ATLANTIC
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# *EVALUATION OF COVER SYSTEMS UTILISING GEOSYNTHETIC LAYERS FOR CLOSURE OF COAL WASTE ROCK PILES IN A SEASONALLY HUMID LOCATION*


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Public Works and Government Services Canada

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Canada


O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

# Presentation Outline

- *Background on Reclaimed Waste Rock Piles*
- *Overview of the Performance Monitoring Systems*
- *Examples of Cover System Performance*
- *Final Comments*

# Enterprise Cape Breton Corporation (ECBC)

- ECBC was a Federal Crown Corporation responsible for environmental remediation associated with coal mining activities in Cape Breton
  - Mining operations began in 1685 and lasted into the 1980s
  - 50 underground mines produced 500 million tonnes of coal

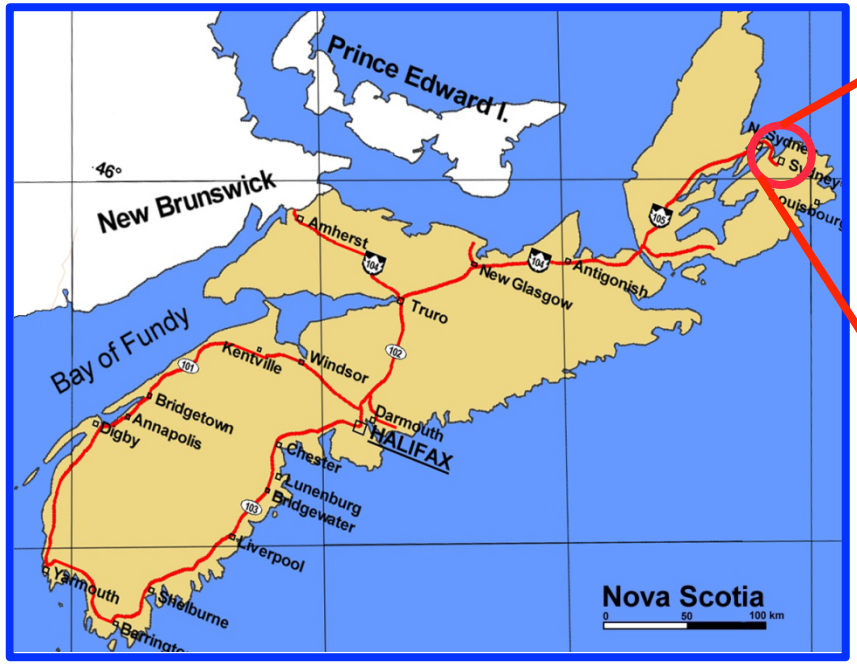
- Consultants through Standing Offer Agreements with PWGSC were engaged to develop closure plans for the coal WRPs
- O'Kane Consultants were engaged to design and install monitoring systems to ensure that the reclaimed WRPs meet closure objectives:
  - 1) Stable landform, 2) Sustainable vegetation and 3) Limiting impacts to receiving environment

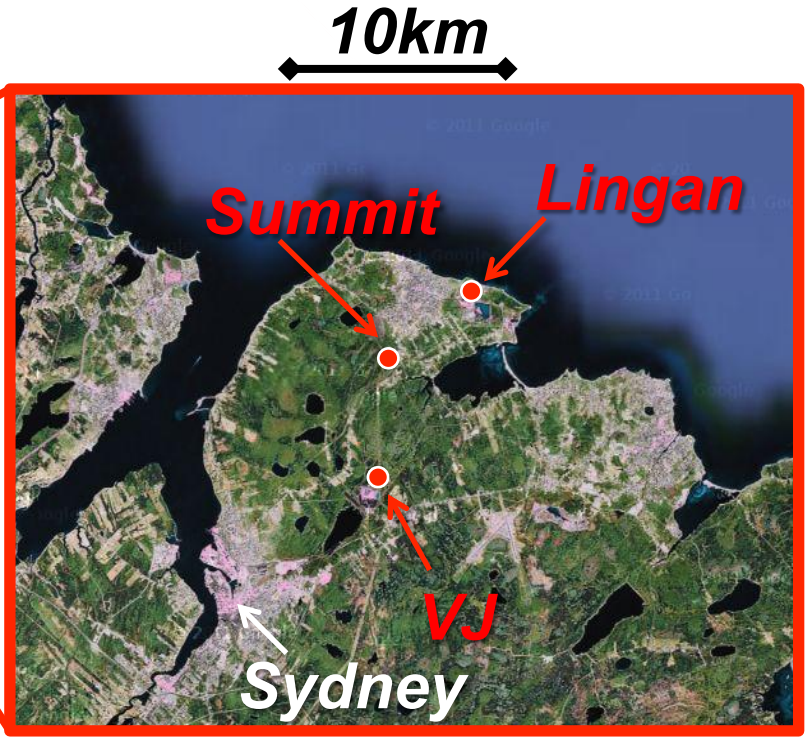
# Site Location

**Site: Near Sydney, NS**
**Cape Breton Island**

- Lingan
- Scotchtown Summit (Summit)
- Victoria Junction (VJ)

