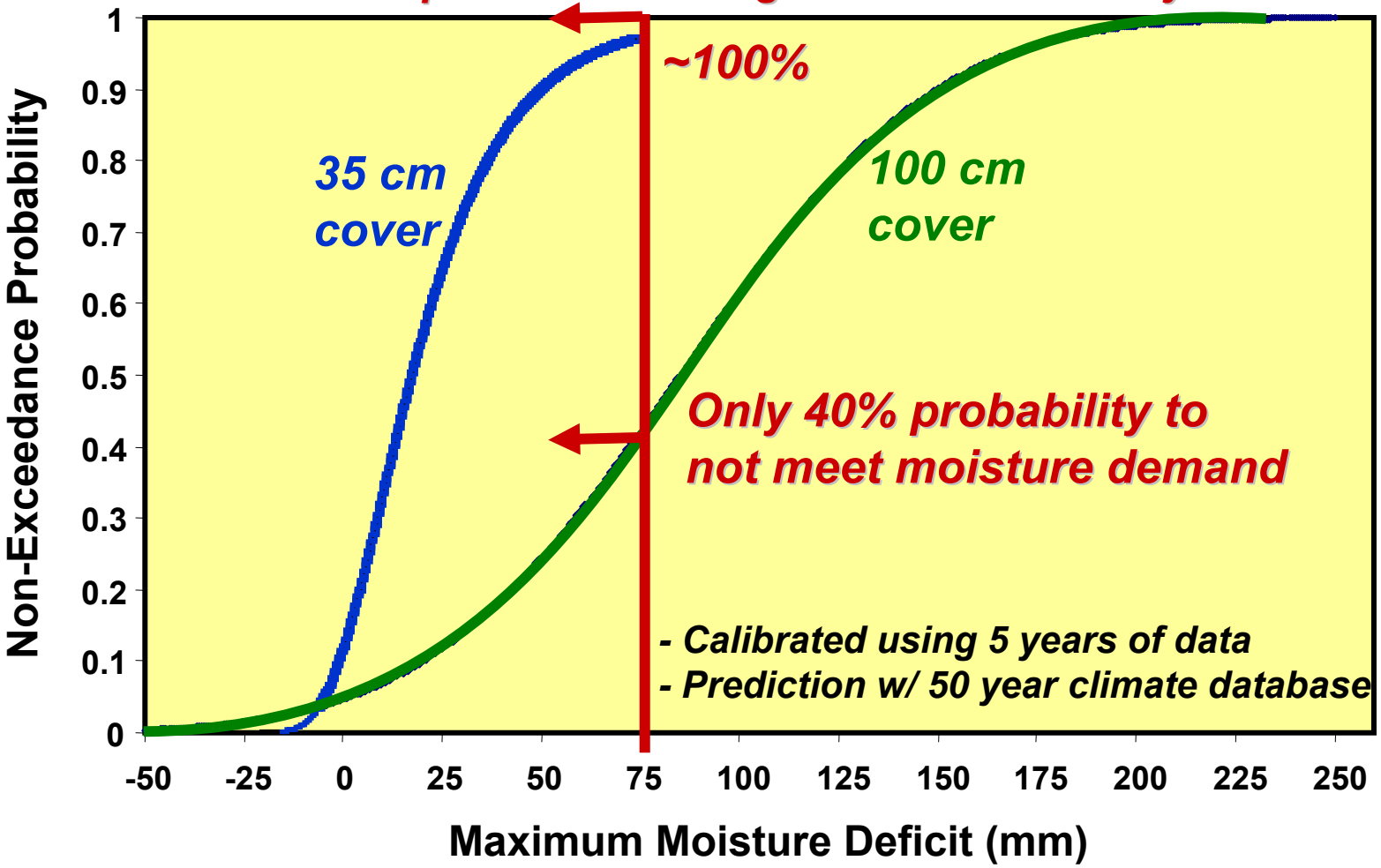


- **Species Richness**
  - Non-native species ~ 25% (all covers, both sampling periods)
  - Increasing richness over time
- **Capping Treatment – Some Differences**
  - MORE species in thicker covers
  - LESS bare ground in thicker covers
- **Succession**
  - Foliar cover less dominated by non-natives in 2005

