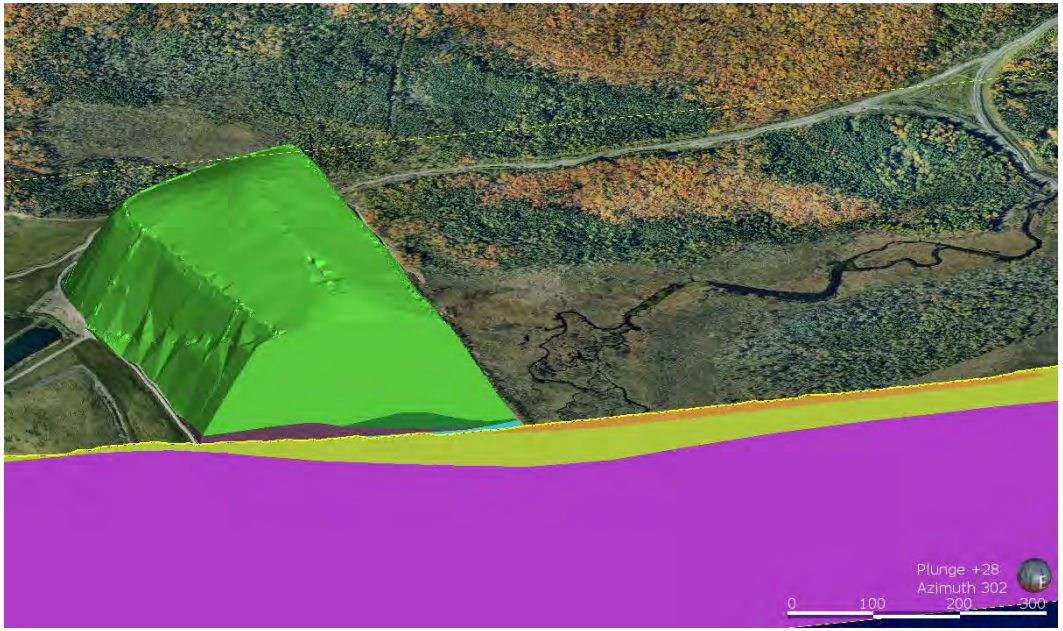
ATLANTIC CLRA | ACRSD

October 21 - 22, 2015 | Fredericton, New Brunswick, Canada

Use of Analytical Estimates and Water Balance Components to Estimate Leakage Rates Through Cover Systems Utilizing a Geomembrane



By: Greg Meiers

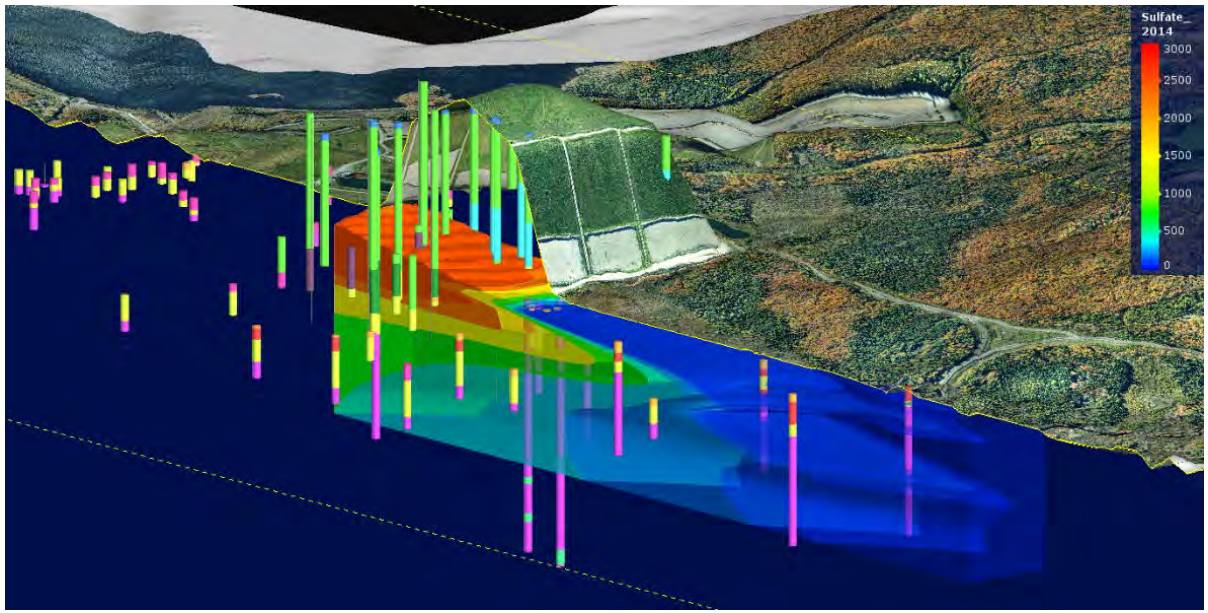
O'Kane Consultants

Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

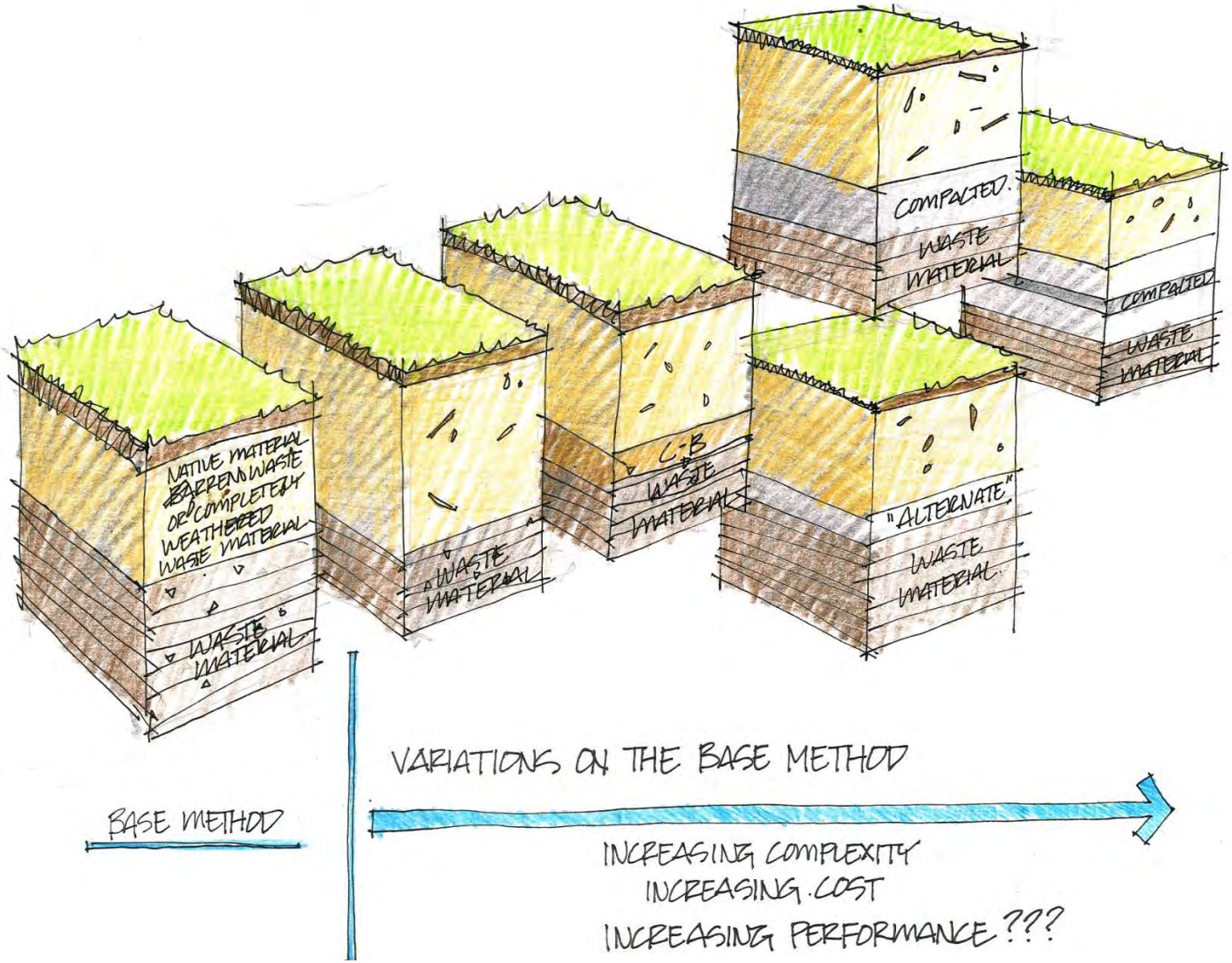
Public Works and Government Services Canada

Presentation Discussion Points

- Cover Systems
- Project Background for case studies
- Design of the Field Performance Monitoring Systems
- Simulated Net Percolation
- Design Considerations
- Summary Discussion Points



Cover System Alternatives



Historical Mine Sites : Sydney, NS.

