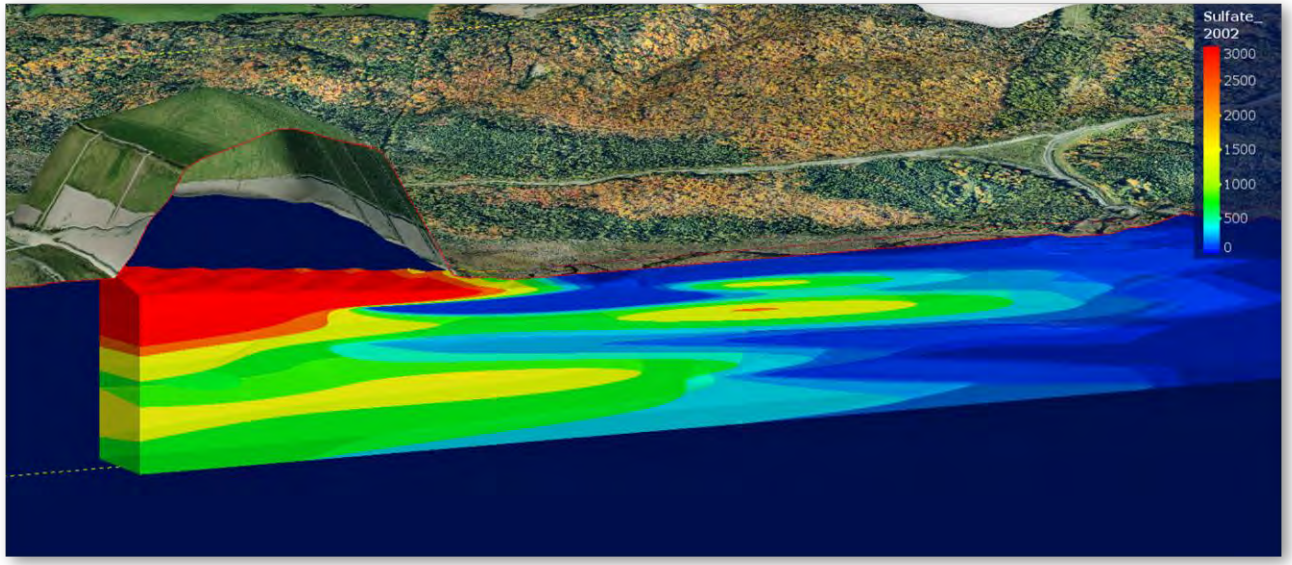
ATLANTIC CLRA | ACRSD

Atlantic Reclamation Conference

October 20 – 22 2016, Fredericton, New Brunswick

Use Of Conceptual Models In Advance Of Numerical Simulations To Demonstrate An Understanding Of Loading From Reclaimed Waste Rock Piles



Cody Bradley

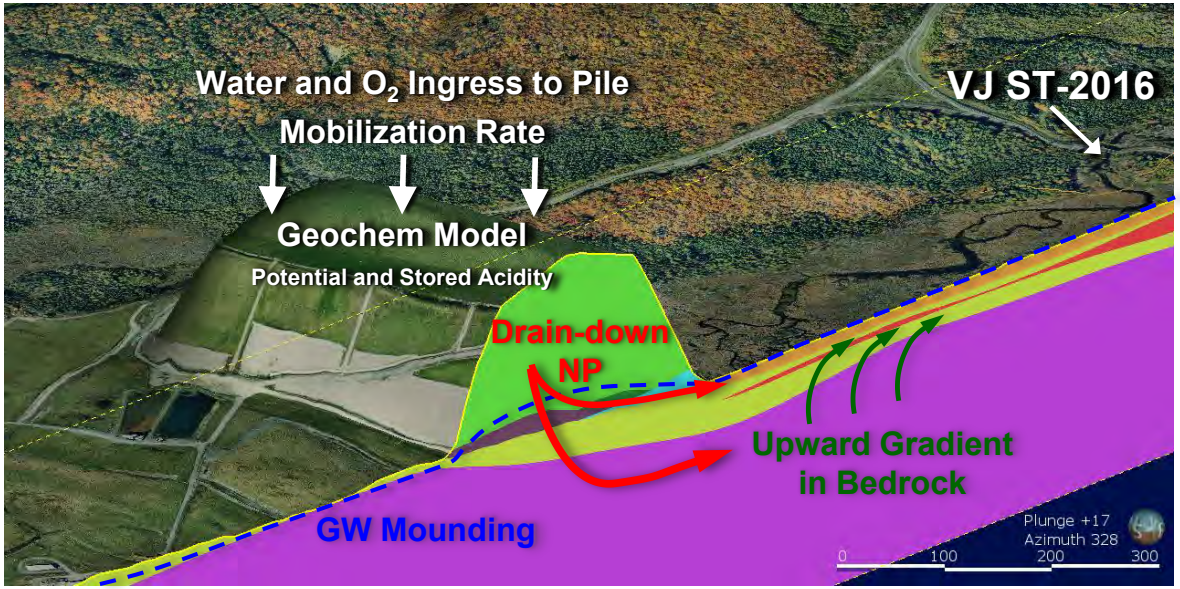
O'Kane Consultants

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

Public Works and Government Services Canada

Presentation Discussion Points

- Overarching Project Background
- Background for Focus of this Presentation
  - Reclaimed Victoria Junction Site
- Conceptual Model
  - Physical
  - Flow
  - Geochemical
- Summary Discussion Points



Conceptual Model

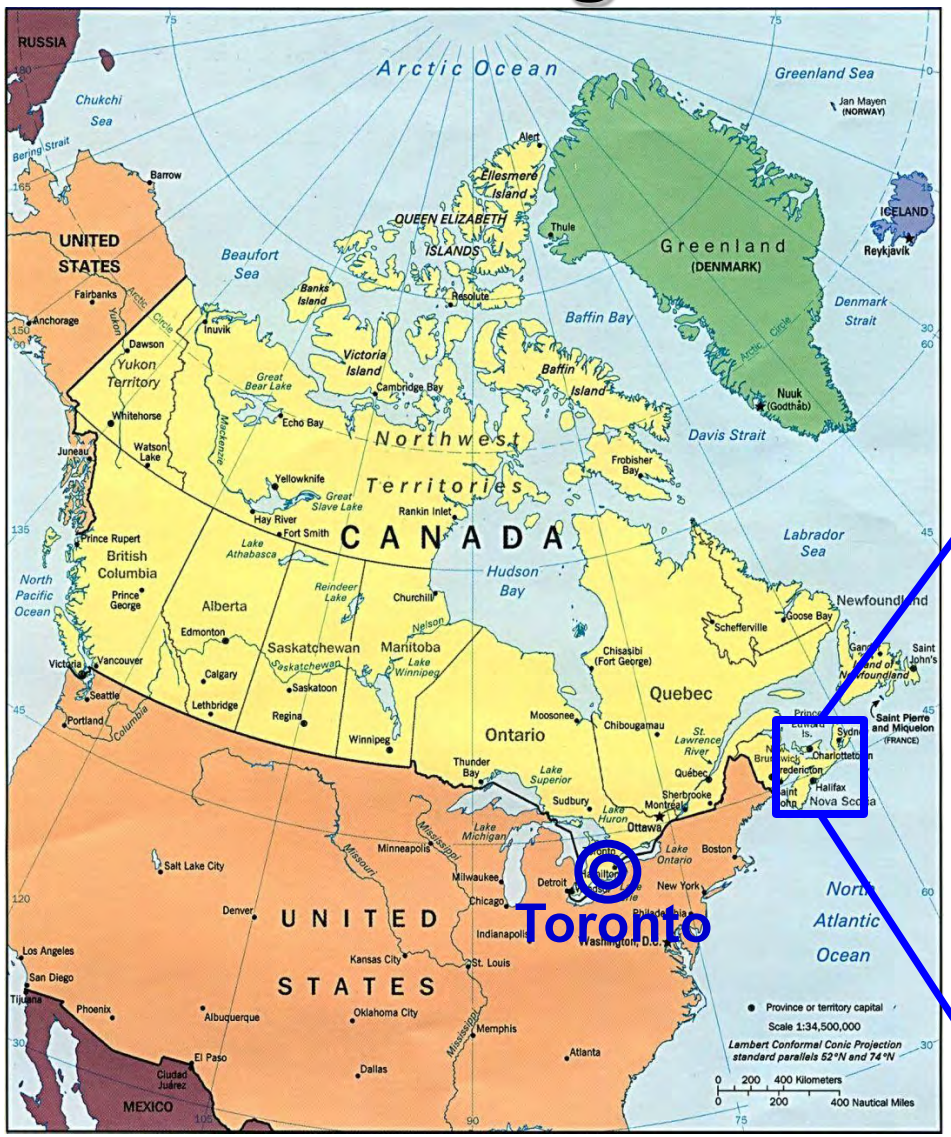
- Analytical tool with several variations and contexts
- Used to collect and organize ideas to be assessed in a holistic manner
- Strong conceptual models capture something real and identifies the problem to be solved
- *Developing a conceptual model (understanding) of past and current conditions*