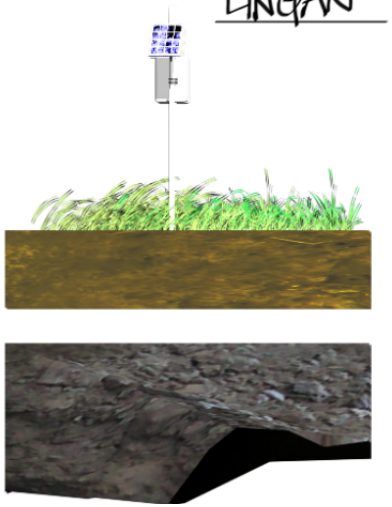
## Atlantic Canada



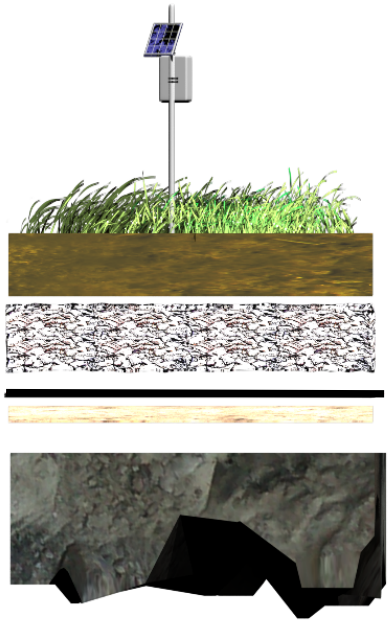



# Background – Cover Profiles

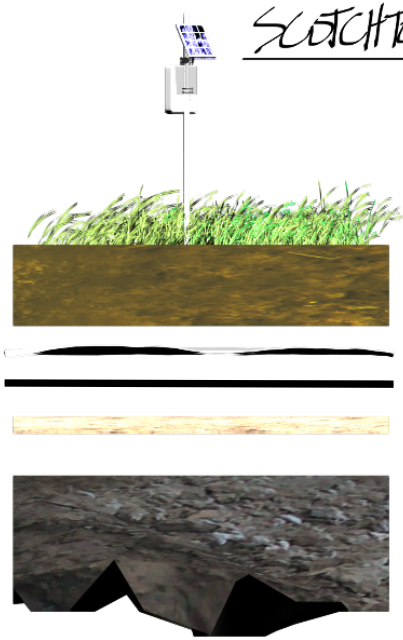
## LINGAN




## VICTORIA JUNCTION



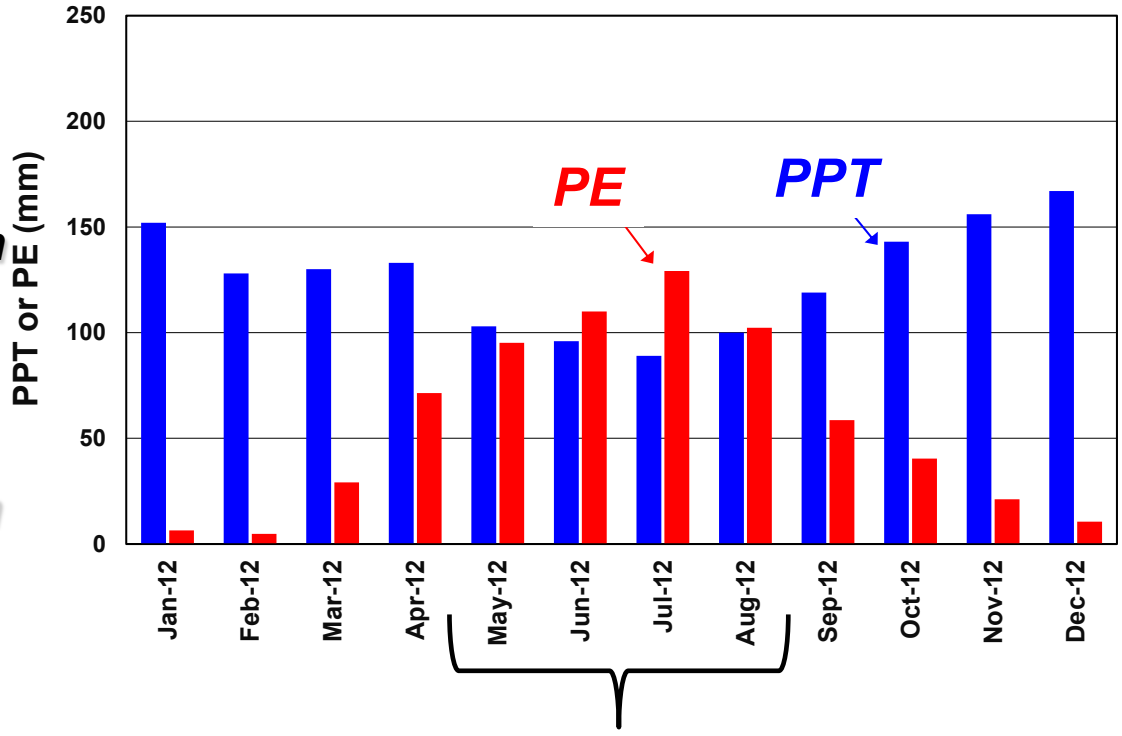

## SCOTCHTOWN SUMMIT



# Background – Sydney, N.S.

## Climate:

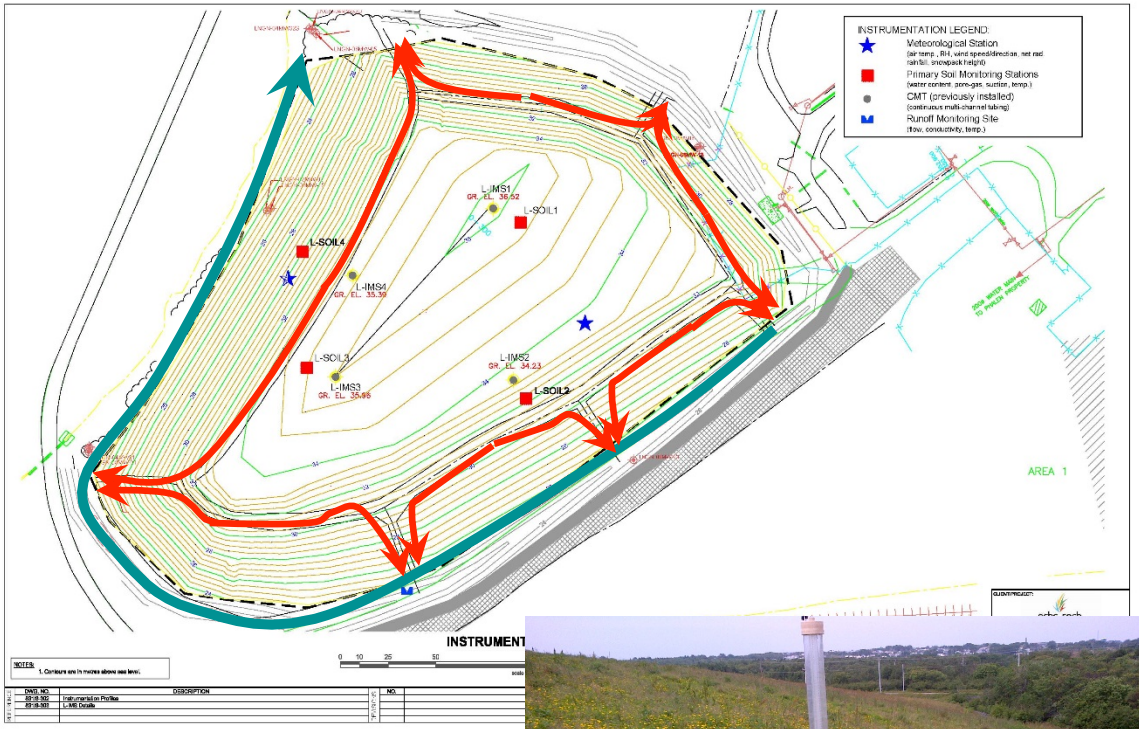
- Mean annual PPT is ~ 1,500 mm
  - 60% occurs in Winter (from October to March)
  - ~50% of winter PPT is snowfall
- Mean annual PE ~700 mm
- Energy deficit in most months

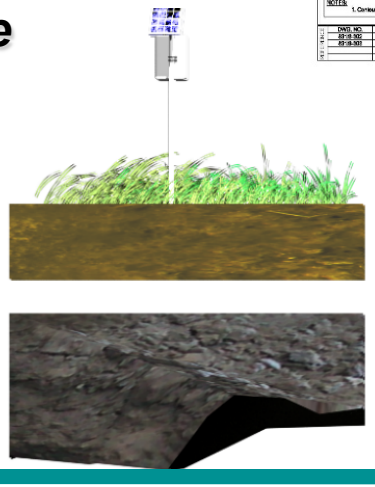


# Background - Lingan

## Landform:

- Covers an area of 8.5 ha
- 15 m high
- Plateau ~3% slope transitioning to 5:1 side slope
- Runoff ditch constructed around plateau which channels flow to drop structures on side slope