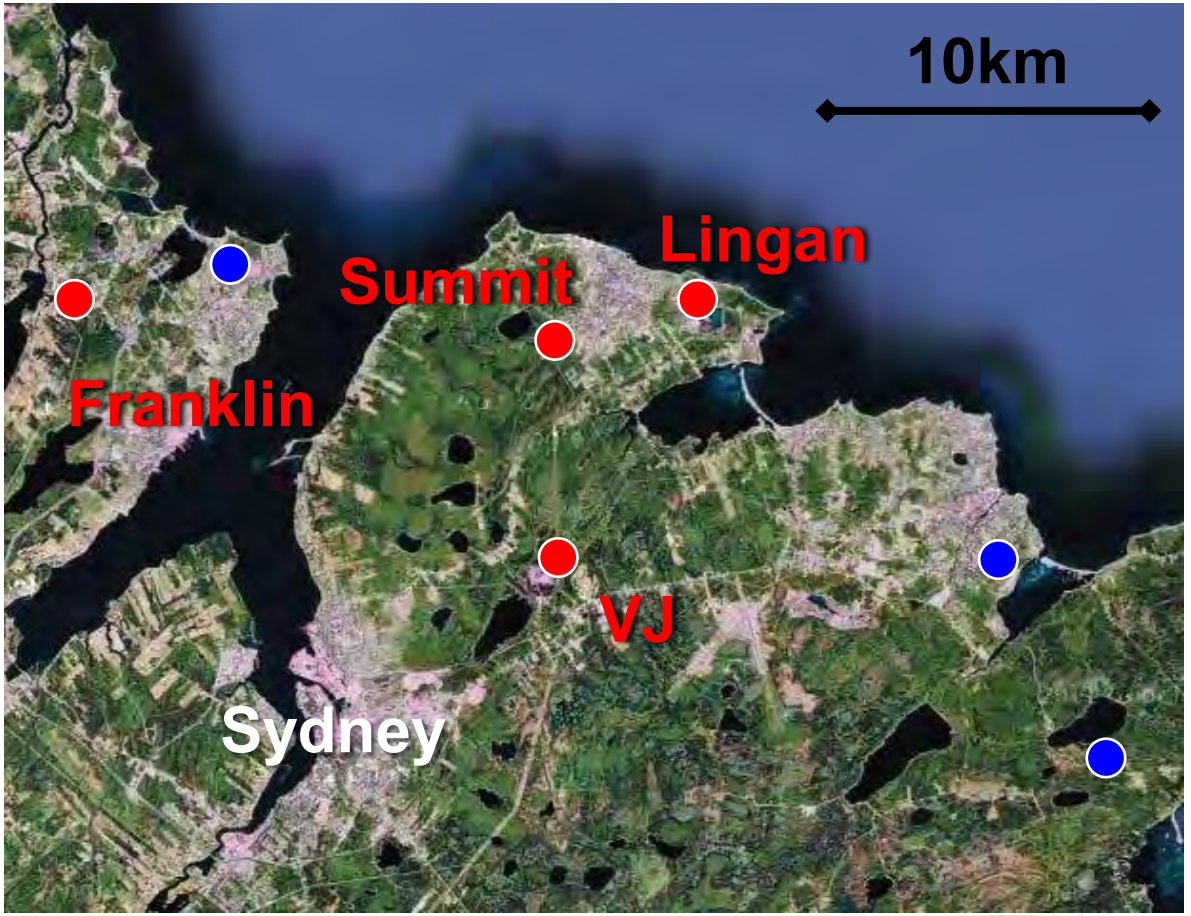
Remediation: **Enterprise Cape Breton Corporation (ECBC)**

Current Management: Public Works and Government Services Canada

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

Other Reclaimed WRPs

- **Dominion No.4**
- **Gowrie**
- **Princess**



Cover System Profiles

- Similar – Growth medium ~0.5m thick and geomembrane
- Different – Franklin and VJ include a drainage layer