Leads Us To

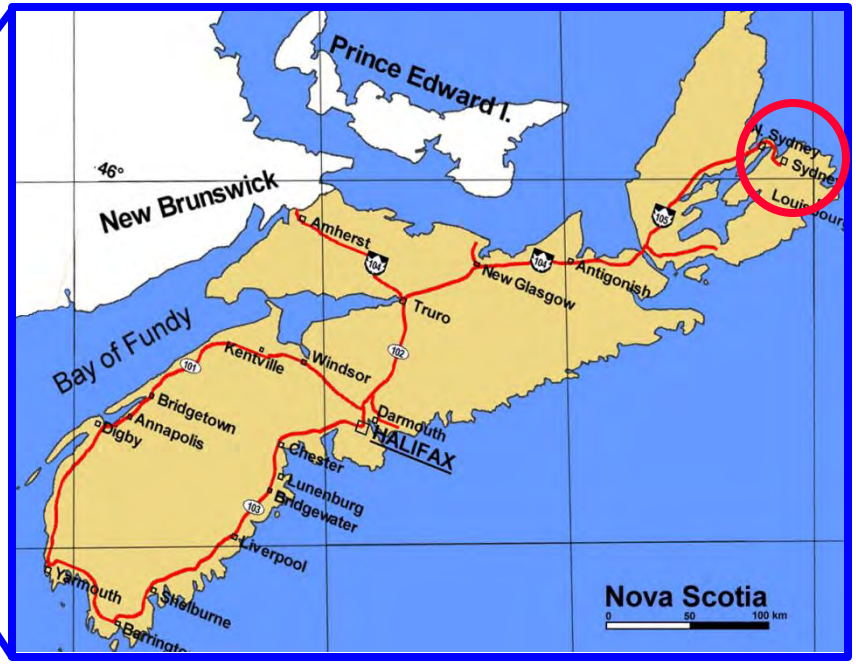
- *An understanding of the strategies required to solve the problem*
- *Minimizes uncertainty and risk*
- *Understanding of likely outcomes before numerical modelling commences… if required*

Background – Site Location

Site: Near Sydney, NS
Cape Breton Island



Atlantic Canada



Background – ECBC

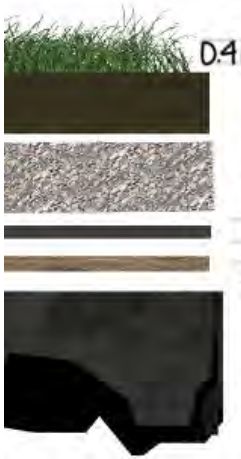
- ECBC is a Federal Crown Corporation responsible for environmental remediation associated with coal mining activities in Cape Breton
  - Mining operations began in 1685 to the 1980s
  - 50 underground mines produced 500 million tonnes of coal

- Responsibility for sites now under Public Works and Government Services Canada
  - O'Kane Consultants installed cover system monitoring system ~5 years ago
  - Evaluation of detailed cover system and overall landform performance for four of the sites
    - VJ, Summit, Lingan, Franklin