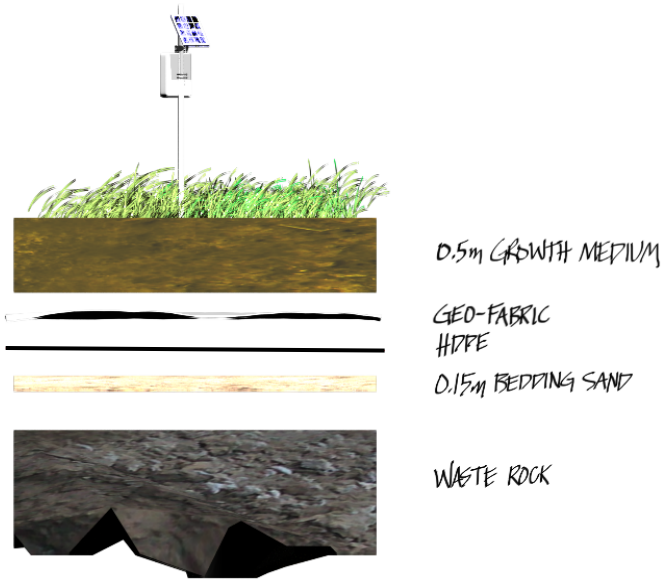


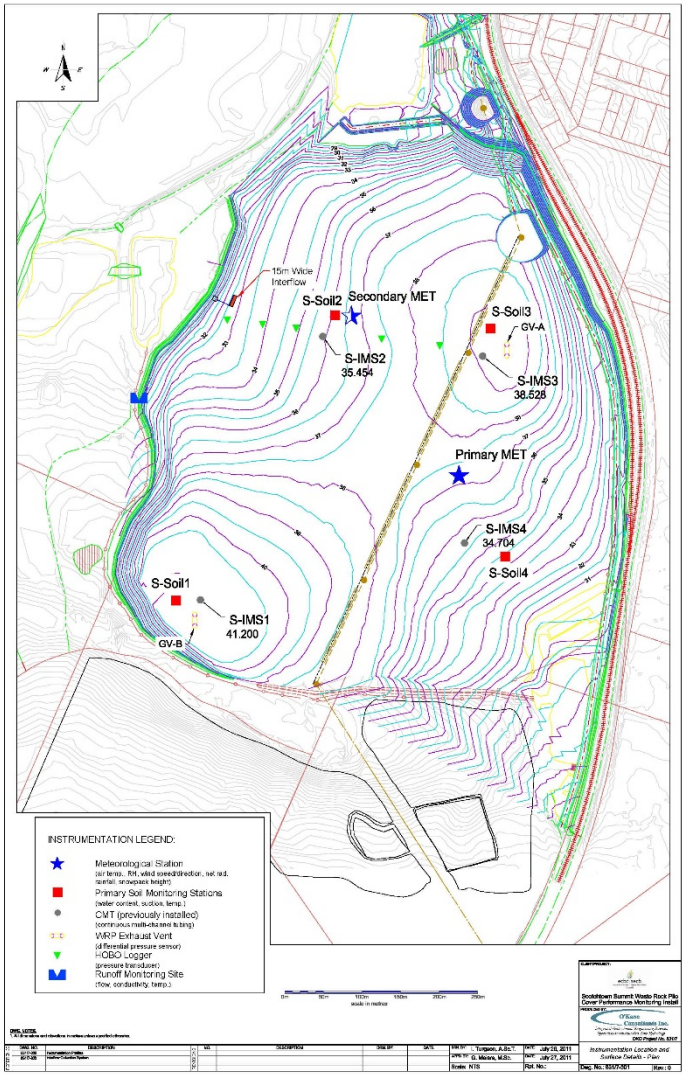




# Background - Summit

## Landform:

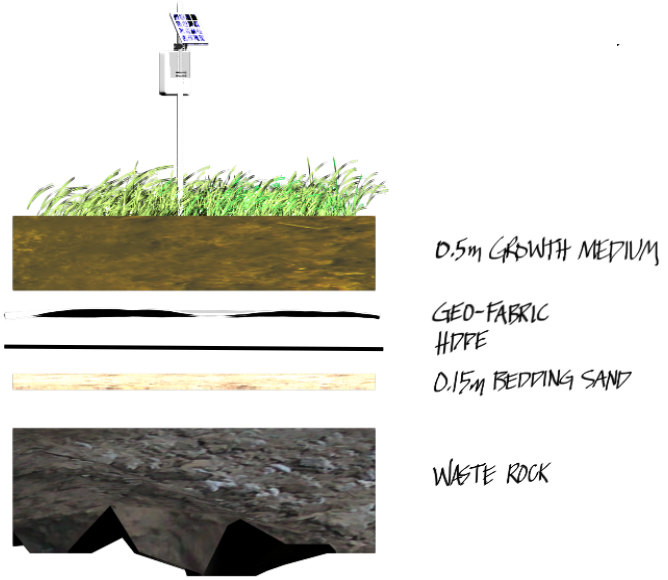
- Covers an area of 44 ha
- Thickness of 1.5m to 10m
- Plateau 3% slope transitioning to 7:1 side slope
- Runoff ditch constructed around perimeter



# Background - Summit

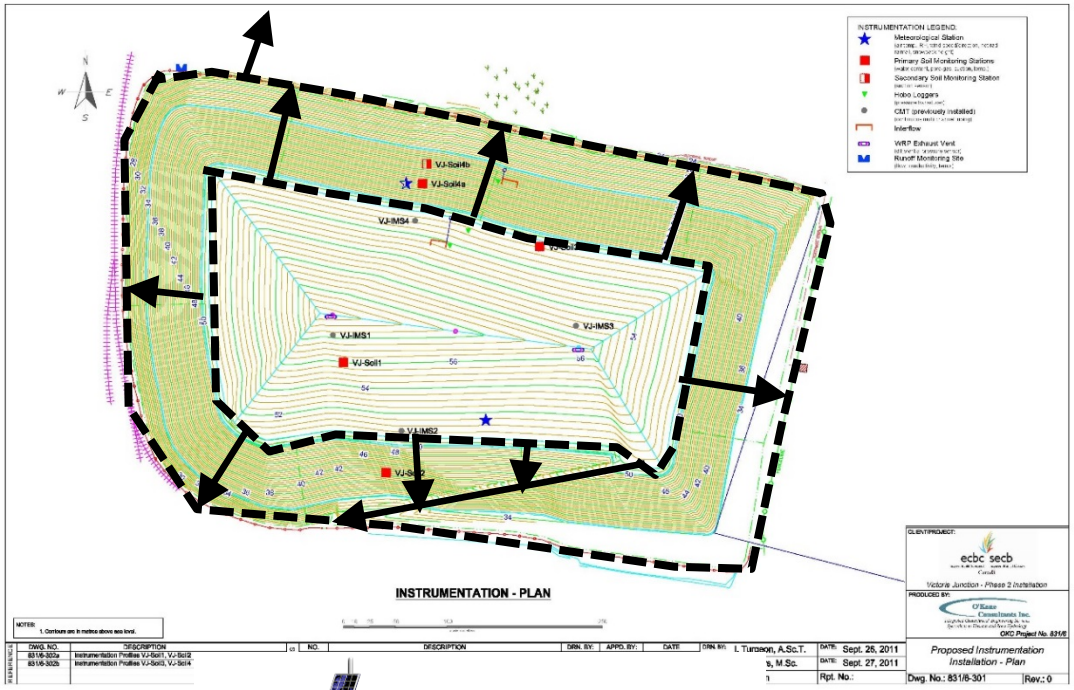
## Landform:



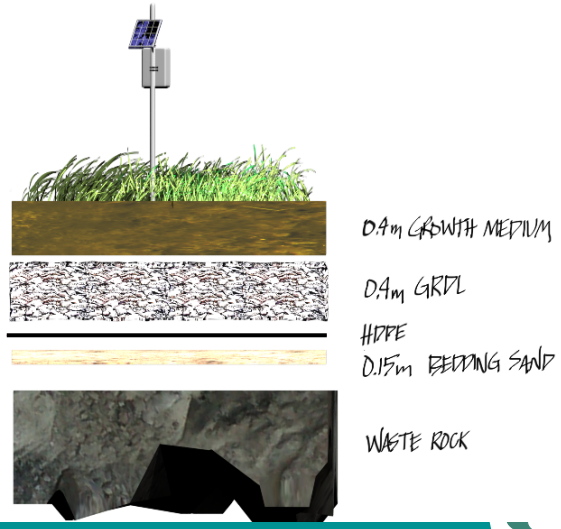

# Background – Victoria Junction

## Landform:

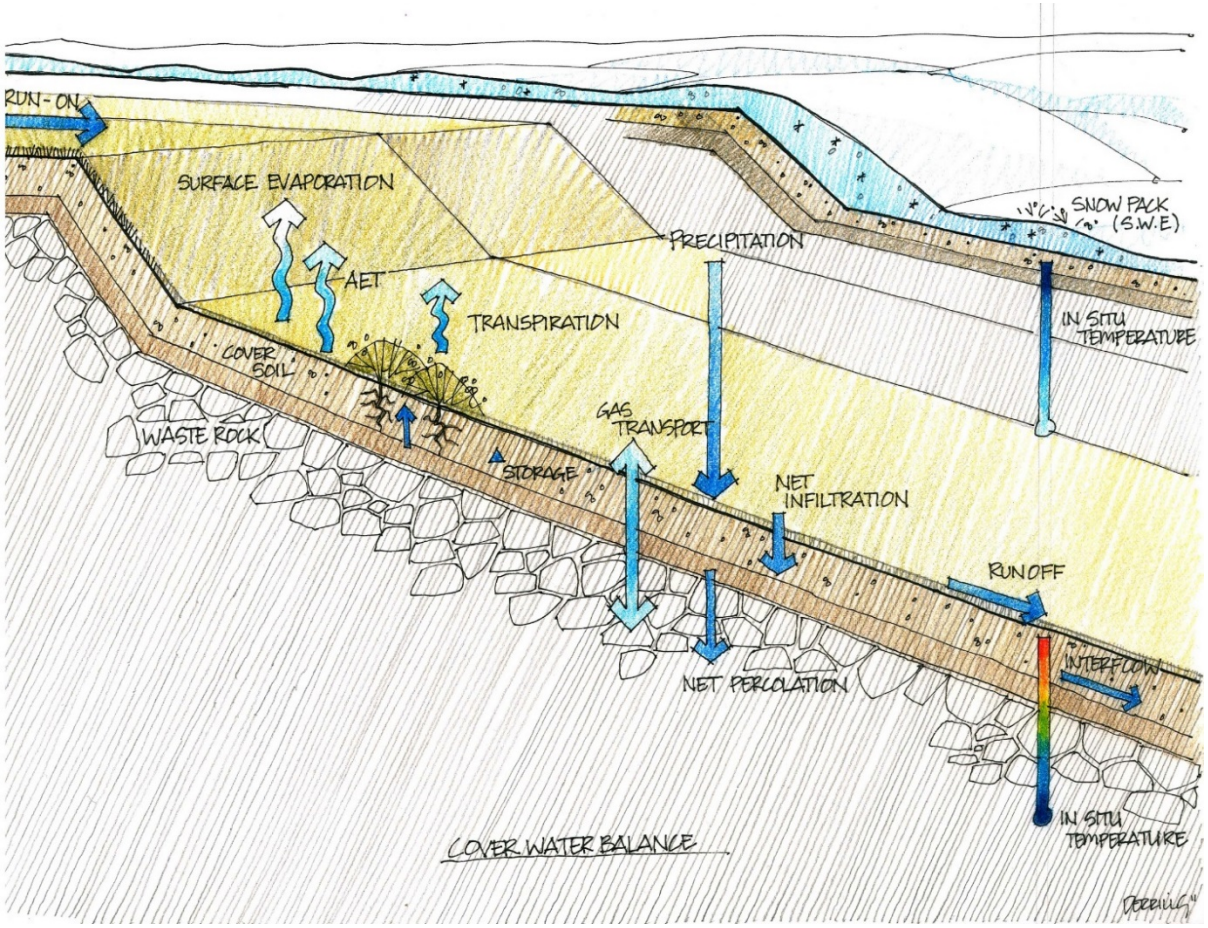
- Covers an area of 26 ha
- Height of 30m
- Plateau ~7%
- Side Slope 3:1
- Ditch constructed around plateau which channels runoff and interflow to drop structures on side slope







# In Situ Direct Monitoring




- **Monitored water balance component:**
  - AET
  - PPT
  - Runoff
  - Interflow
  - Water Storage
  - Net percolation (NP)
- **NP Estimated through:**
  - Water balance
  - Conservative tracer
- **Internal WRP Monitoring System:**
  - Temperature
  - Pressure
  - GW elements
  - Pore-gas concentrations
  - Pore-water quality

# In Situ Cover Monitoring

**Fully Automated Meteorological Station**

**Calculate Potential Evaporation**

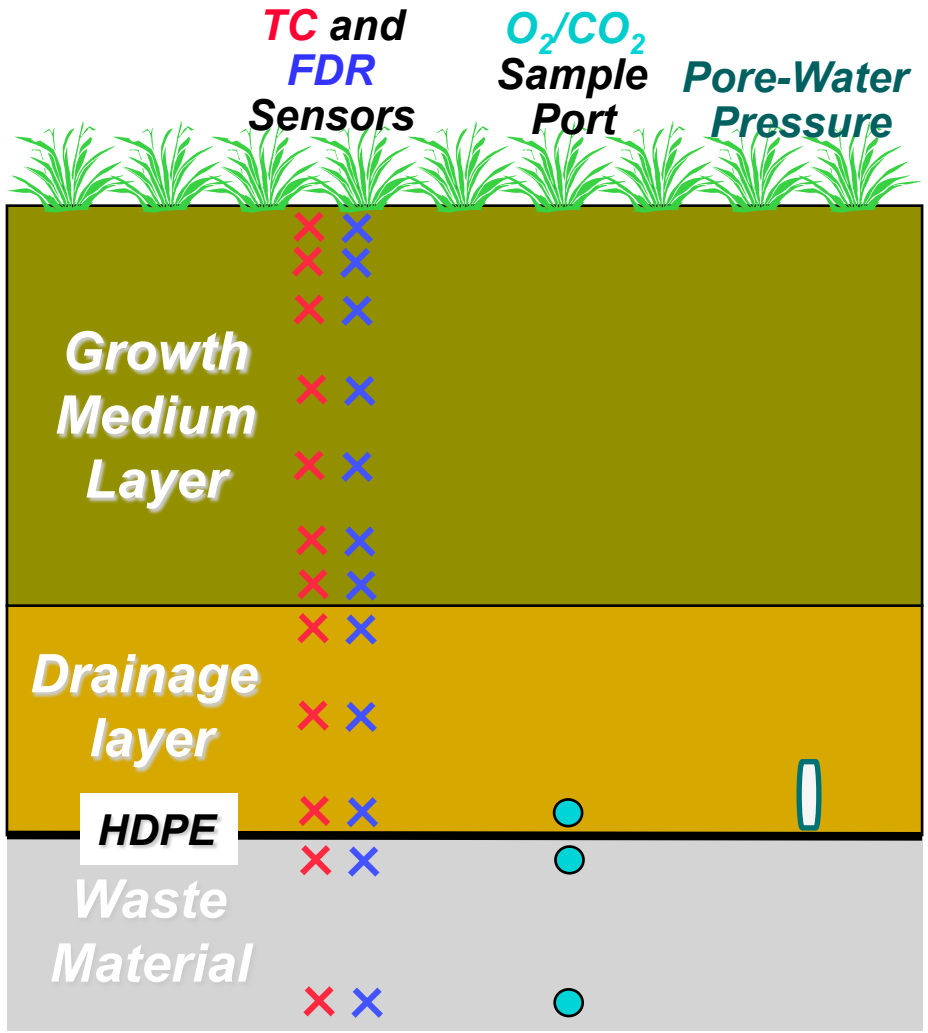
- **Monitored Climatic Parameters *at each Site:***
  - precipitation
  - air temperature
  - relative humidity
  - wind speed and direction
  - net solar radiation
- **Installed multiple net radiometers (north aspect)**
- **Snowpack (i.e. SWE) measurements Automated and manual**