Franklin

Drainage Net

Scotchtown Summit

No Drainage

Victoria Junction

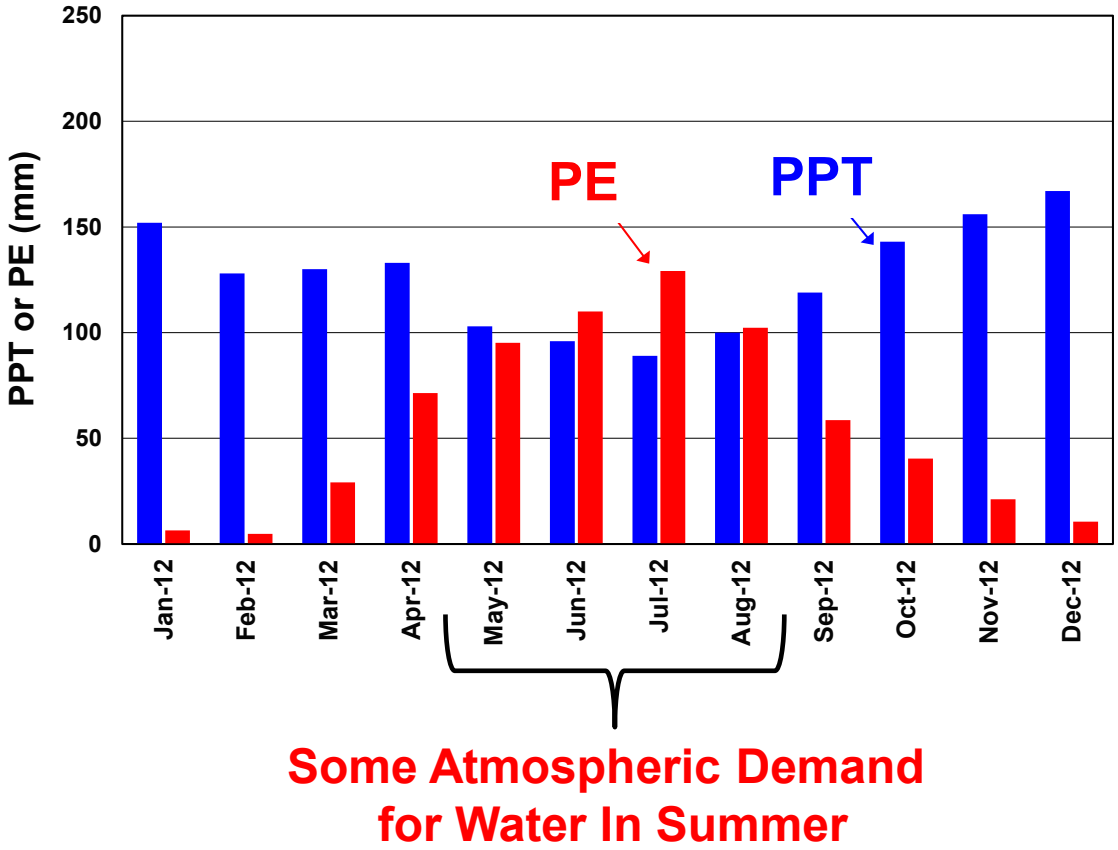
Granular Drainage

Meiers et al 2014

Typical Site Climate Conditions

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



Meiers et al 2014

Reclaimed Summit WRP

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

Reclaimed Victoria Junction WRP

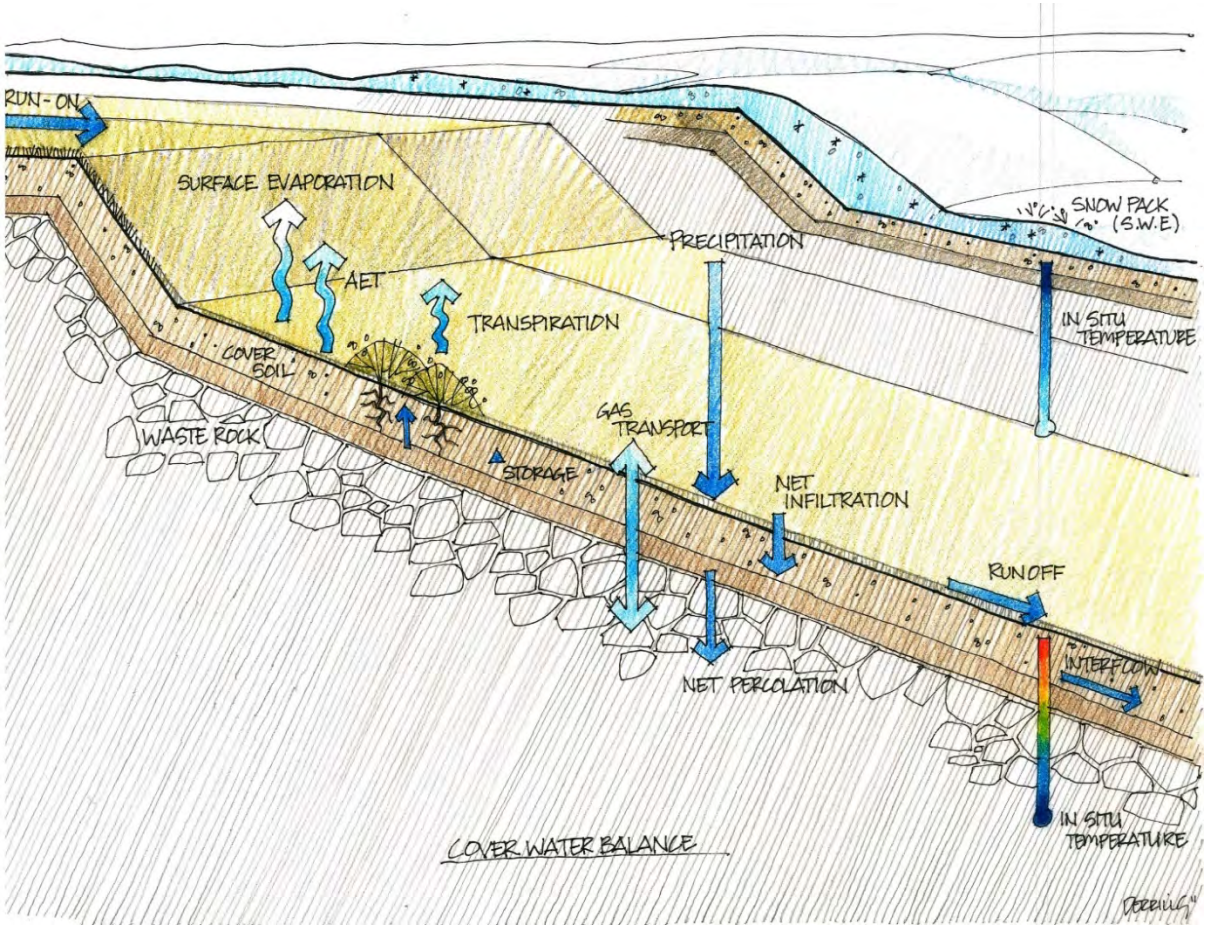
Landform:

- Covers an area of 26 ha
- Height of 40m
- Plateau ~7%
- Side Slope 3:1
- Runoff ditch constructed around plateau which channels runoff to drop structures on side slope

Reclaimed Franklin WRP

- Covers an area of ~2.5 ha
- Height of 13 m
- Gently sloping platea
- Side Slope 4:1
- Runoff ditch constructed around perimeter

In Situ Direct Cover Monitoring



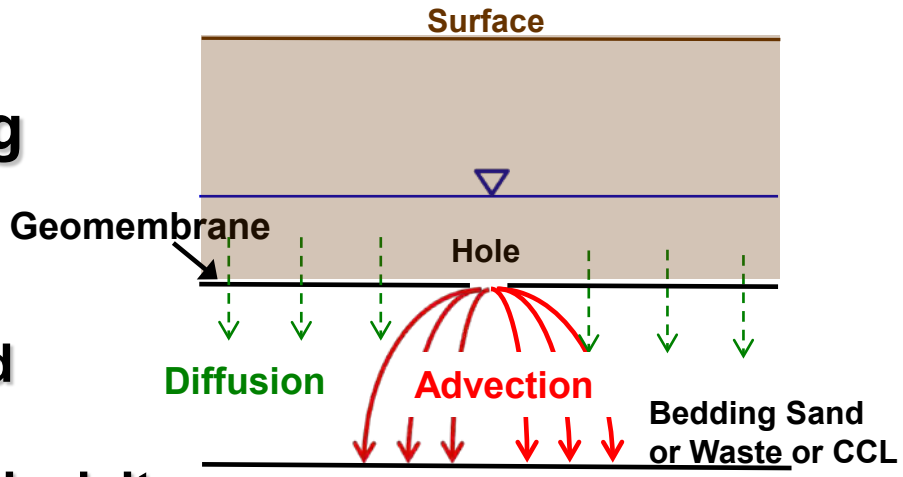
- ***Monitored water balance component:***
  - ***AET***
  - ***PPT***
  - ***Runoff***
  - ***Interflow***
  - ***Water Storage***
  - ***Net Percolation (NP)***
- ***NP Estimated through:***
  - ***Water Balance***
  - ***Analytical Estimates***
  - ***Conservative Tracer***
- ***Internal WRP Monitoring System:***
  - ***Temperature***
  - ***Pressure***
  - ***GW Elevations***
  - ***Pore-Gas Concentrations***
  - ***Pore-Water Quality***

Meiers et al 2014

Simulate Net Percolation

- The head of water that develops above a geomembrane is a key parameter for estimating leakage and can be:
  1) Measured directly
  2) Estimated using measured lateral drainage above the geomembrane and transmissivity
  3) Estimated using water balance and transmissivity of drainage layer

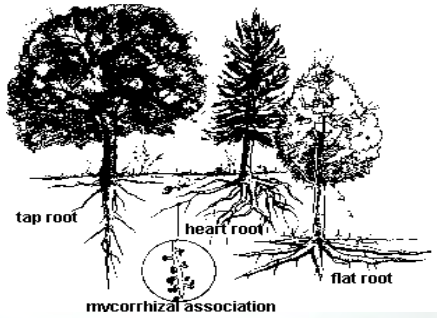
Advection >>> Diffusion

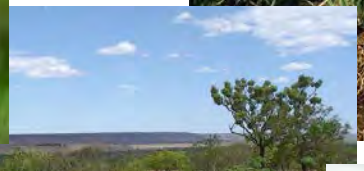


- Simulated net percolation over a range of defects
  - 2 and 30 defects/ha each at 9mm in diameter

Geomembrane Defects

- Construction (wrinkles, tears, welds, punctures, ...)
- Post Construction
  - Services stress (differential settlement, Δ temp)
  - Anthropogenic (e.g. artisanal mining)
  - Bioturbation
  - Vegetation (roots, blow down, etc.)