Meiers et al 2014

Background – Cover System Profiles

Victoria Junction

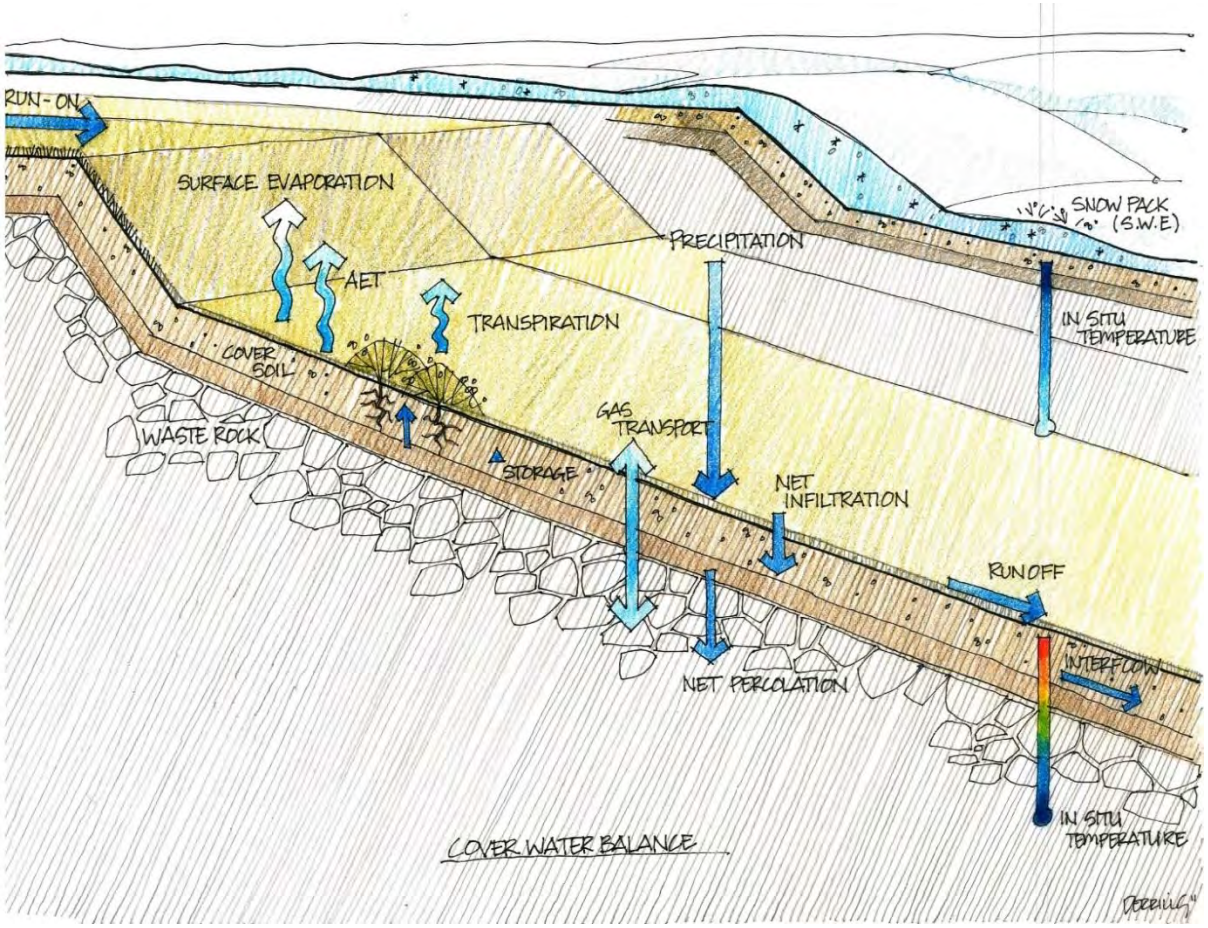


Franklin

Scotchtown Summit

Lingan

Background – In Situ Monitoring



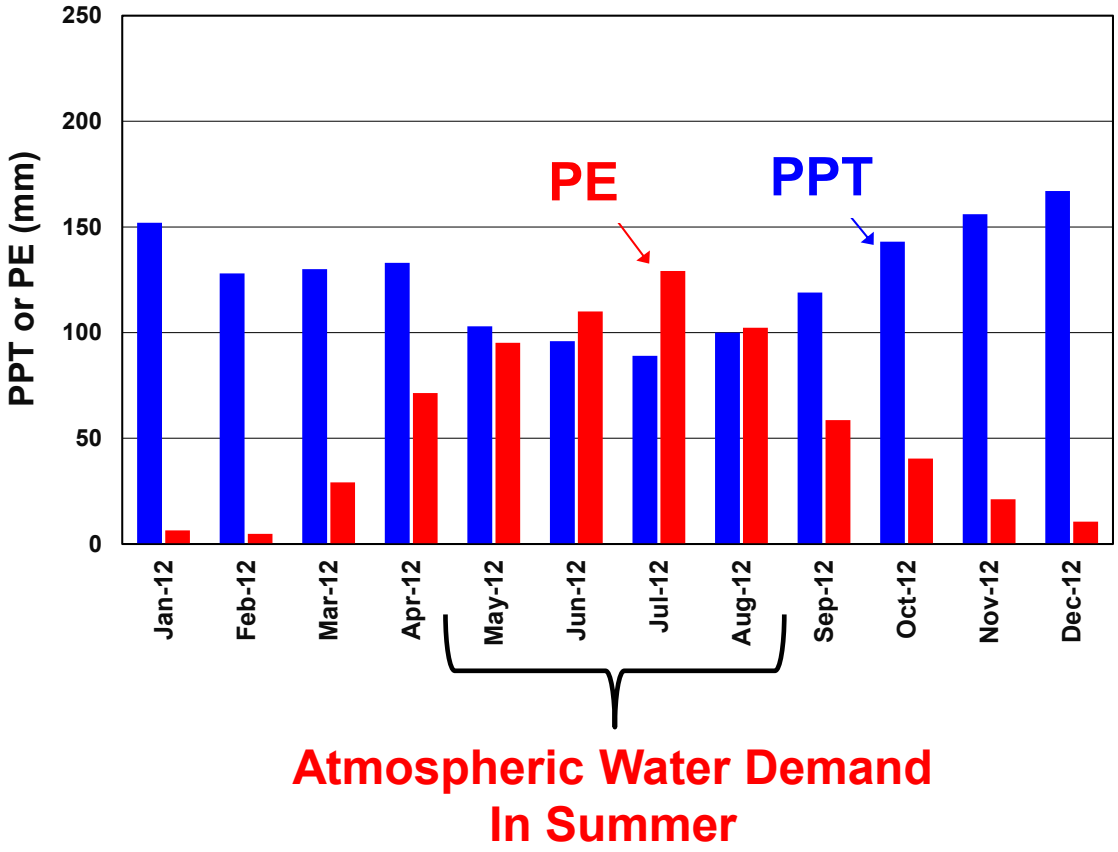
- **Monitored water balance component:**
  - AET
  - PPT
  - Runoff
  - Interflow
  - Water Storage
- **NP Estimated through:**
  - Water Balance
  - Conservative Tracer
- **Internal WRP Monitoring System:**
  - Temperature
  - Pressure
  - GW Elevations
  - Pore-Gas Concentrations
  - Pore-Water Quality

Meiers et al 2014

Background – Typical Climate

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

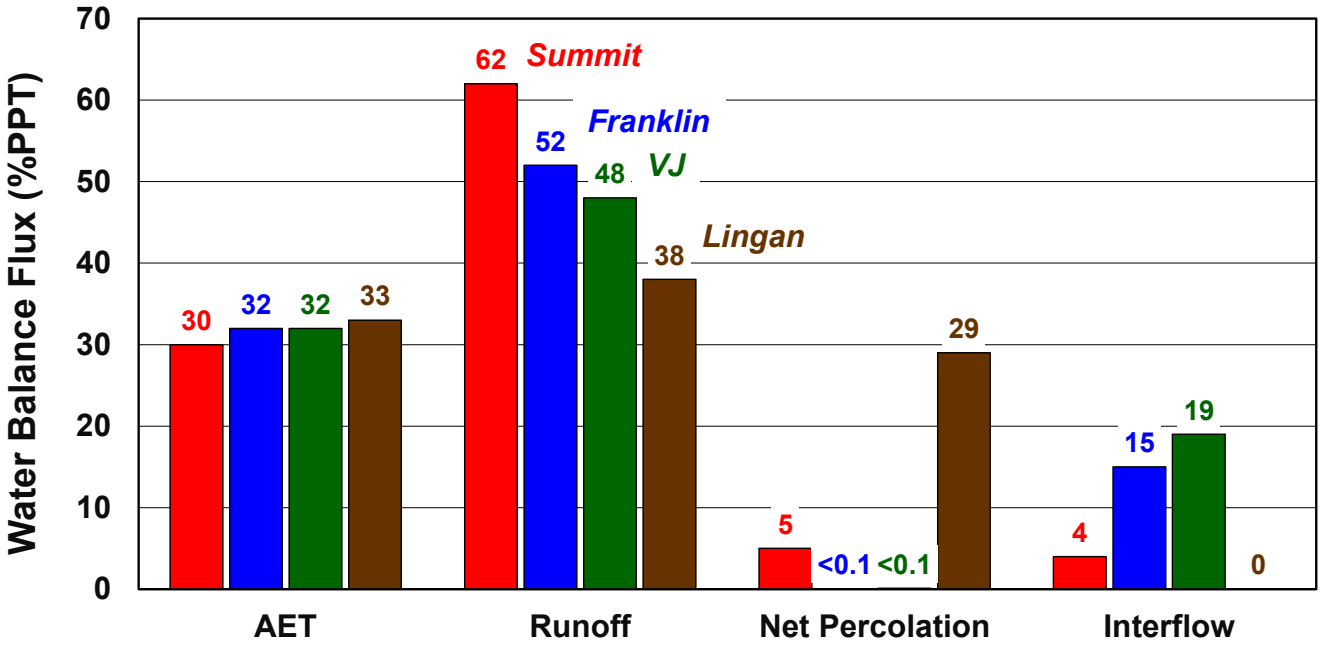


Meiers et al 2014

Background – Monitoring Comparison

Water Balance:

- *Runoff and Interflow ~66%*
- *Greater Interflow at Victoria Junction & Franklin*
  - *Interflow offsets proportional runoff volume*
- *Net Percolation at Lingan ~30%*
  - *Net percolation offsets a proportional runoff volume*