# In Situ Cover Monitoring

## Eddy Covariance Station
## (direct measurement of AET)

# In Situ Cover Monitoring

## Soil Nest Sensor Configuration




- Thermal conductivity (TC) sensors
  - soil suction and temperature
- TDR sensors
  - volumetric water content
- Gas sampling ports
  - $O_2$ / $CO_2$ concentrations
- OTT water level sensor
  - Positive pore-water pressure
- Fully automated monitoring
- Numerous monitoring sites to quantify heterogeneity in water dynamics

# In Situ Cover Monitoring

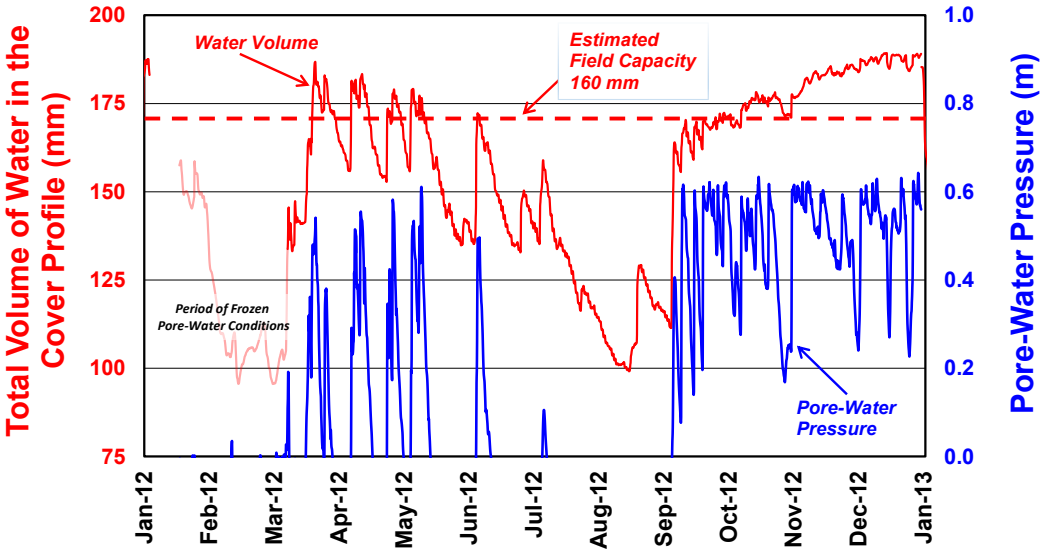
## *Victoria Junction Sensor Nest*

# Surface Runoff Monitoring

# Surface Runoff Monitoring

# Monitoring Data – Summit

## Water Dynamics: Erosion



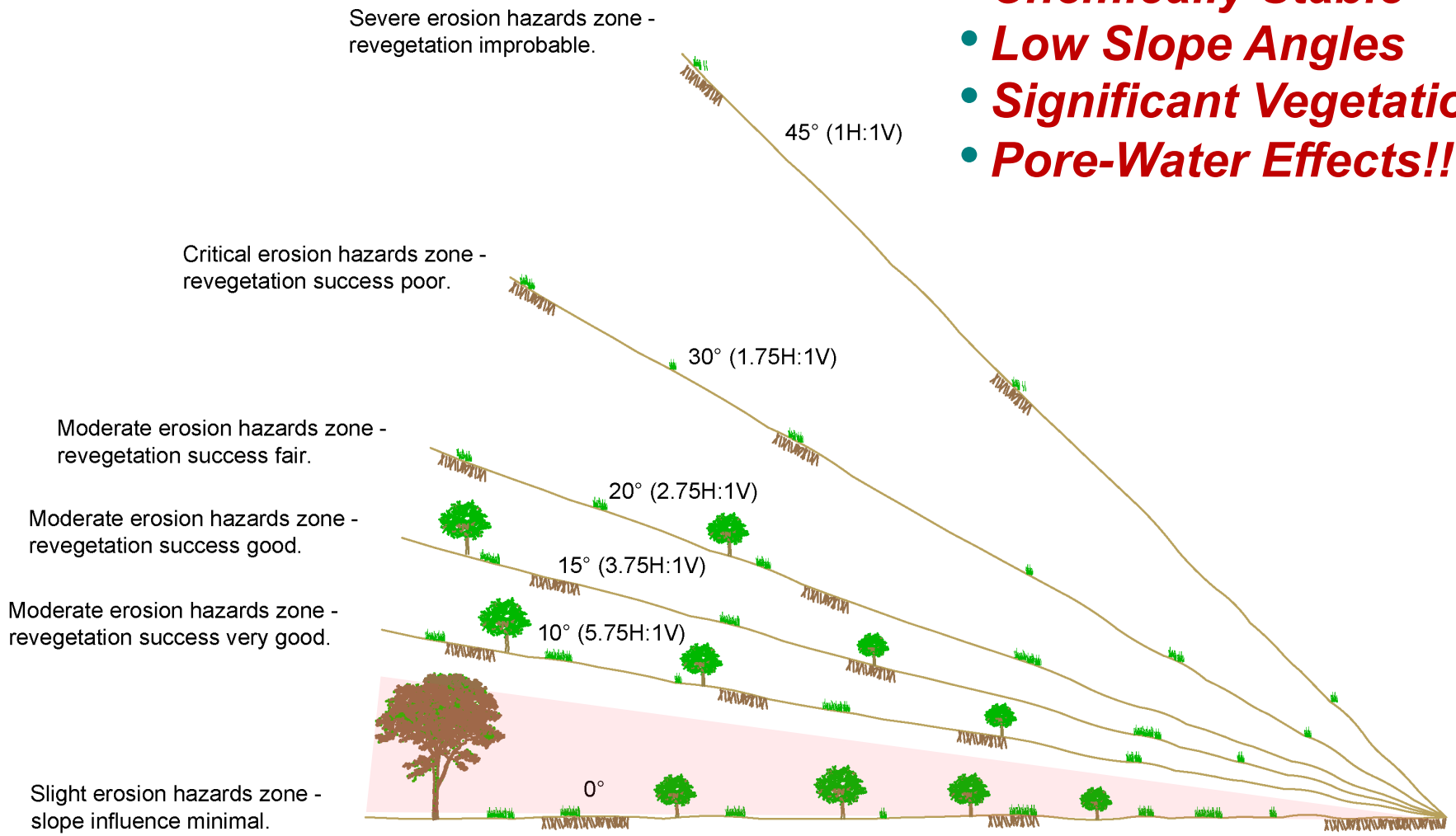

### Comparative Analysis for Slope Section

| Ks (cm/s) | Infiltration Rate (mm/day) | | | | |
|---|---|---|---|---|---|
| | 2.7 | 2.0 | 1.4 | 0.7 | 0.27 |
| | Maximum Height of Water in Cover (m) | | | | |
| 1E-04 | 1.5 | 1.2 | 1.0 | 0.6 | 0.4 |
| 1E-03 | 0.4 | 0.3 | 0.3 | 0.2 | 0.1 |
| 1E-02 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| 1E-01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