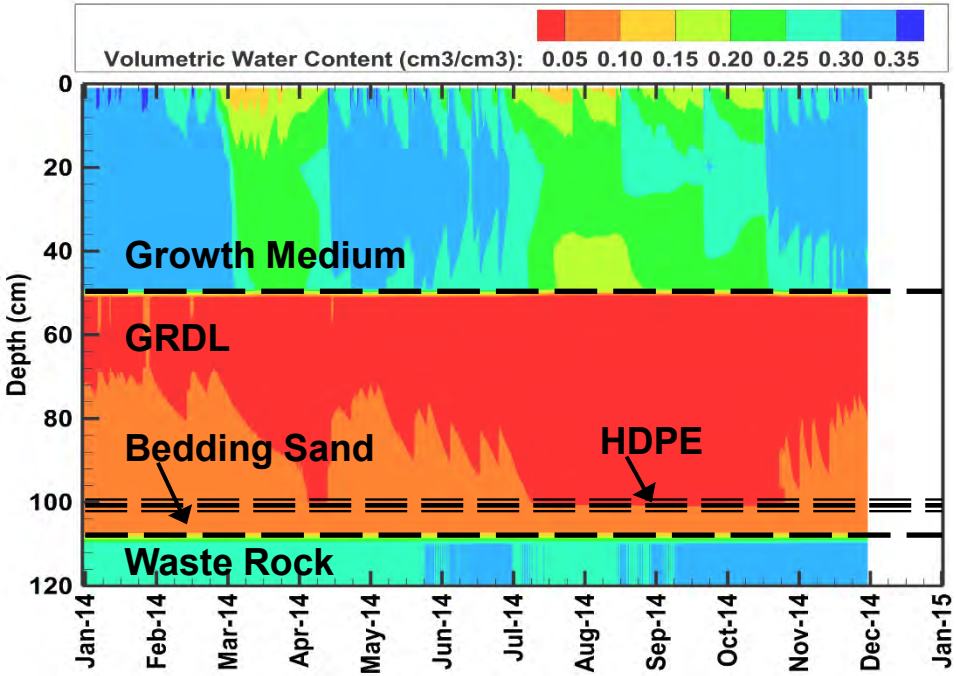
http://heapsolutions.com/applications/heap-liner-leak-detection/

O'Kane and Meiers 2014

Water Dynamics – Victoria Junction

- GRDL at VJ limits head of water above geomembrane
- Approximately 15% of precipitation moves through the GRDL

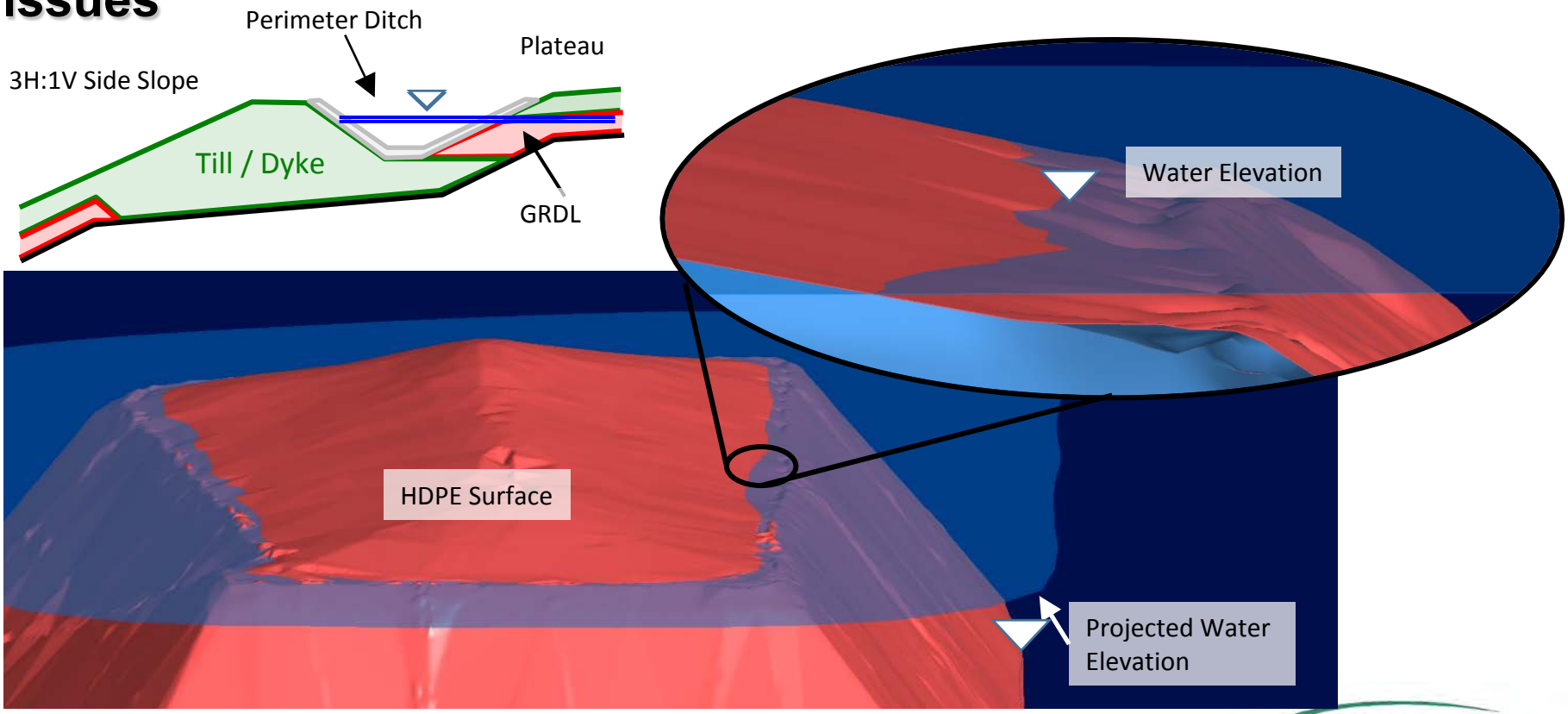
Victoria Junction



- Runoff and lateral drainage from plateau is brought back to surface and channeled to drop structures on side slope

VJ - Direct Cover Monitoring

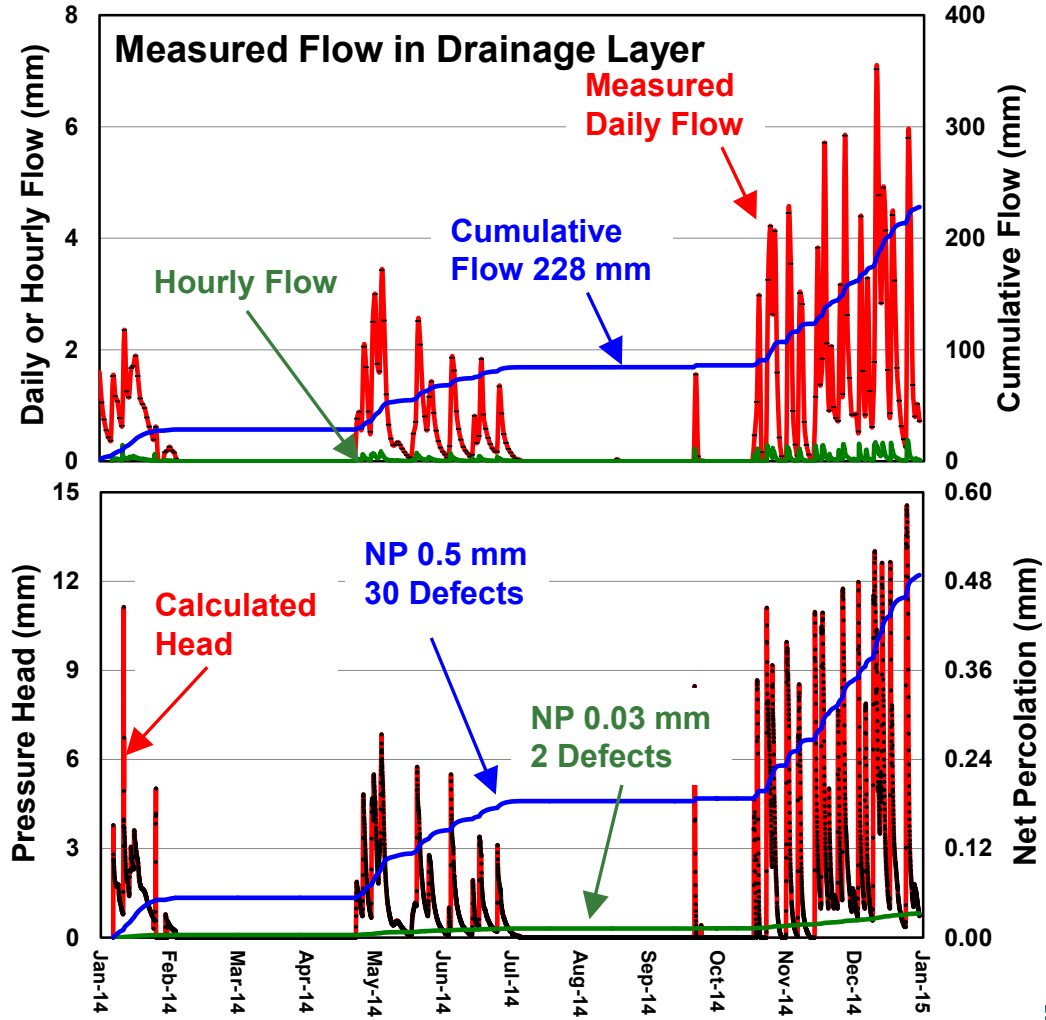
- Lateral drainage capacity is adequate… however a restriction to flow at the outlet to the GRDL
- Flow restriction affects ~ 6% of landform surface
- Informs on potential for and risk of leakage and stability issues