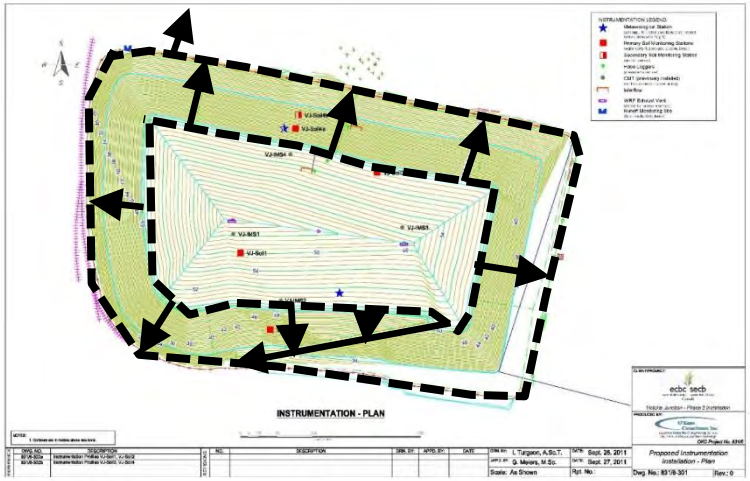


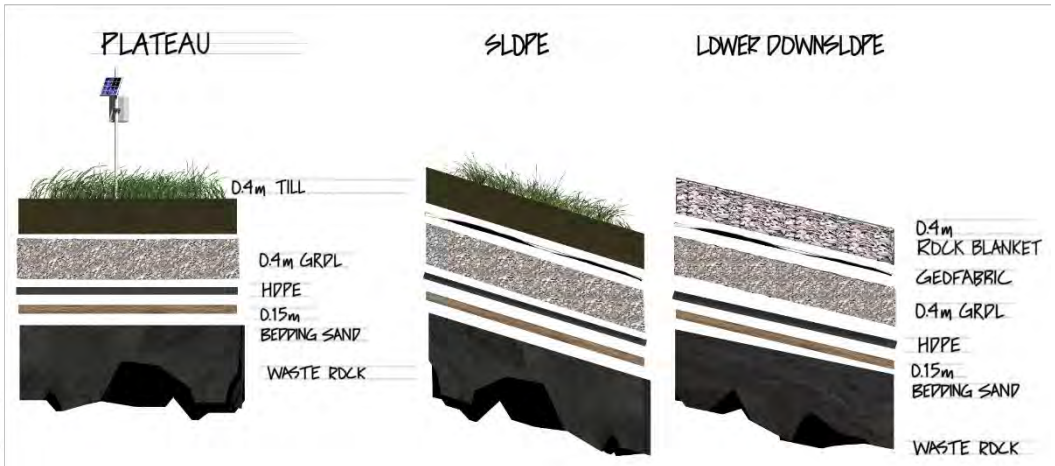
Meiers et al 2014

VJ – Site Background

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





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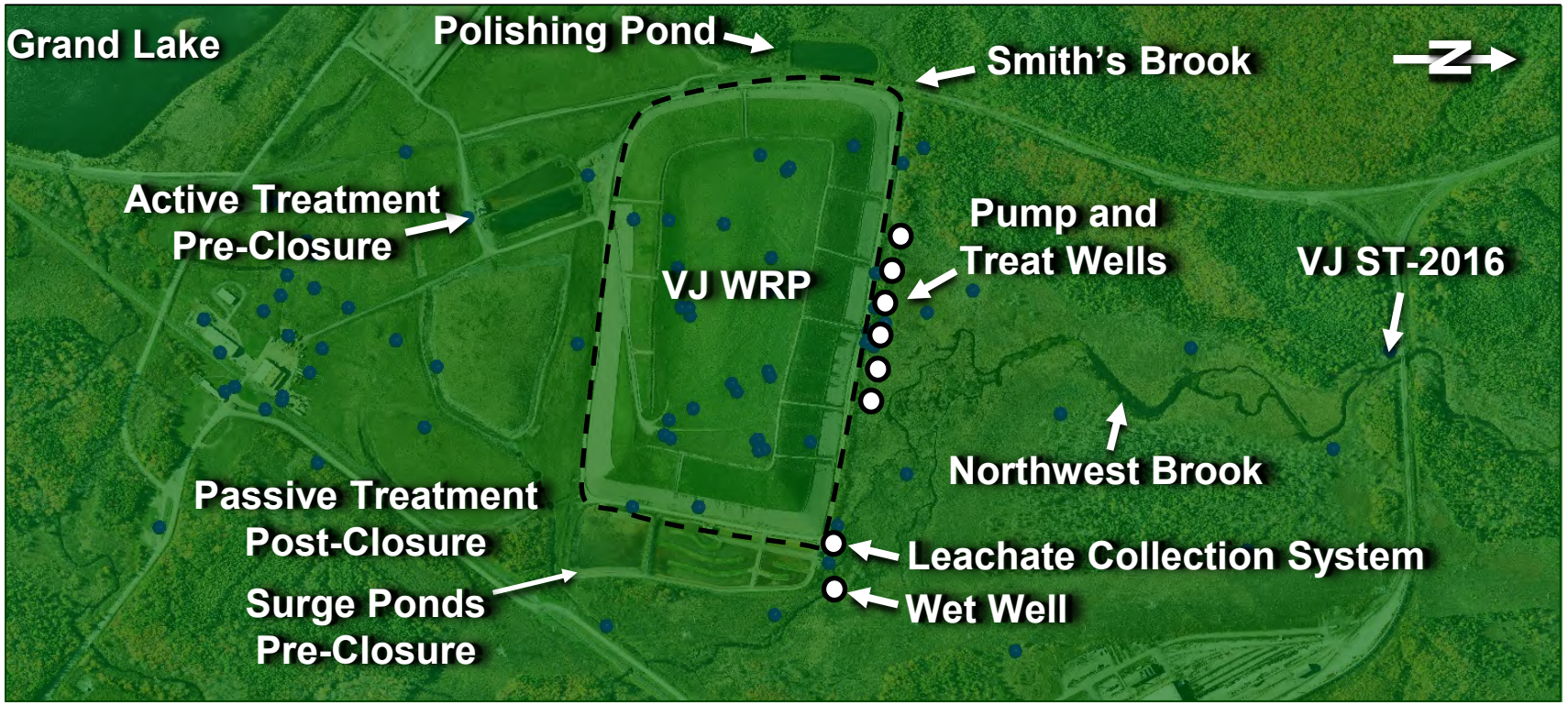
VJ – Developing Conceptual Model

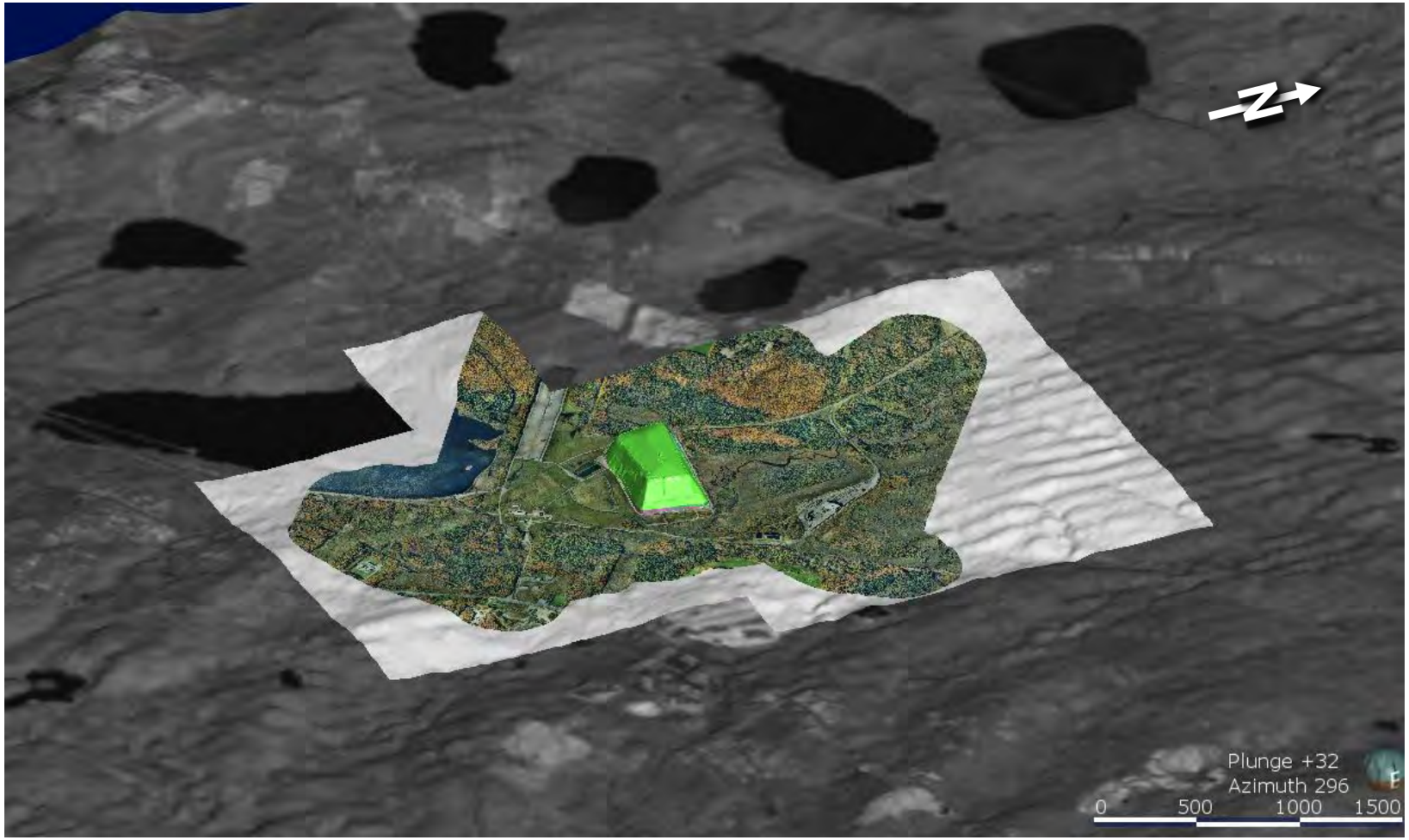
VJ ST-2016 Indicator / Receptor of changes to loading allowing geochemical model to be evaluated