System Dynamics Watershed Model

Illustrative Modelling of Long Term Moisture Storage

- relative probability of ability to supply moisture requirements through various climate cycles -



Elshorbagy et al. (2005)

Layered vs. Mono-Layer

Mono-Layer

100 cm

Layered

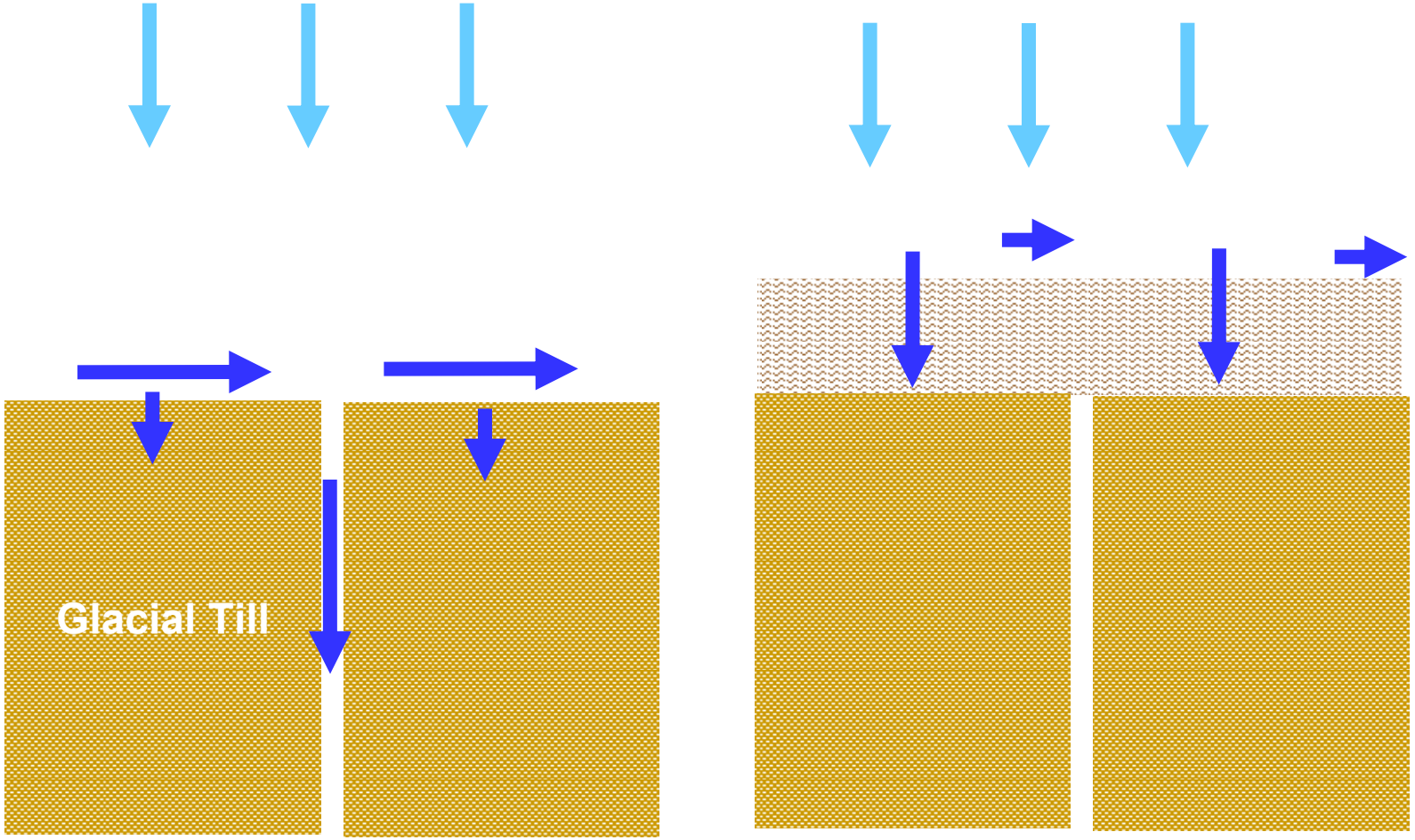
Peat

Secondary

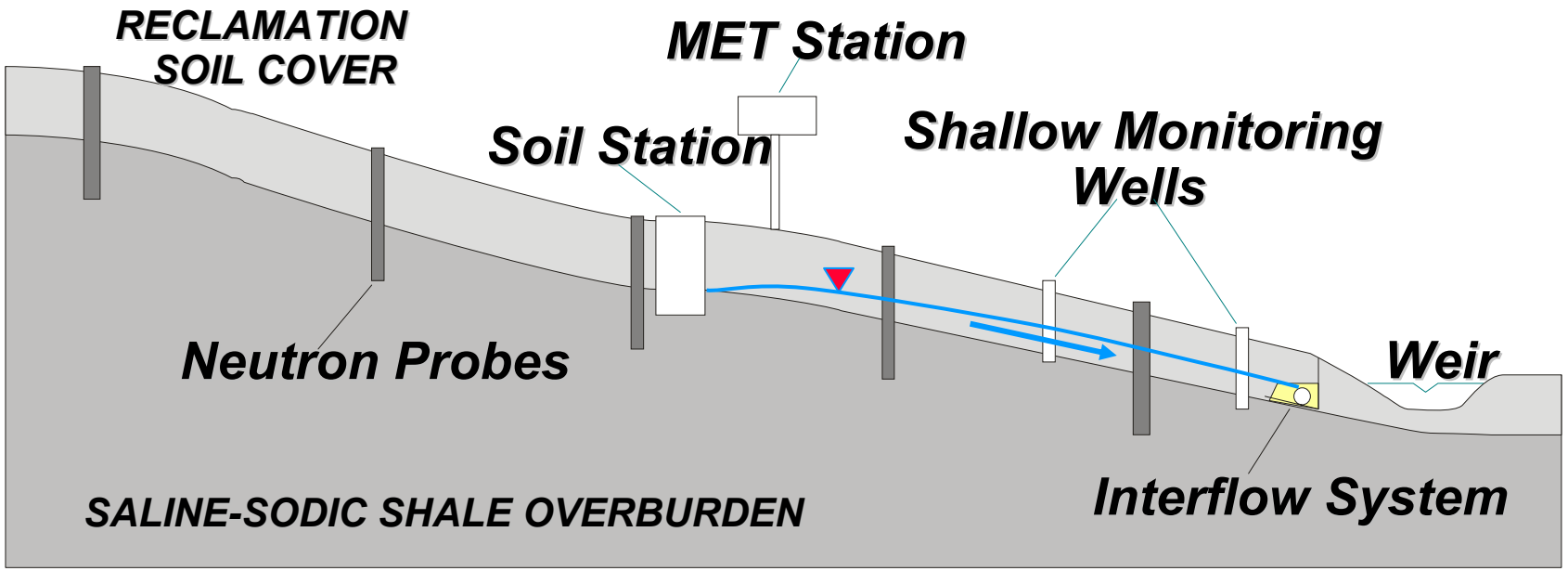