Simulated Net Percolation – VJ

Initial conceptual model – Potential for and risk of NP is low

…..need to consider restriction to flow at GRDL outlet



- **Measured lateral flow** in GRDL used **to estimate head**
- **Growth medium attenuates flux** to GRDL (**max 8×10^{-6} cm/s or 0.3 mm/hr**)
  - Highlights importance of the growth medium layer
- **Maximum head is ~12mm,** supports transmissivity
- **Simulated NP...** Is **very low <1mm**
- **Risk associated with leakage is low**

O'Kane Consultants

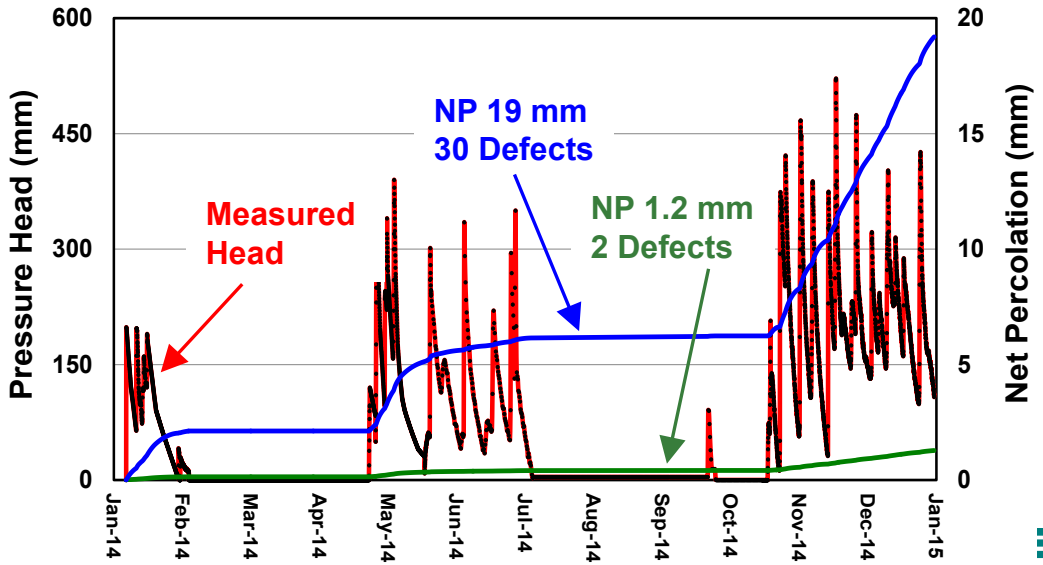
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

Simulated Net Percolation – VJ

Initial conceptual model – Net percolation in very low range

…..need to consider restriction to flow at GRDL outlet

- **Used measured head** in GRDL used to estimate leakage
- **Maximum head is >450mm**
- **Simulated NP, <19mm for the area of restricted flow**



Daily Flux Rate (cm/s)	Head (mm)	Defects per hectare		
		2	15	30
		Net percolation (mm/yr)		
Adequate drainage (94% of surface and 30% of total NP)				
transient	transient	0.03	0.2	0.5
Inadequate drainage (6% of surface and 70% of total NP)				
transient	transient	1.2	10	19
Landform				
		0.1	0.8	1.6

- **~6% of surface area contributes 70% of total NP**
- **Simulated landform NP, very low < 2mm**
- **Risk associated with leakage through defects low**