- ***Loading to wetland and groundwater***



VJ – Physical Model

Surface



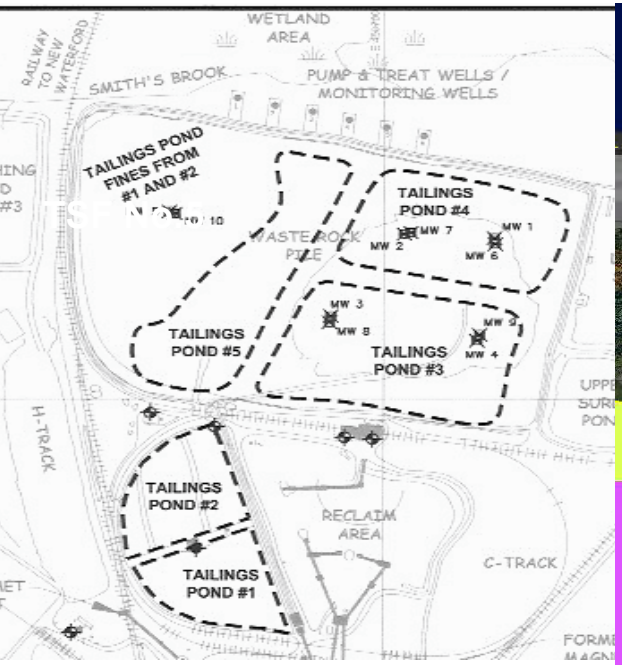
VJ – Physical Model

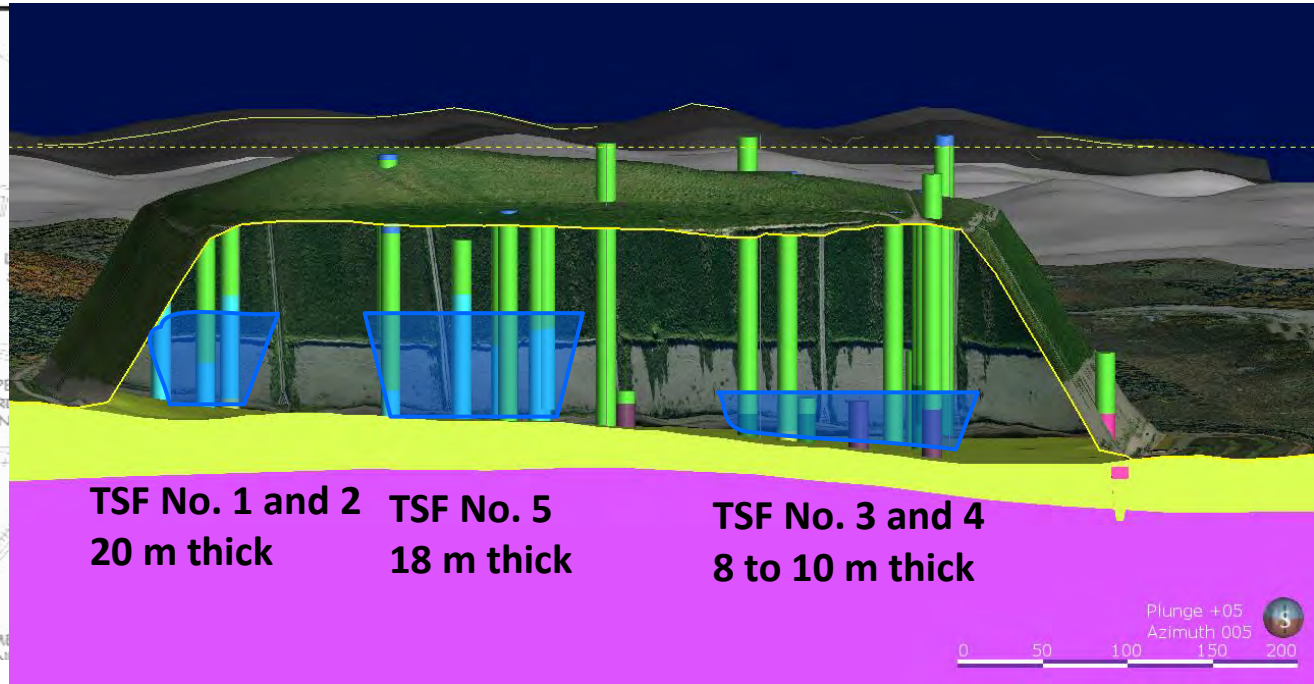
Lithology

VJ – Physical Model

WRP: Waste Rock / Tailings

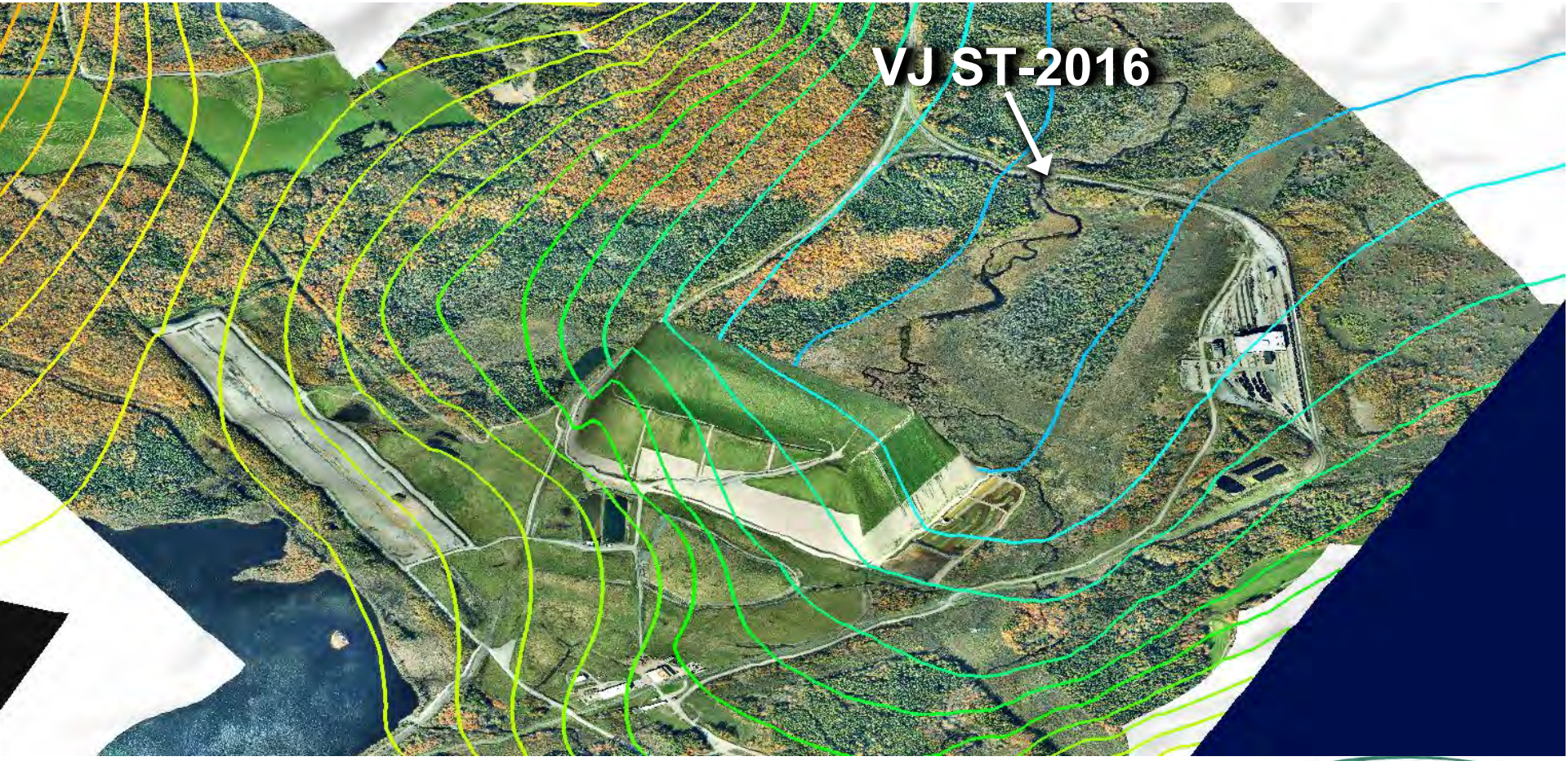
- *TSF No.1 and No.2 relocated to WRP*
- *TSF No.3 and No.4 covered in 1987*
- *TSF No.5 active until 1988*
- *Effect of tailings facilities on WRP drain-down*





VJ – Flow Model

- Surface and groundwater contaminant load focused to Monitoring Point 2016 (VJ ST-2016)
- Upward gradient in bedrock drives contaminant plume to surface