Shale

Hydraulic Role of Top Soil Layer

Moisture Storage Response

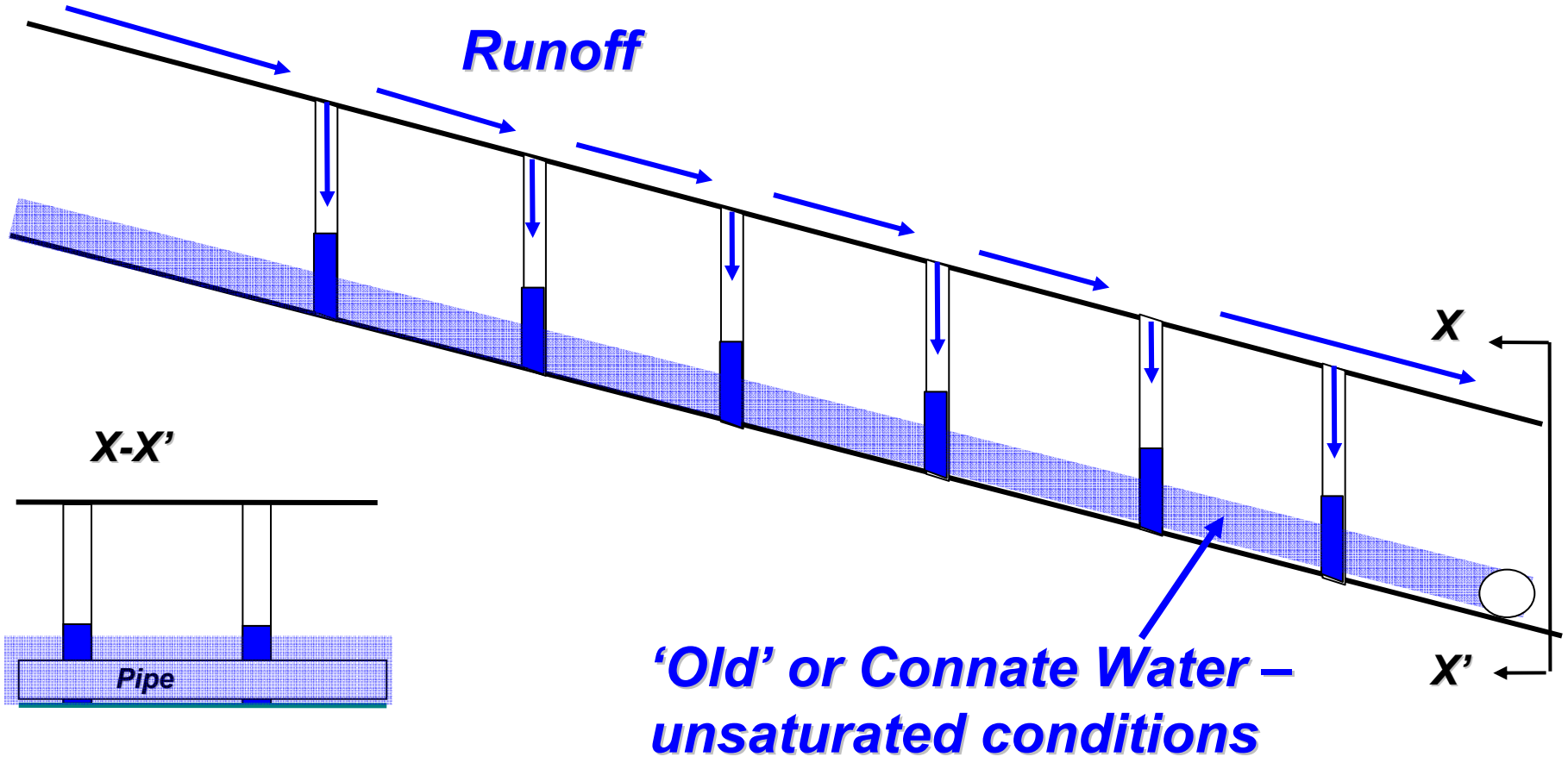


Lateral Flow over a Lower K Layer



Mechanisms at "Play"