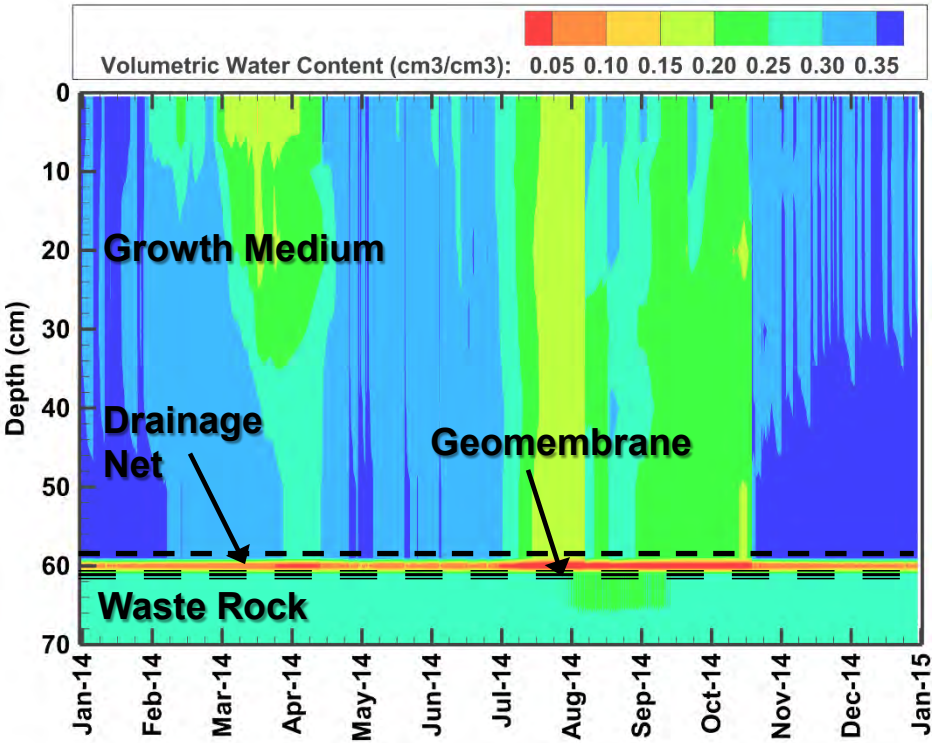
O'Kane Consultants

Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

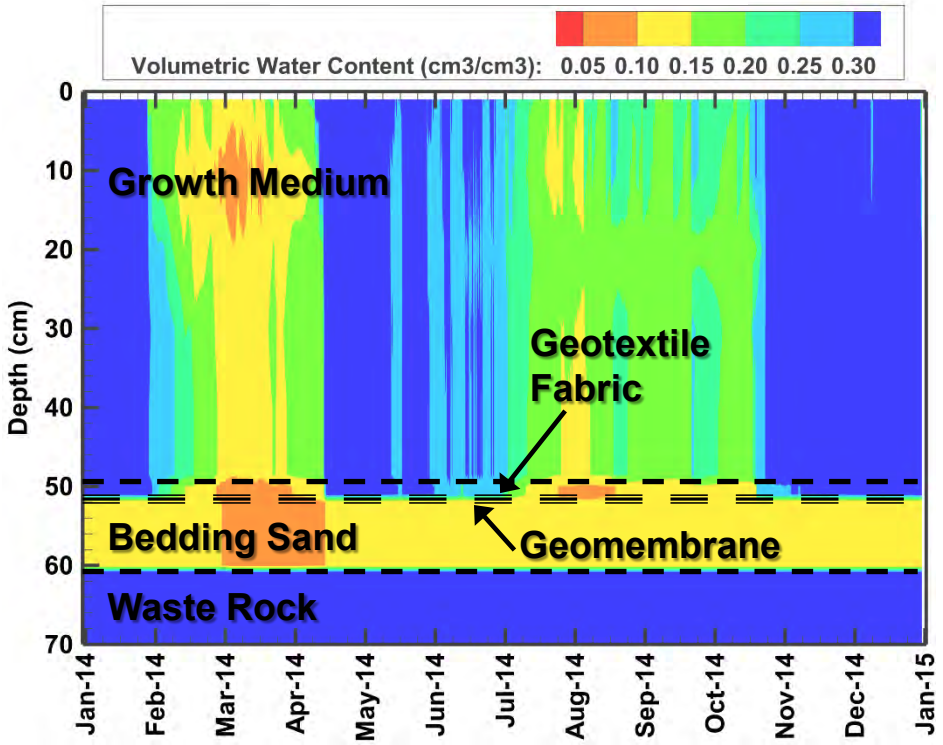
Water Dynamics – Franklin & Summit

- Franklin – Drainage Net limits head of water above geomembrane
- Summit – Transmissivity inadequate to limit head of water

Franklin



Scotchtown Summit



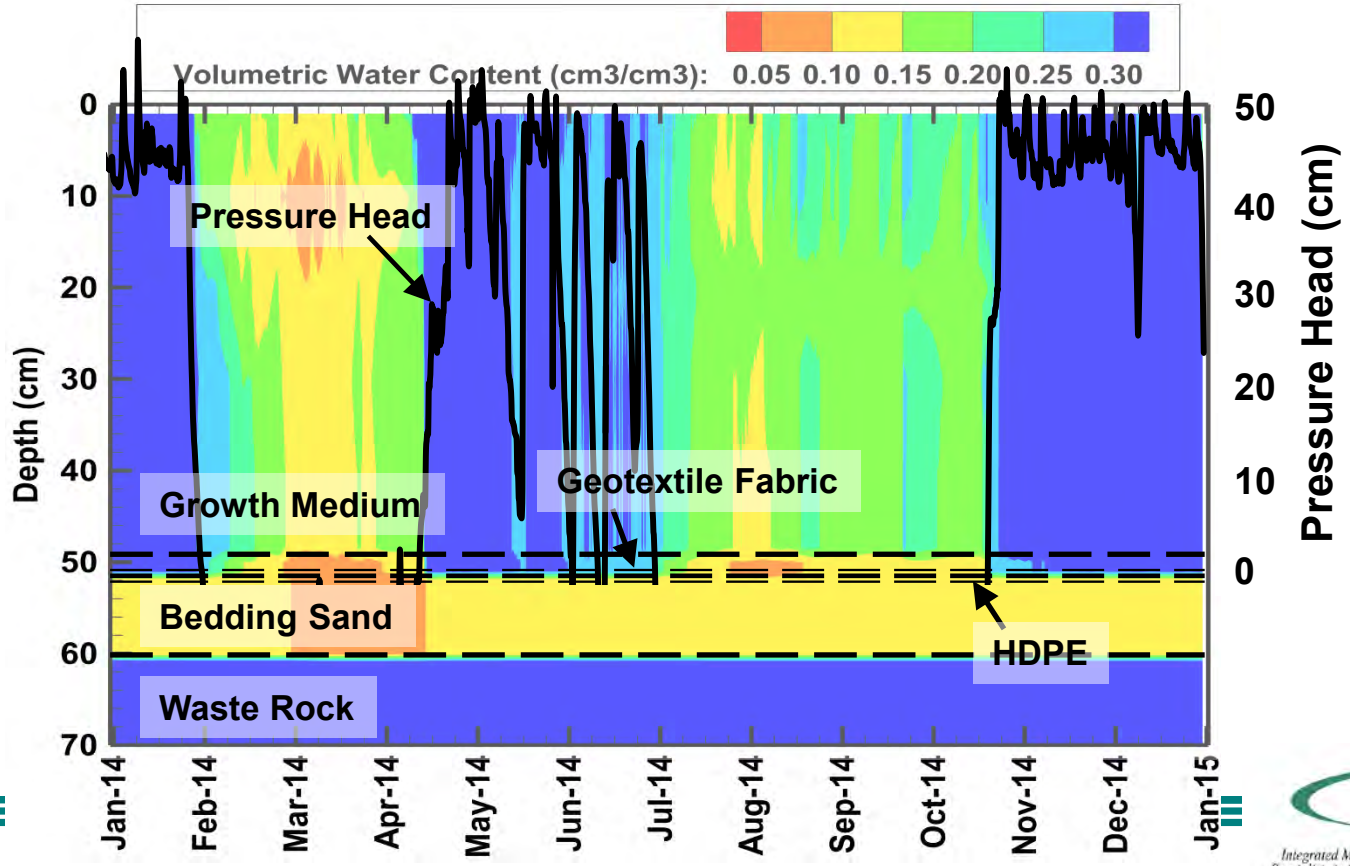
- Summit cover system inherently carries a greater risk of leakage
- Conceptual understanding of performance is established

O'Kane Consultants

Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

Hydraulic Head – Summit

- Inadequate lateral drainage capacity to limit head of water above geomembrane
- Enhance understanding of risk associated with leakage
- Transitions rapidly from positive to negative pore-water pressure (~14 mm or water)



O'Kane Consultants

Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

Biological Monitoring Example

Millions of spiderwebs cover Scotchtown field

Sharon Montgomery-Dupe
Published on November 19, 2014

Sharon Montgomery-Dupe
Published on November 19, 2014

SCOTCHTOWN — There might not be a Spider-Man in Cape Breton but apparently there was a spiderland.

Allen McCormick recently took a picture of a field at the summit in Scotchtown covered with spiderwebs.

"It was like a cotton field — all white."

He estimated the field to be a couple of square kilometres.

"They are saying millions," he added.

© Photo by Al McCormick
A field in Scotchtown was covered with millions of spiderwebs. The curator of the Nova Scotia Museum says this is rare, having heard of three such incidents over the past 20 years. Submitted by Allen McCormick

Biological Monitoring Example

Millions of spiderwebs cover Scotchtown field

Sharon Montgomery-Dupe
Published on November 19, 2014

Hebda explained these are not webs for catching food but rather webs for "ballooning" by small spiders.

"They basically produce a long single strand and let the wind catch it and carry them."

He said if there conditions make the place no longer suitable — such as flooding or drastic change in temperature — spiders will disperse.

"It's got to be something fairly large scale that covers a relatively large area. They will all move at the same time and travel the same distance."