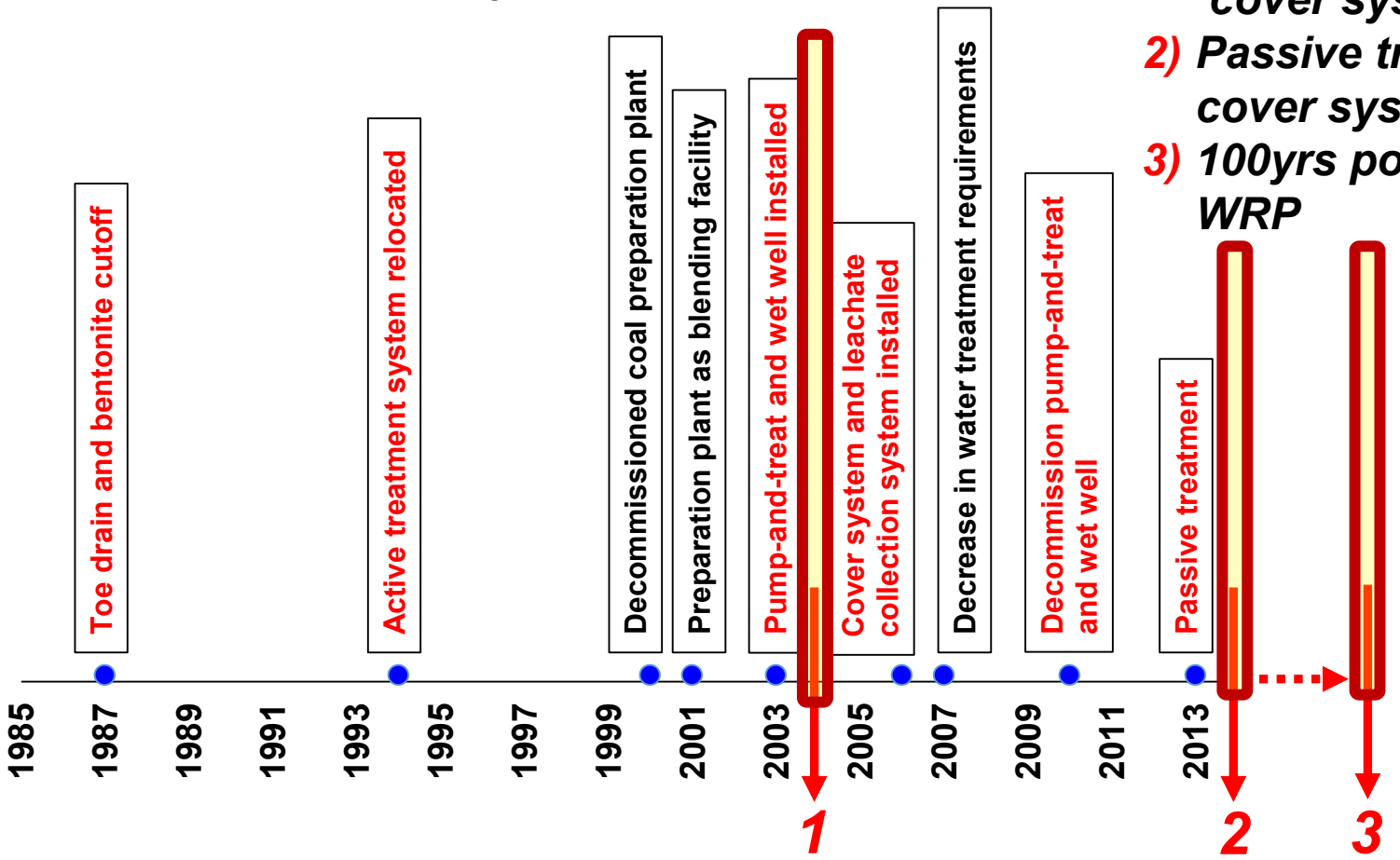
VJ – Developing Conceptual Model

Progressive changes to site operations:

- *Factors leading to changes in loading and water quality*

Acid Load Mass Balance to Test Three Conceptual Models:

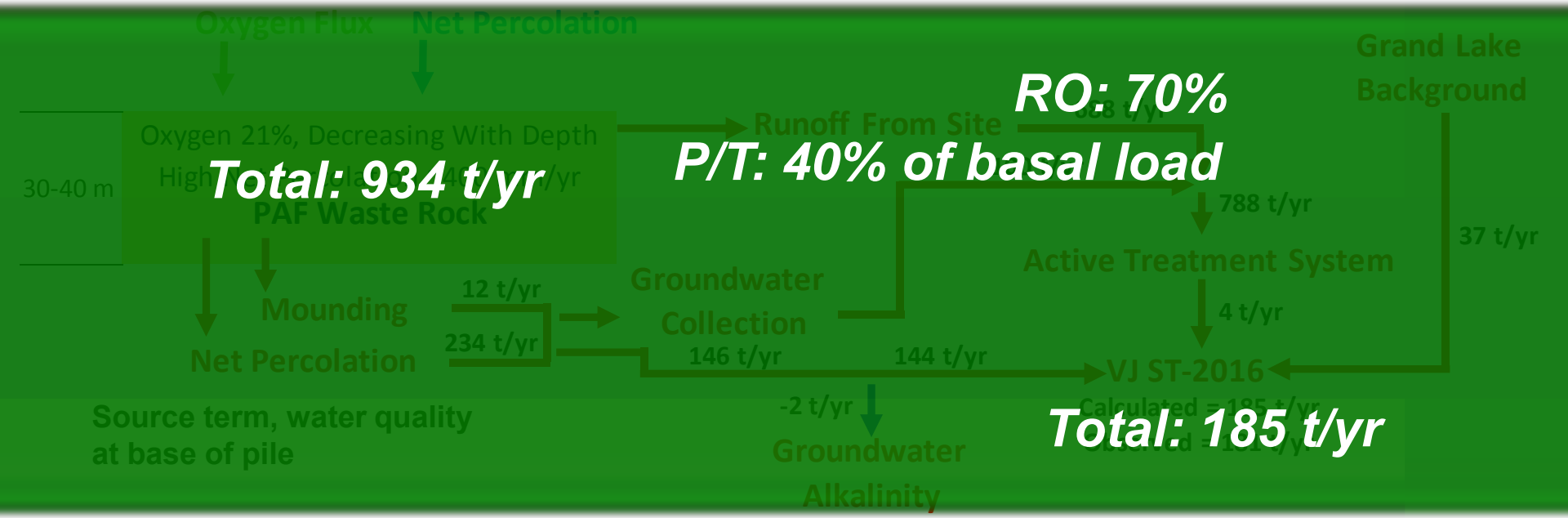
1) *Active treatment no cover system*
2) *Passive treatment with cover system*
3) *100yrs post reclaimed WRP*