# Monitoring Data - Summit

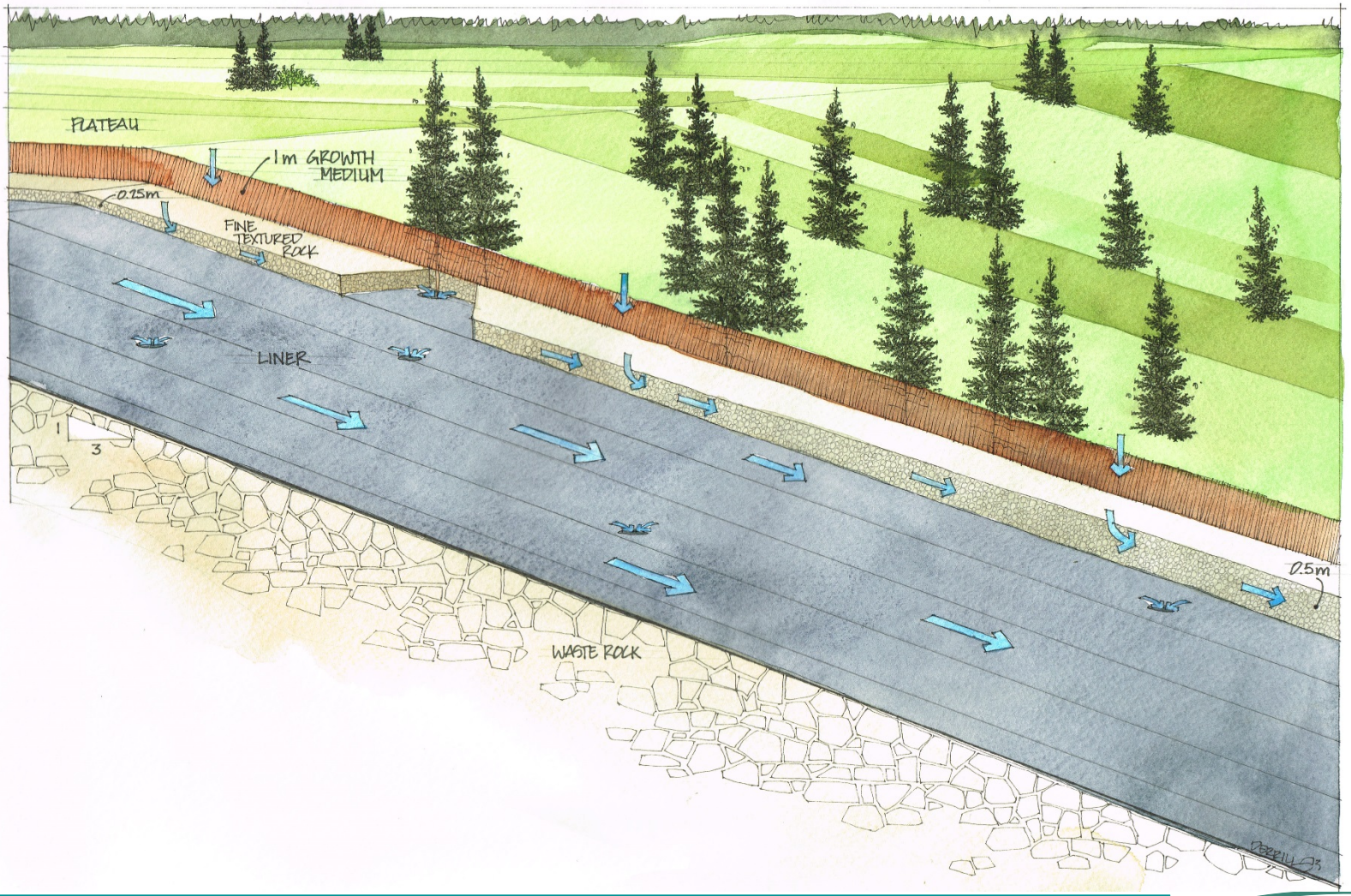
## Long-Term Erosion

- Chemically Stable
- Low Slope Angles
- Significant Vegetation
- Pore-Water Effects!!!