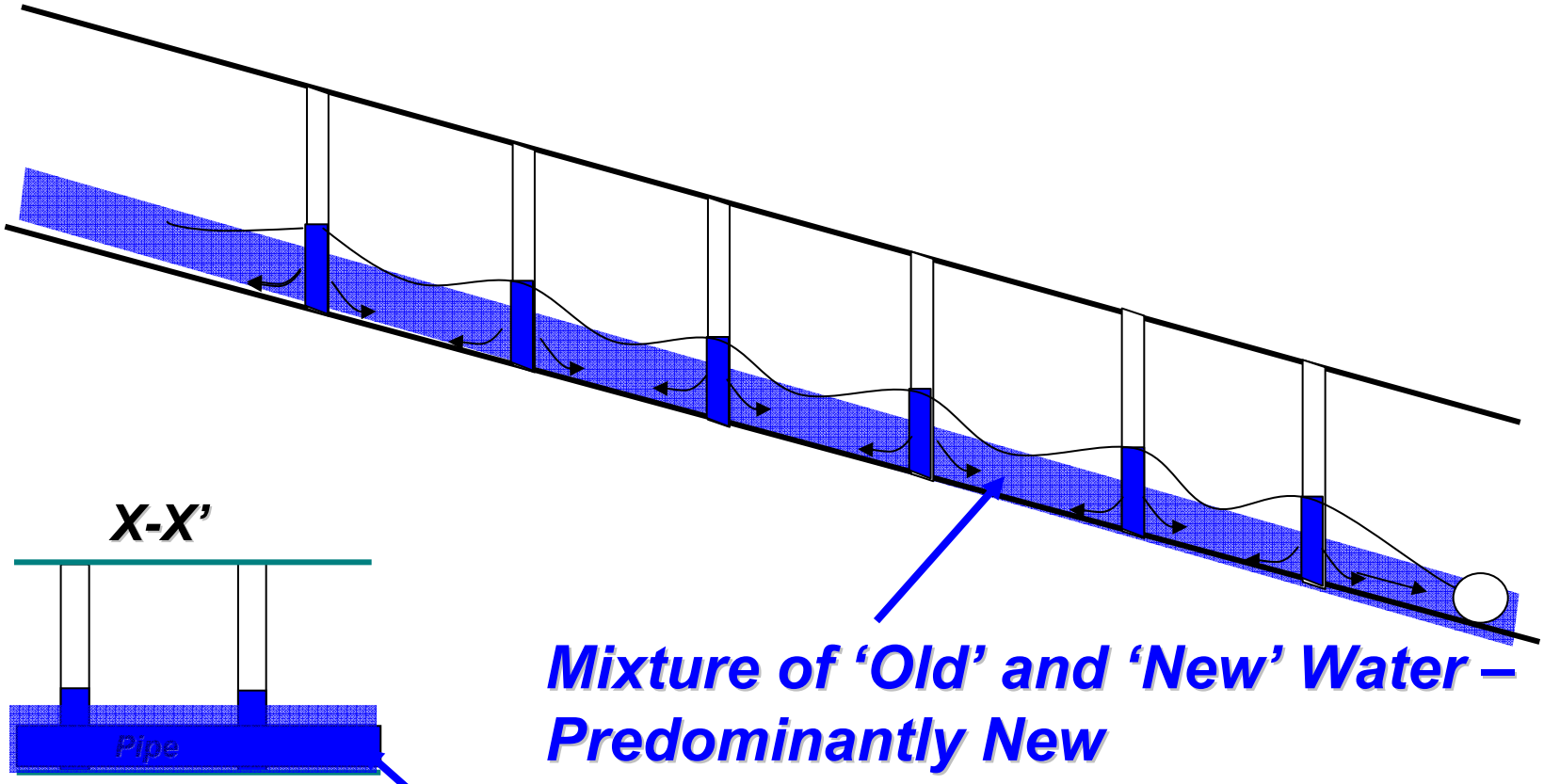
Frozen Ground – Snow Melt



Kelln et al. (2008)