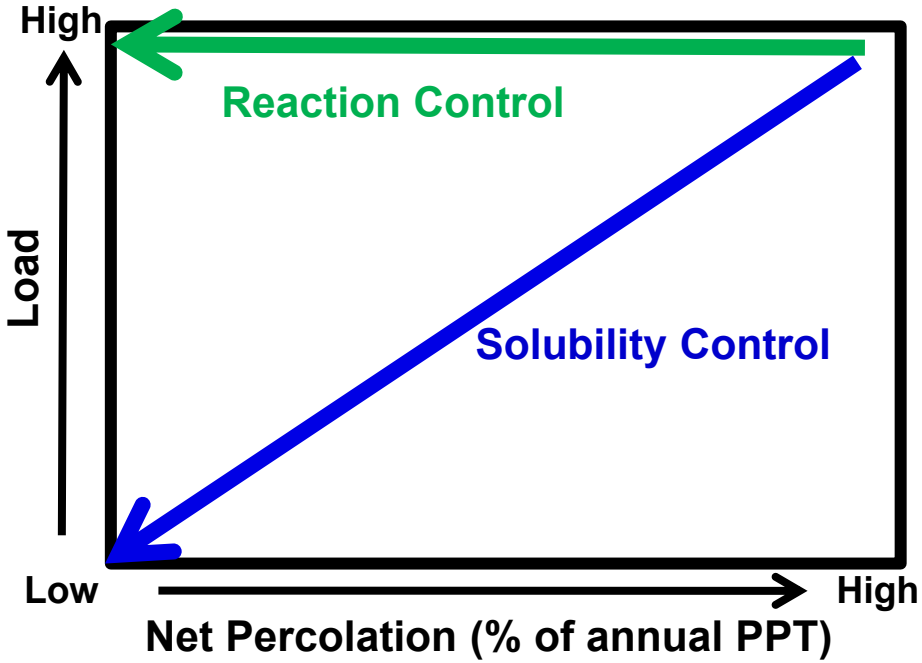
VJ – Acid Load Phase 1

Pre-cover system with active treatment

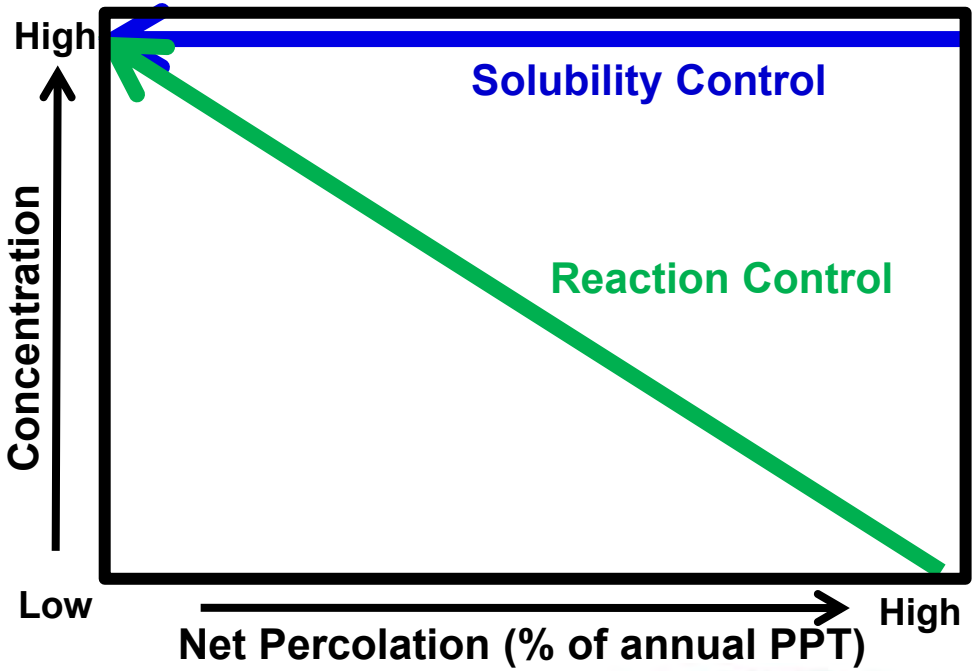
- ***Load = Flow × Concentration***
- ***NP ~400 mm/yr***
- ***Load – Basal seepage and runoff***
- ***Water treatment removes ~788 t/yr – groundwater collection system and surface runoff***



Managing Load & Cover Systems



Two "Models", or Approaches, used to Typically Evaluate Benefits of Managing Net Percolation and Oxygen to Sulphidic Waste



Acid Load vs. Acidity

Acid Load:

Concentration x Flow Rate

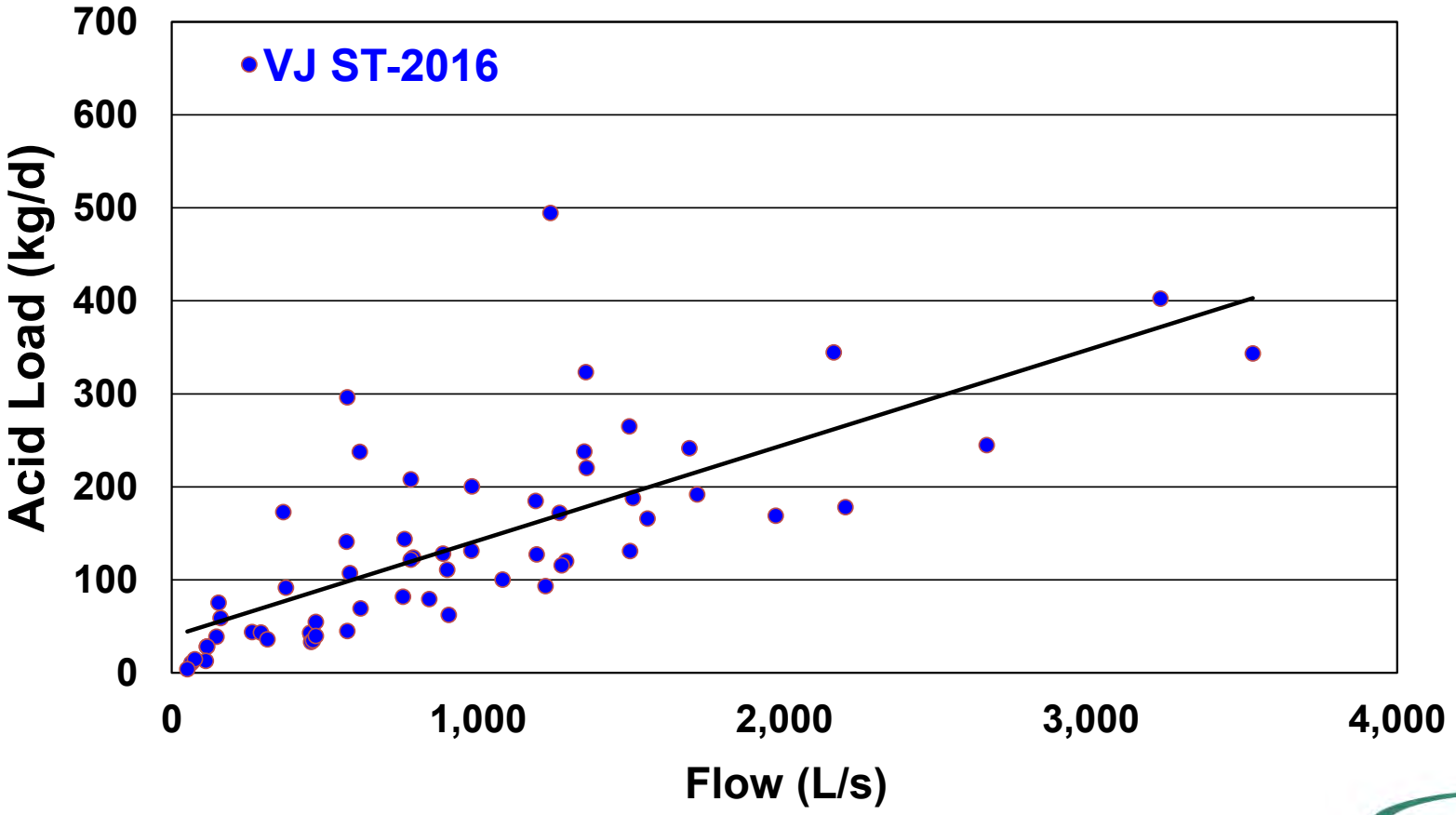
Acidity:

Concentration

VJ – Managing Load

Seasonal Changes in Acid load at VJ ST-2016 would support:

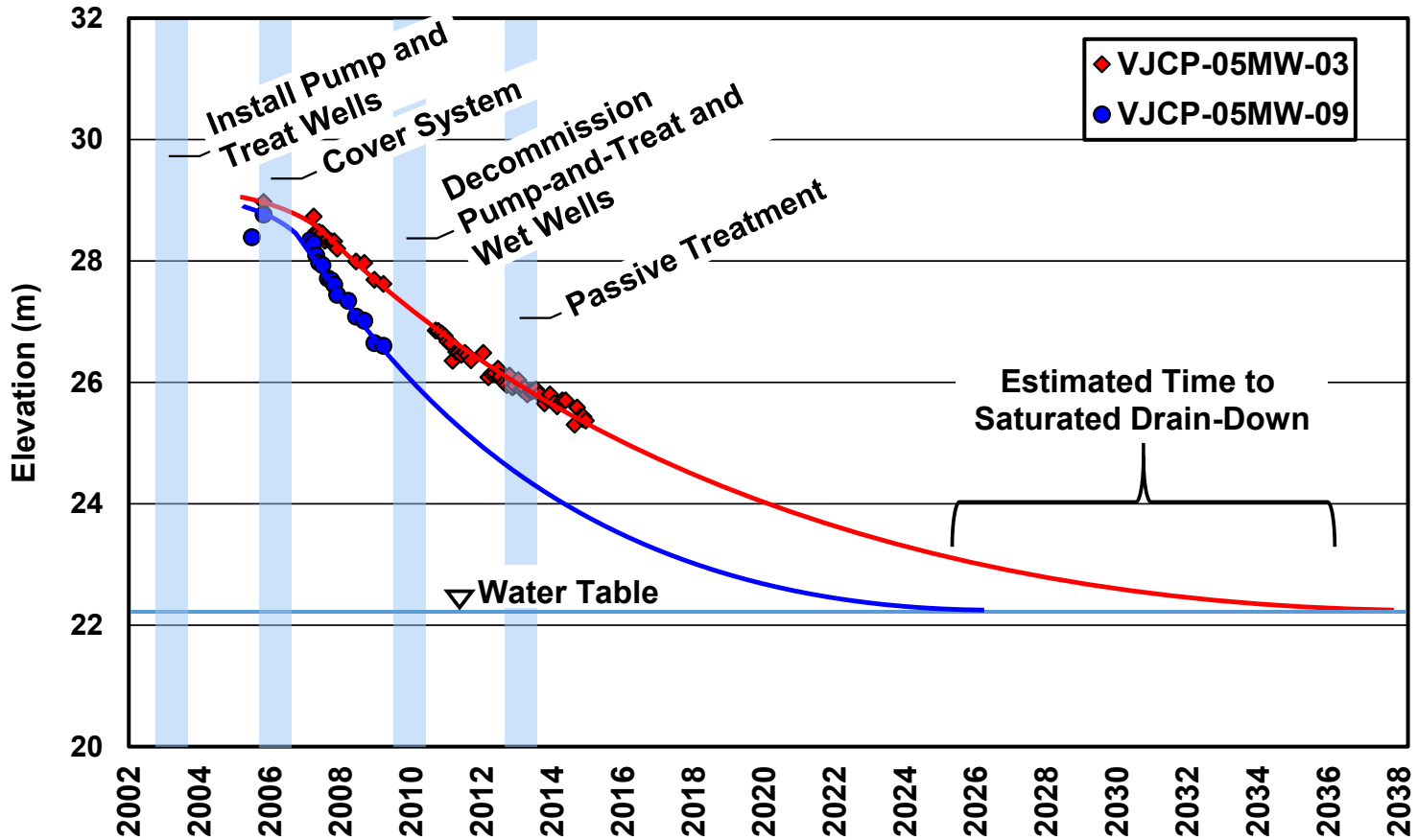
- ***Solubility Controlled – Constant Concentration***