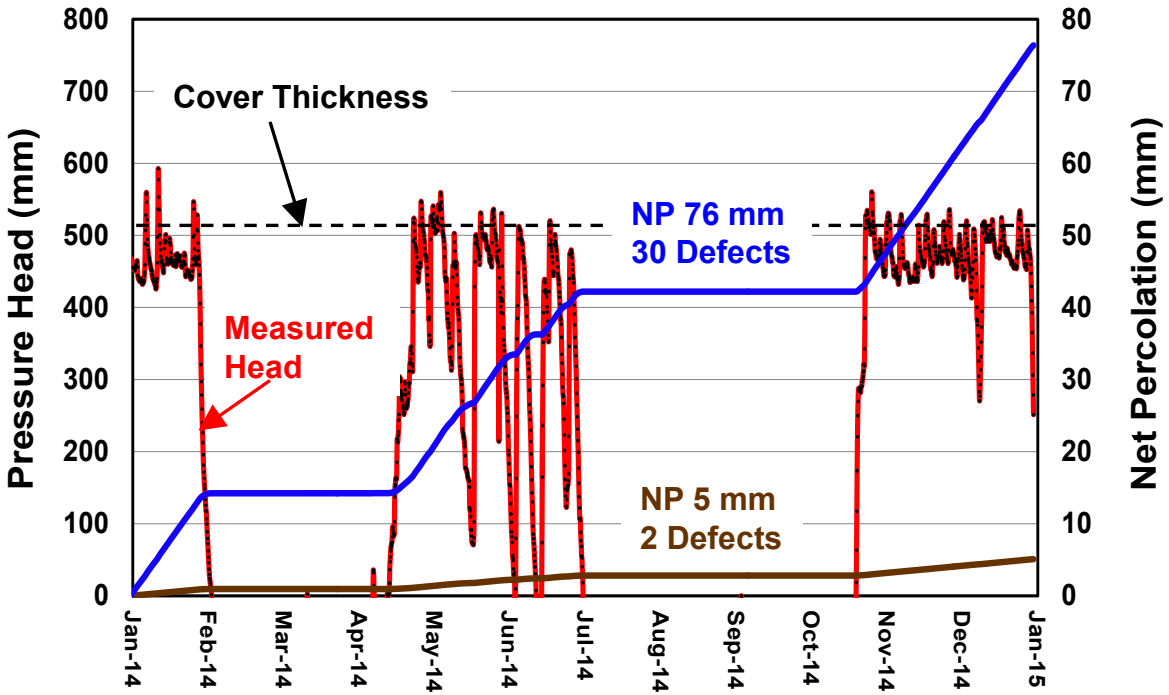
0 Comment Send to a friend Print

© Photo by Al McCormick
A field in Scotchtown was covered with millions of spiderwebs. The curator of the Nova Scotia Museum says this is rare, having heard of three such incidents over the past 20 years. Submitted by Allen McCormick

Summit: Simulated Net Percolation

Initial conceptual model – Risk of NP associated with defects

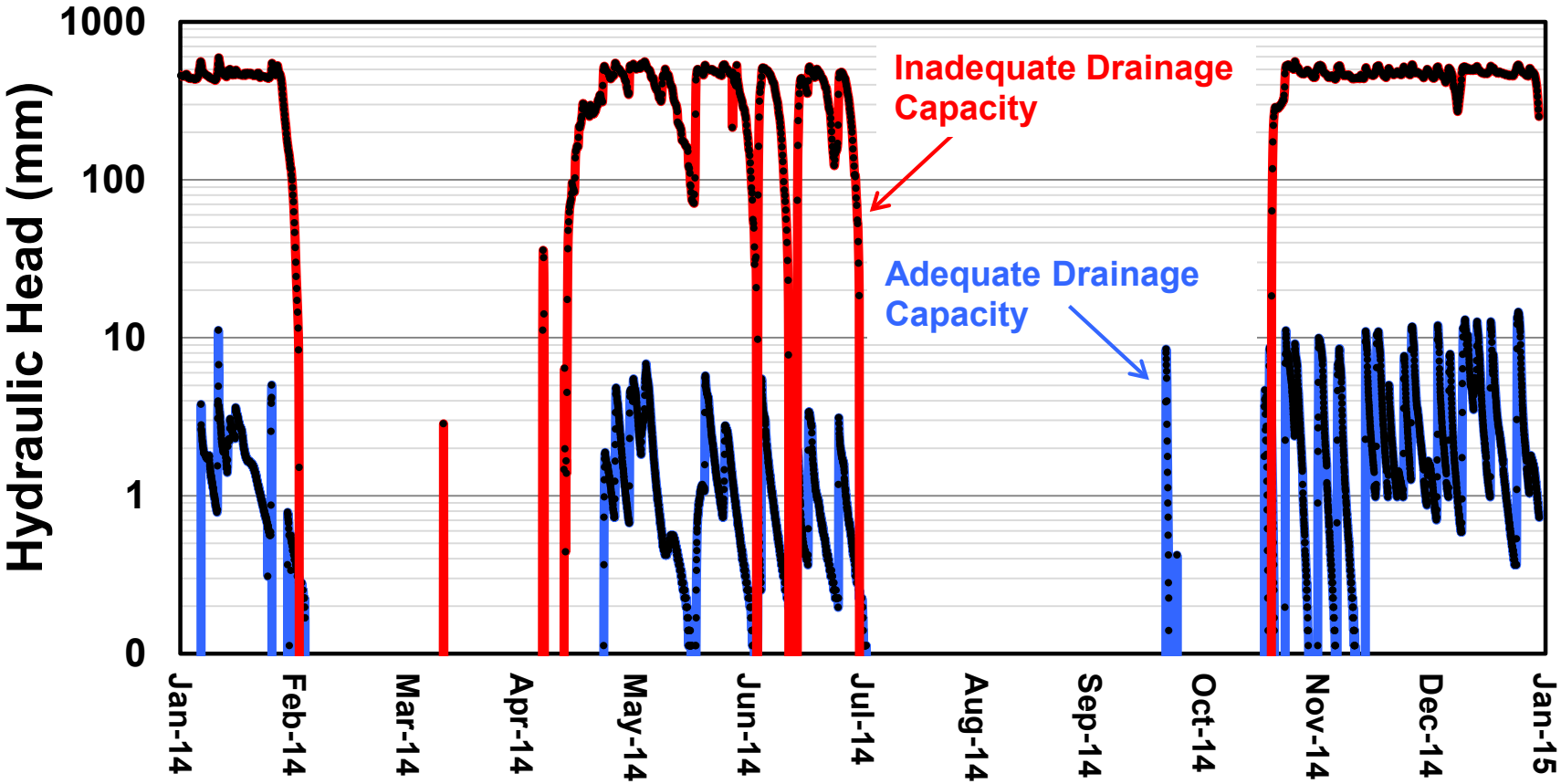
- Use measured head
- Maximum head is >500mm over prolong periods
- Simulated NP, 76mm or 5% of PPT for 30 defects