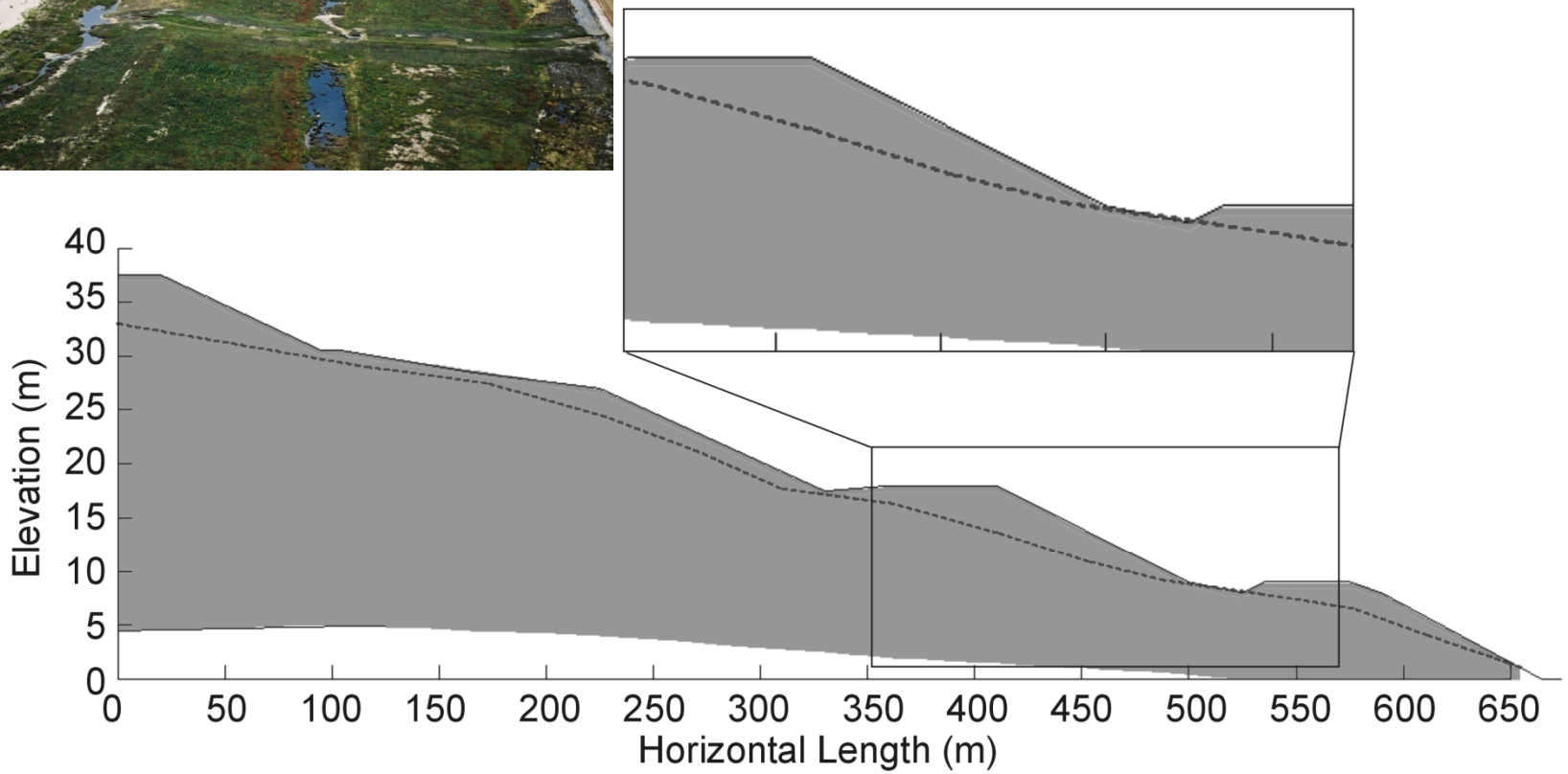
Mechanisms at "Play"