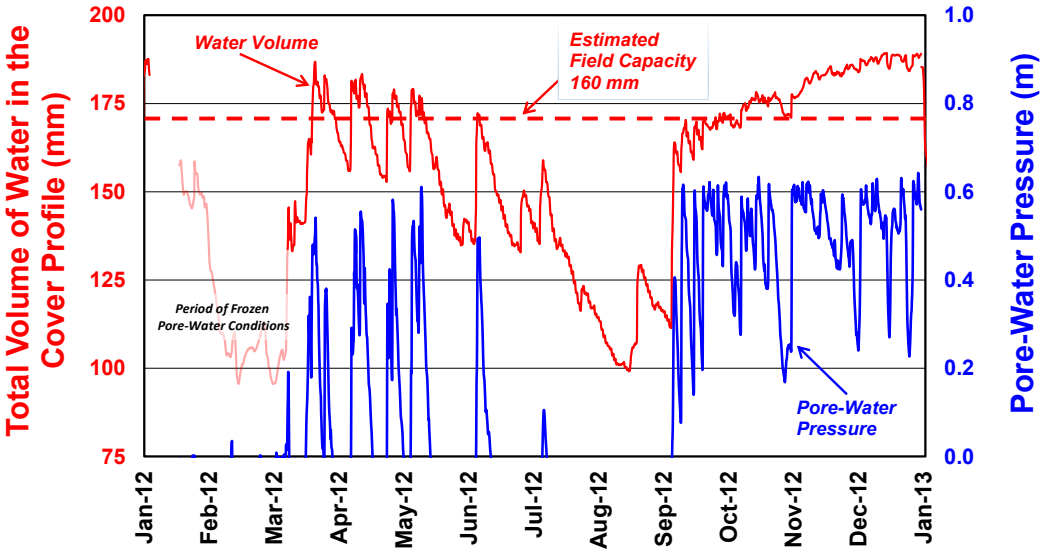
# Monitoring Data – Summit

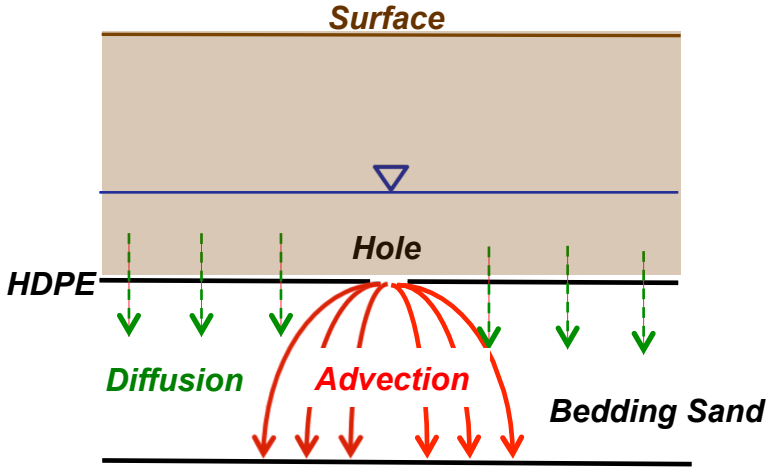
## Water Dynamics: Leakage



# Monitoring Data – Summit

## Water Dynamics: Leakage



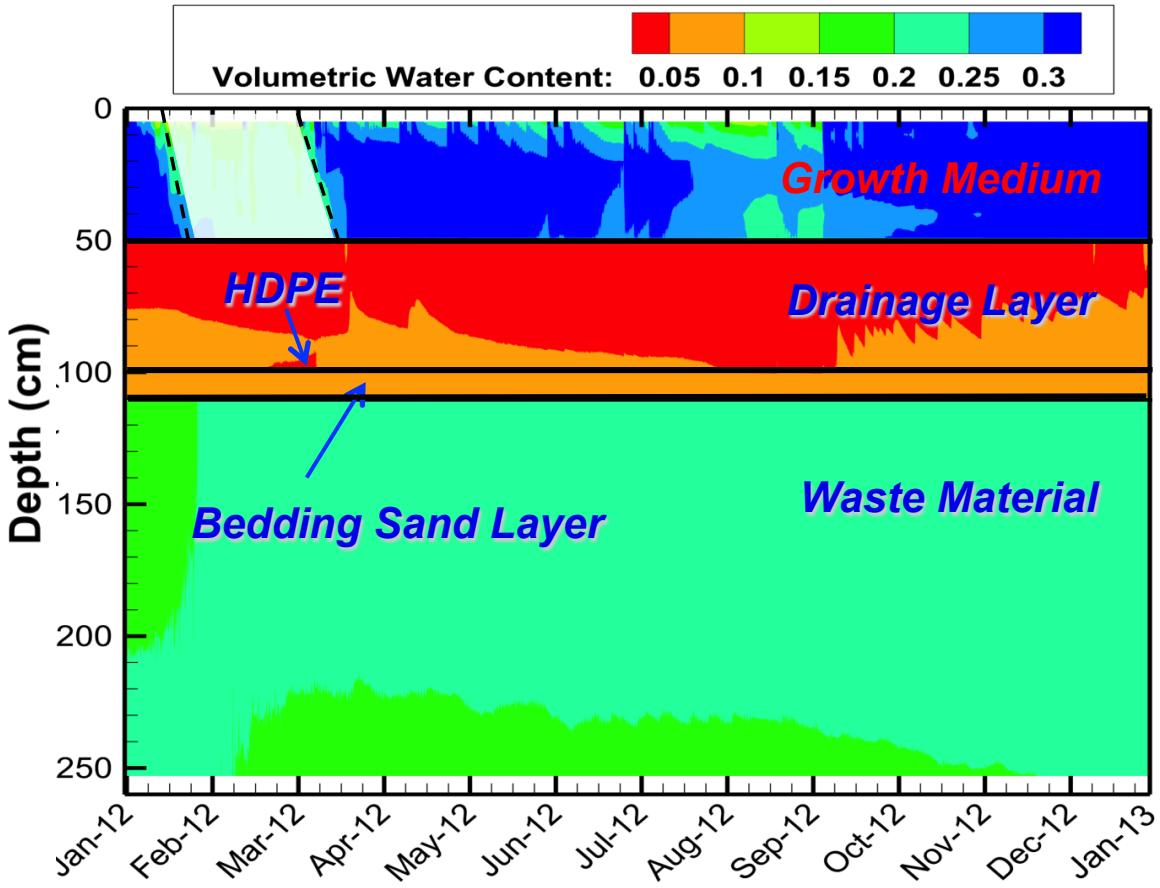

### Comparative Analysis for Plateau

| Ks (cm/s) | Infiltration Rate (mm/day) | | | | |
|---|---|---|---|---|---|
| | 2.7 | 2.0 | 1.4 | 0.7 | 0.27 |
| | Maximum Height of Water in Cover (m) | | | | |
| 1E-04 | 17.5 | 14.7 | 11.5 | 7.5 | 4.2 |
| 1E-03 | 4.2 | 3.6 | 2.8 | 1.9 | 1.1 |
| 1E-02 | 1.1 | 1.0 | 0.8 | 0.6 | 0.4 |
| 1E-01 | 0.4 | 0.3 | 0.2 | 0.2 | 0.1 |

# Monitoring Data – Victoria Junction

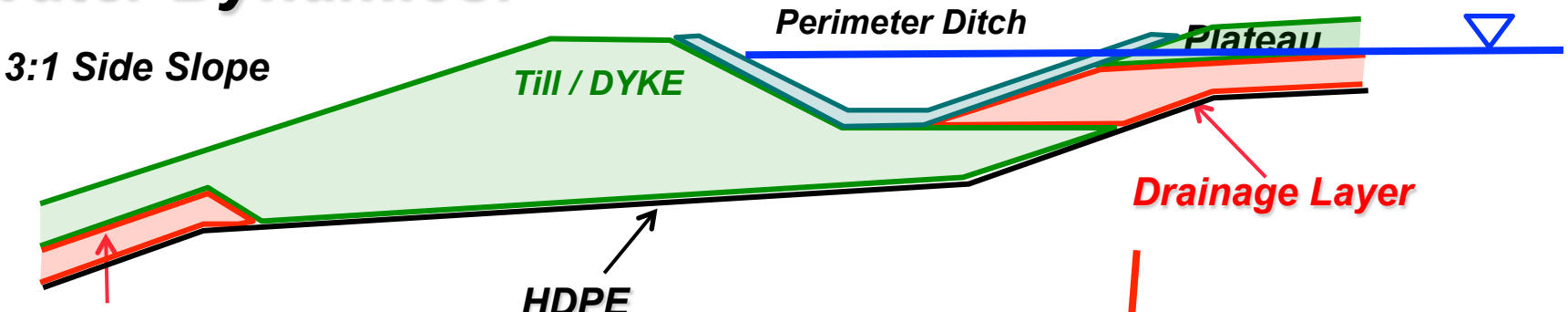
## Water Dynamics:

- *VJ granular drainage layer is drained, minimizes potential for leakage, maximize slope stability*