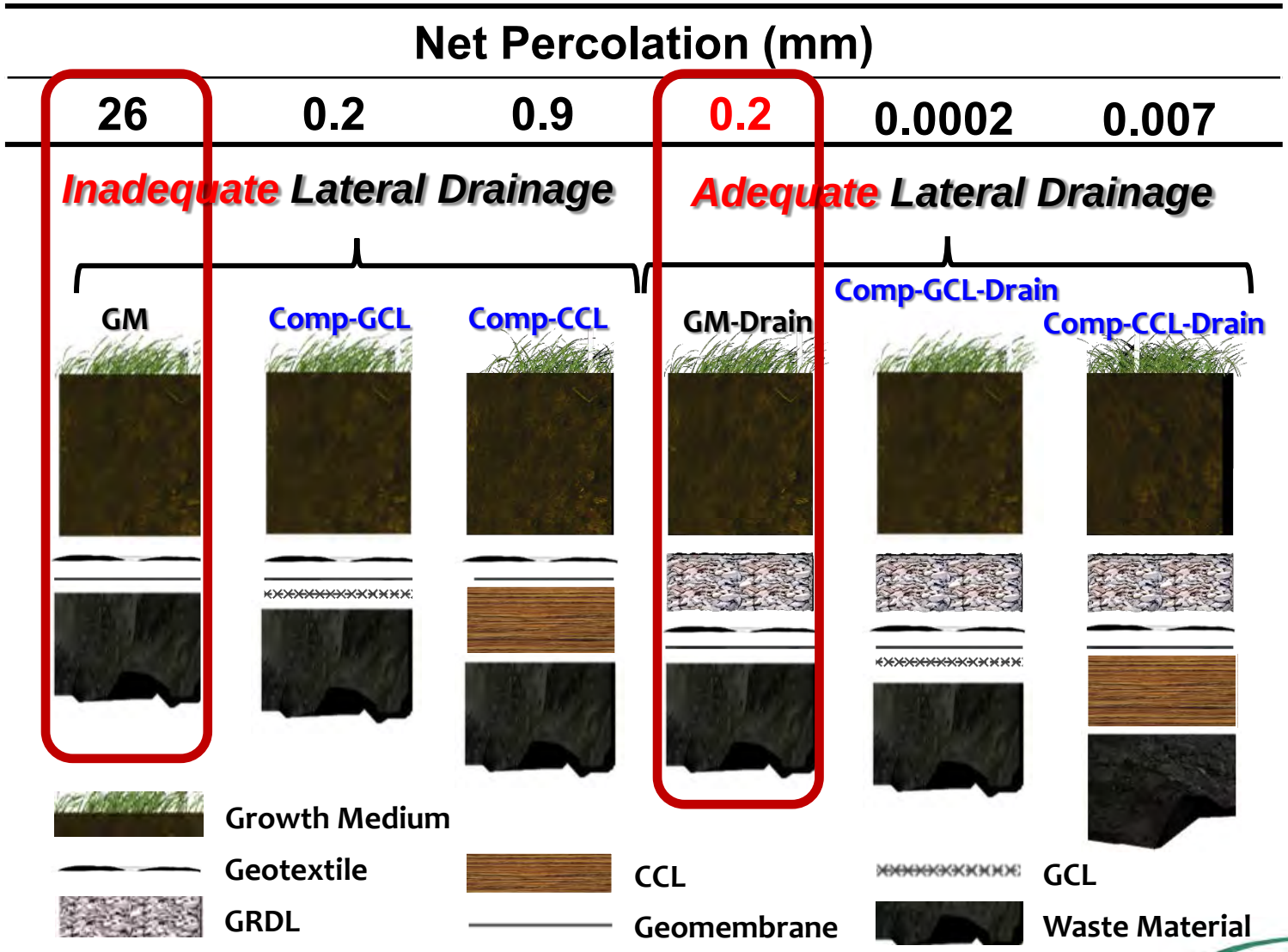
- Risk associated with leakage through defects is much higher – Defects are a concern!
- ARD/ML loading to the receiving environment would be different under the simulated range of NP
- Require additional interpretation of field performance to provide context for NP…

Design Consideration

- *Cover systems design is site specific*
- *Climate, materials, and landform contribute to the measured performance*



Design Considerations...



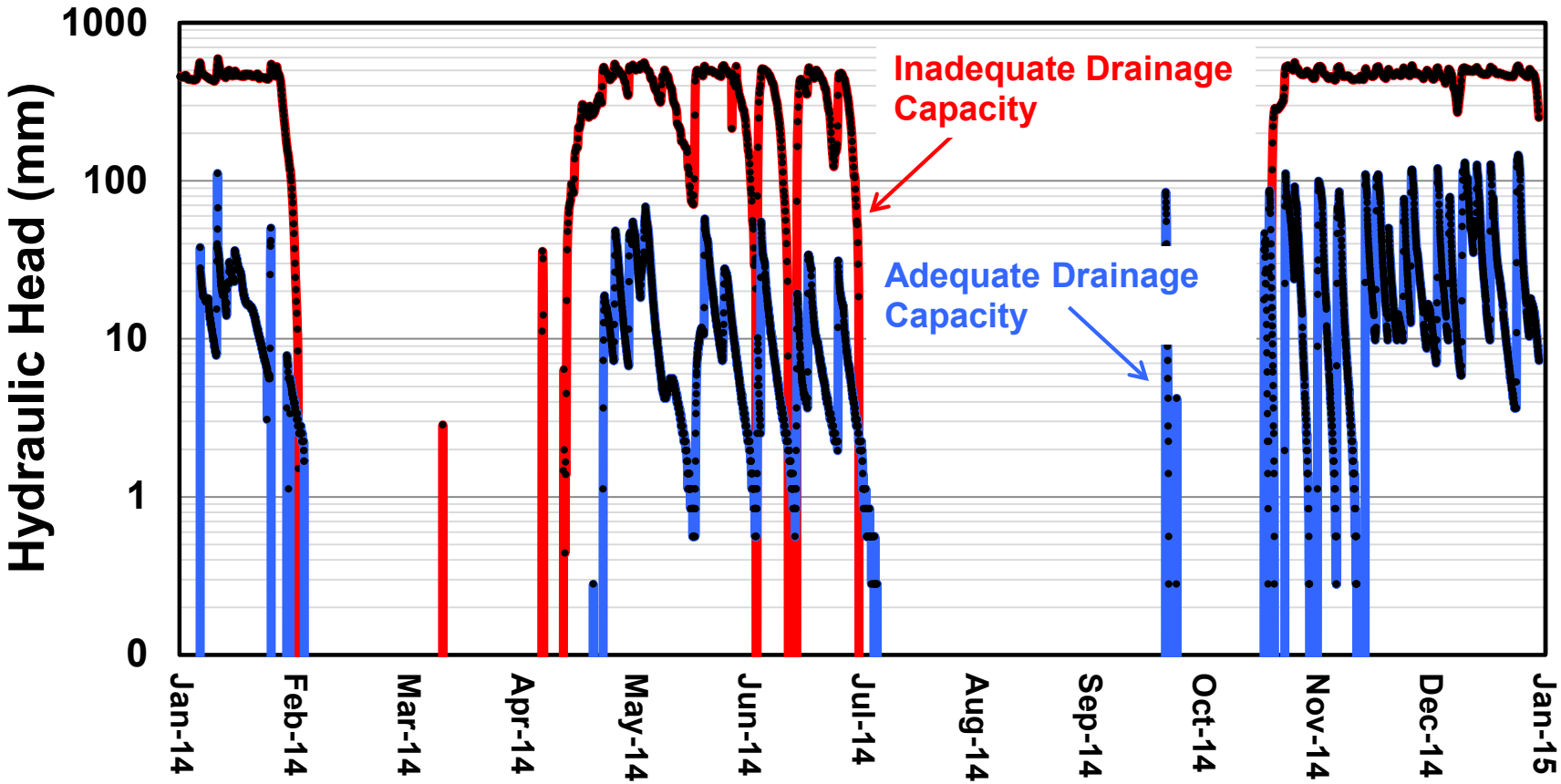
Design Considerations...

Factors influencing long-term performance

- GCL compatible with in situ conditions (i.e. cation valency, Na, Ca, Mg)
  - Increase in Ks of GCL in composite cover system application ($1x10^{-9}$ to $1x10^{-6}$ cm/s)
- CCL in intimate contact with geo-membrane
  - Trampolining over surface or folds in the geomembrane
  - CCL not built to engineered specifications
- Reduction in Ks of drainage layers
  - Root matting, fines ingress and deformation

Design Consideration..

Decrease in Ks of drainage layer from 1 cm/s to 0.1 cm/s



Design Considerations...

	Net Percolation (mm)					
	26	0.2	0.9	0.2	0.0002	0.007
In-service?	26	26	4.8	1.6	0.2	0.7

Inadequate Lateral Drainage | *Adequate* Lateral Drainage

Summary Discussion Points

- Estimates of net percolation were developed for each of the reclaimed WRP and understanding for the risk of…
- Question: What post-closure defects are reflective of your site
- Preferred Response: Not sure but…we have demonstrated adequate lateral drainage
- Cover system design is site specific… climate, materials and landform need to be considered

Summary Discussion Points

- ***Cover system design with geosynthetics require an understanding of physical, biological and chemical processes that will lead to long term in-service performance…***

Thank You!

O'Kane Consultants Inc.

Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

Habitat for Humanity®

O'Kane Consultants Inc.
Habitat for Humanity Initiative – El Salvador

Rainbow of HOPE for Children