Ground Thaw – Interflow Begins



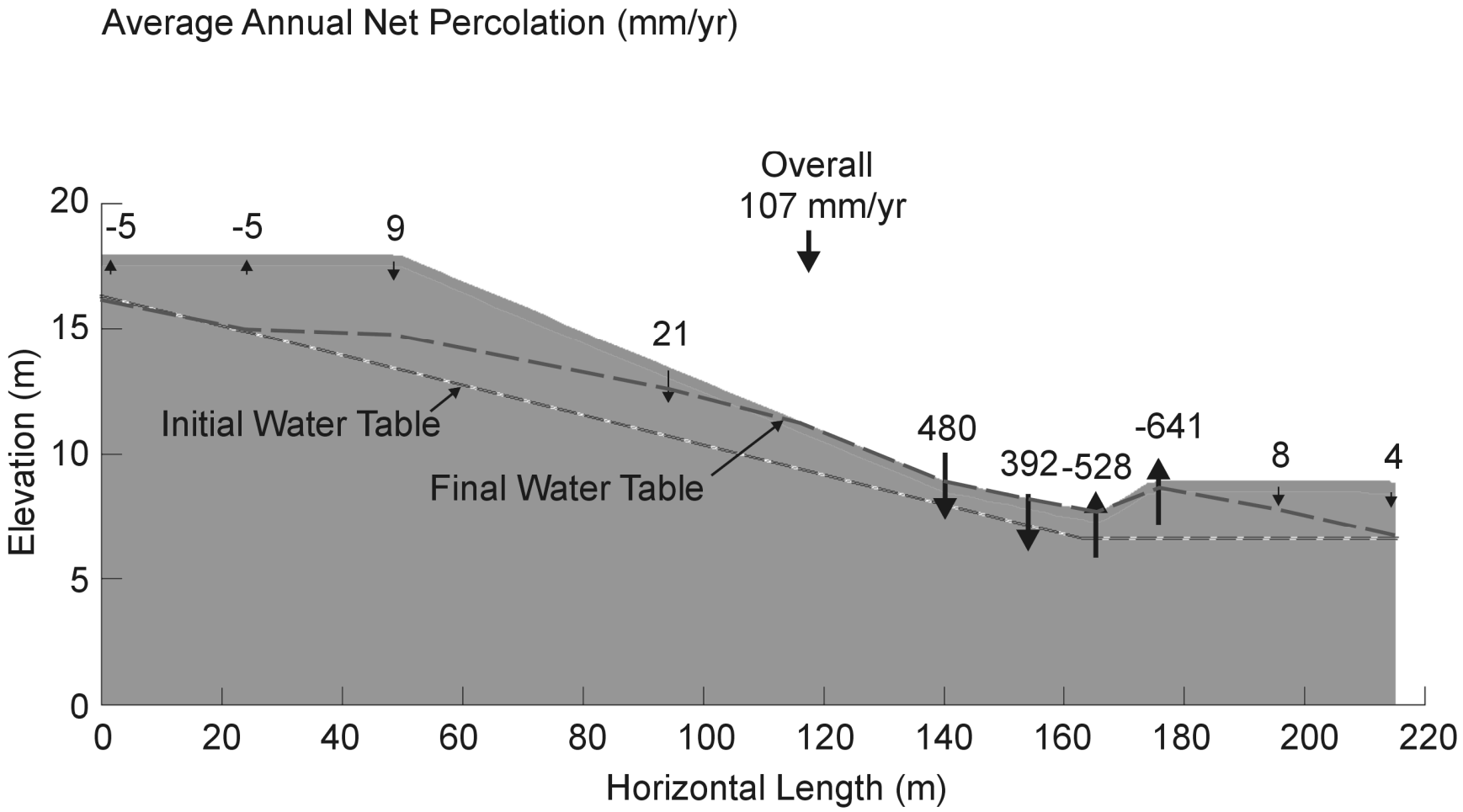
Kelln et al. (2008)

Numerical Solution *(2D Transient – 3 yrs)*



Vertical scale exaggerated for illustration purposes

Numerical Solution (2D Transient – 3 yrs)



Vertical scale exaggerated for illustration purposes

Overarching Key Messages

- **Mechanisms:**
  - Interact and change in importance over time as the plant community develops
- **Trajectory:**
  - 2 years monitoring not sufficient
  - Oil Sands: 15 – 20 years??
    - e.g. Salt transport
- **Risk:**
  - Key Mechanisms "at play", which results in Different Levels of Risk with Different Cover System Designs for a Project
    - Fundamental that Cover System Designers Understand these Mechanisms
    - such that….
      for a given design these Risks are Managed, and/or Accepted