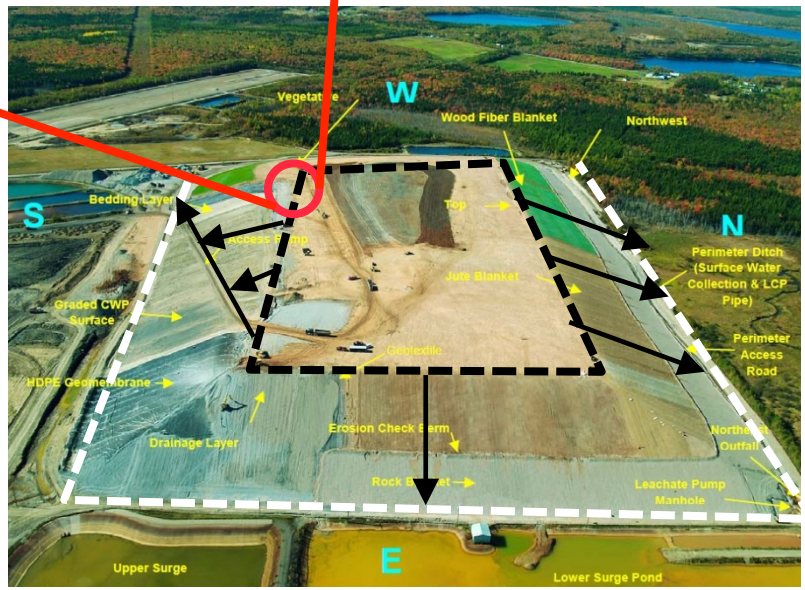


# Monitoring Data – Victoria Junction

## Water Dynamics:

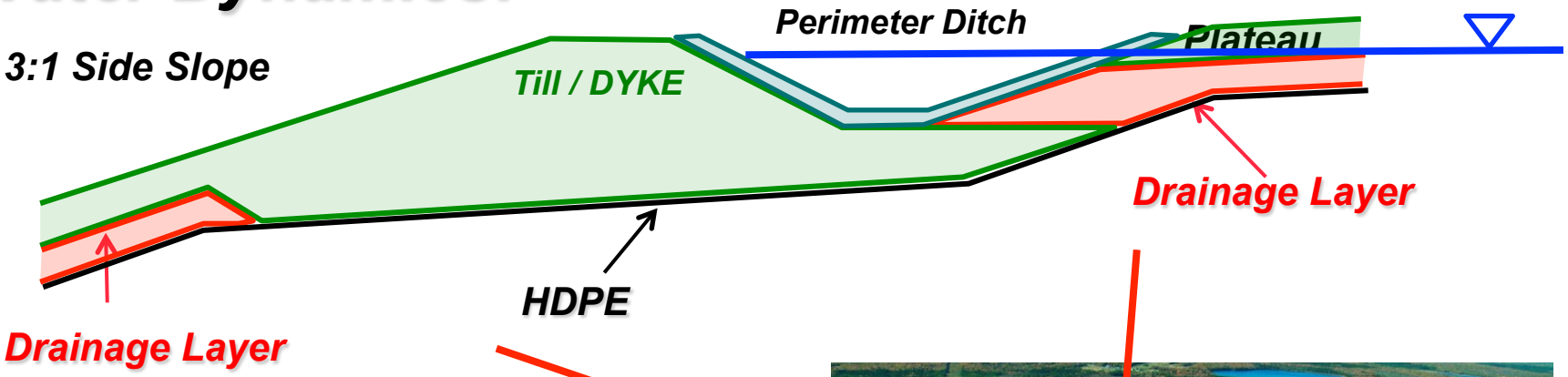


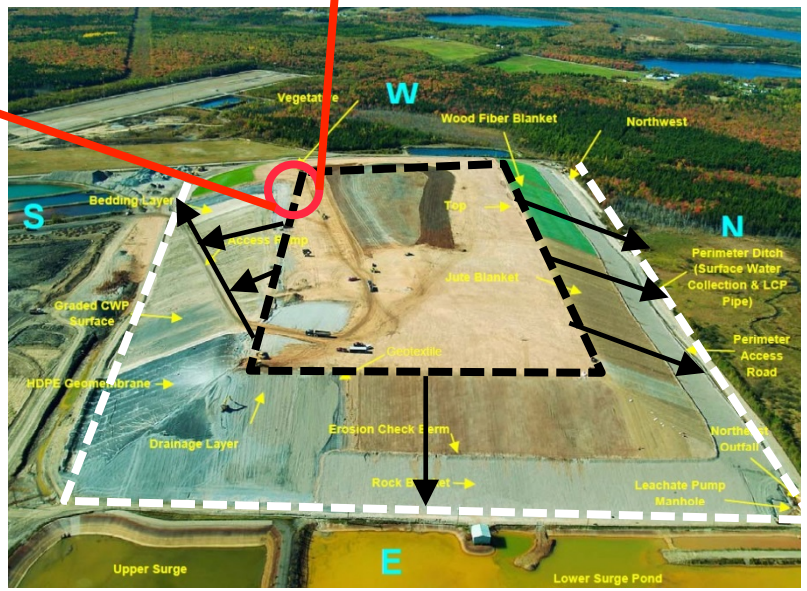

- The outlet from the plateau drainage layer is a bottle neck to flow and could result in erosion or failure
- Perimeter ditch constructed perpendicular to slope along the crest will be 'fighting' natural geomorphic processes



# Monitoring Data – Victoria Junction

## Water Dynamics:

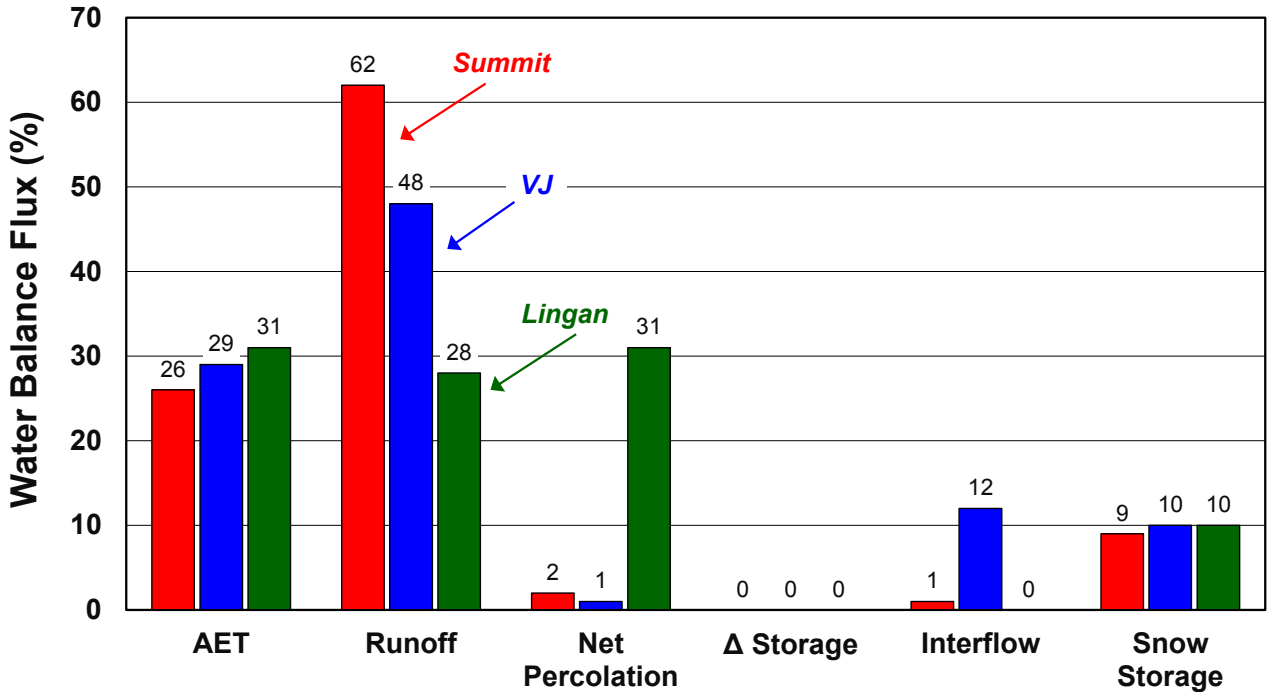


# Monitoring Data – Lingan / VJ / Summit

## Water Balance:

- Runoff at Summit ~60%
- Interflow at Victoria Junction ~15%
  - Interflow offsets proportional runoff volume
  - Minimum 20% interflow volumes to minimize buildup of positive pore-water pressures
- Net Percolation at Lingan ~30%
  - Net percolation offsets a proportional runoff volume



# Net Percolation Rates

## Cover System Type

Geomembrane — Growth Medium

| <5% | 10% | 20% | 30% |
|---|---|---|---|
| Very Low | Low | Moderate | High |

Range of Net Percolation Rates

# Runoff Rates

## Cover System Type

Growth Medium — Geomembrane

20 to 30% — 50% — 60%

Range of Runoff Rates

Very Low — Low — Moderate — High

Drainage Layer — No Drainage

# Final Comments

- *Reclaimed WRPs have resulted in improvements to the receiving environment*
- *Given the relatively small WRPs, the issues identified here would be more significant when scaled up to a larger landform*
- *As environmental regulations become more stringent geosynthetics may become more common as a closure option*
- *An understanding of the engineering properties for geosynthetics have been developed but limited information is available in regards to the in-service performance*

# Final Comments

- Focus your engineering design on protecting and maximizing the performance of the barrier layer

# Thank You!

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