Thank You!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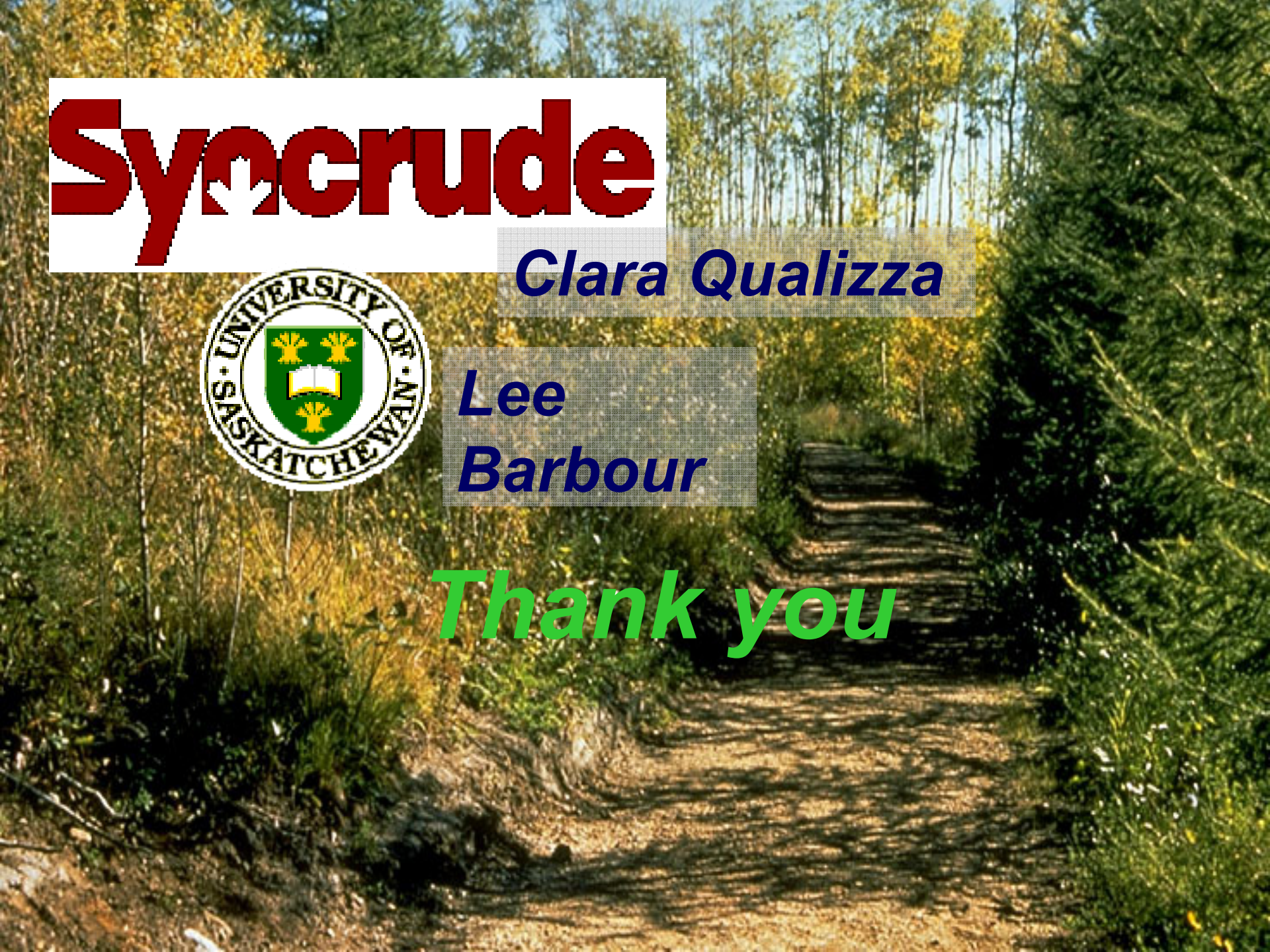
Syncrude
Clara Qualizza
UNIVERSITY OF SASKATCHEWAN
Lee Barbour
Thank you