VJ – WRP Drain-Down

Saturated drain-down estimated at 75 mm/yr and will terminate in approximately 20 years

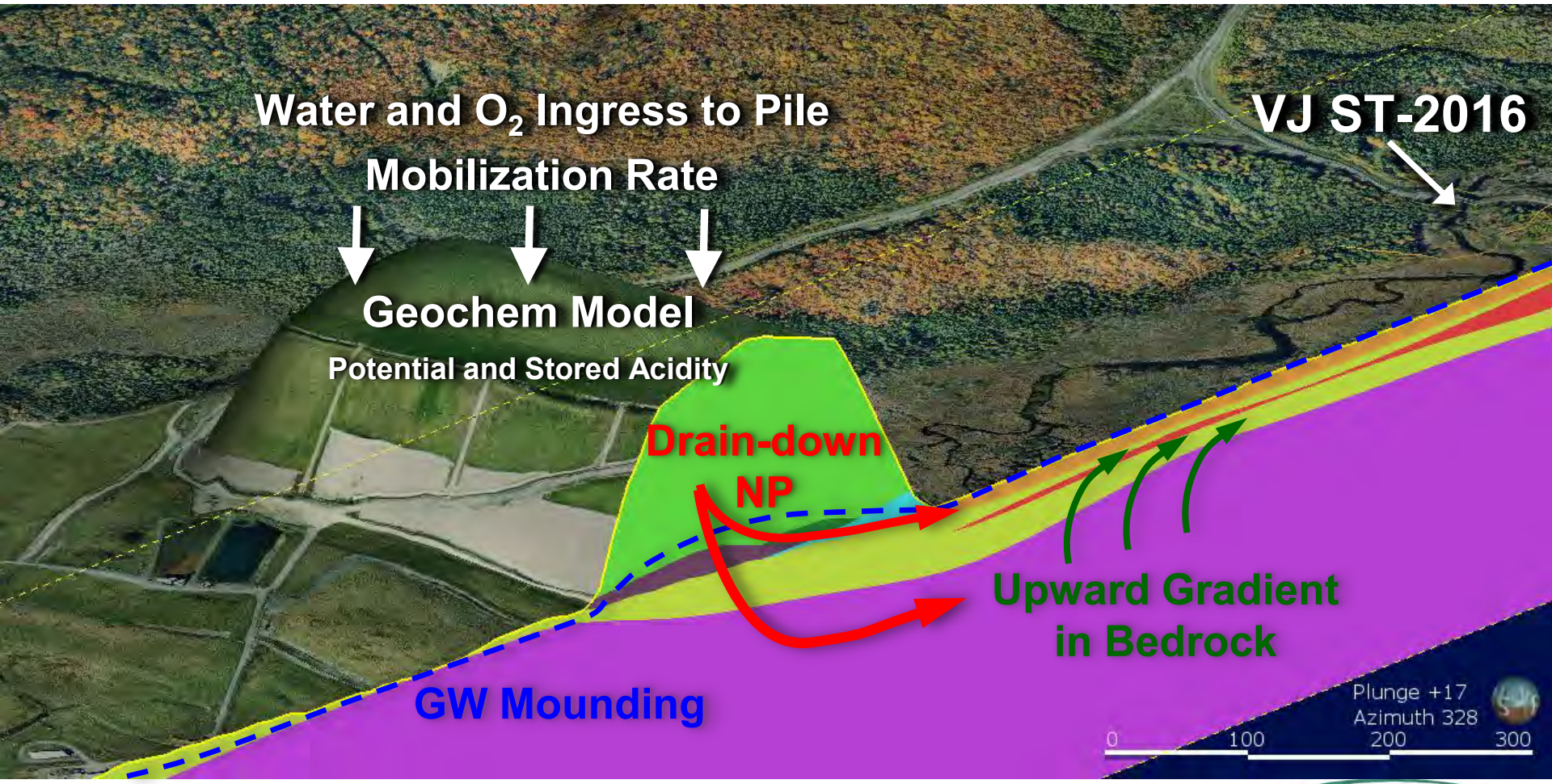
- ***Numerical modelling completed to verify rates and unsaturated drain-down***



VJ – Conceptual Model

Post-Cover System

- Upward gradient in bedrock drives contaminant plume to surface

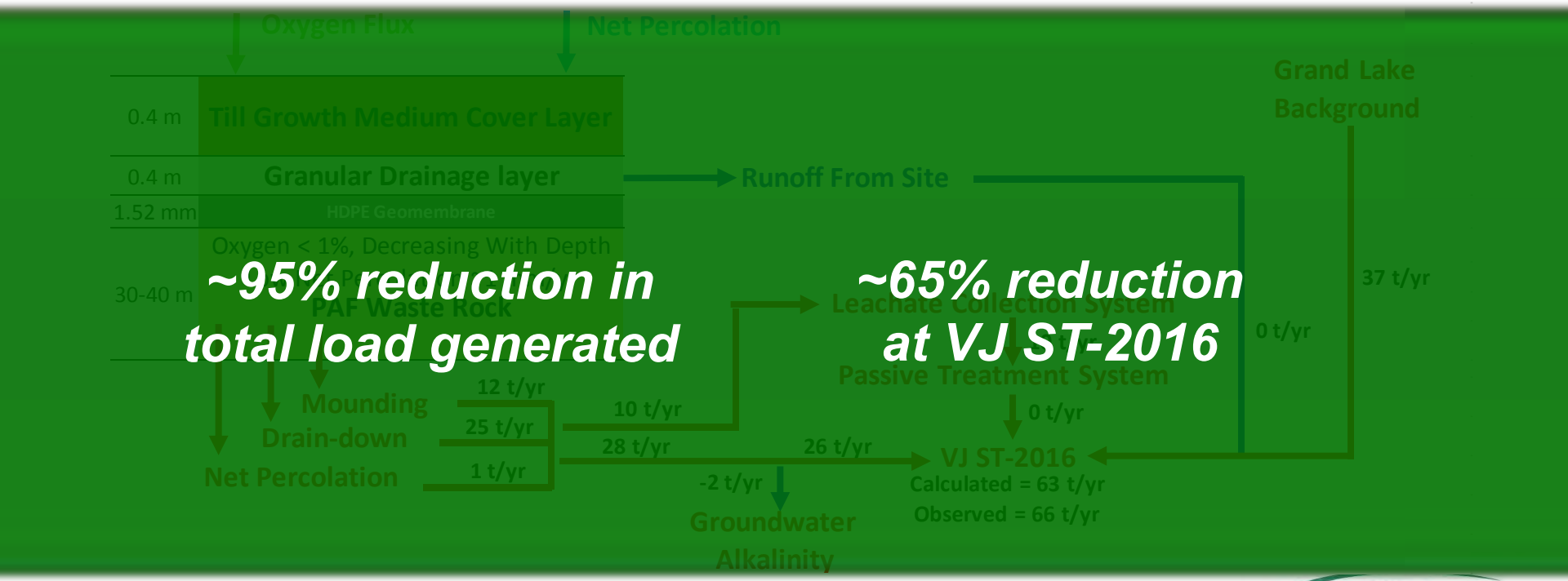


VJ – Acid Load Phase 2

Post-cover system with passive treatment

- Load contributed through basal seepage, load from runoff removed
- Total acid load generated reduced from ~934 t/yr to ~38 t/yr
- Approximately 26% of load collected in leachate collection system

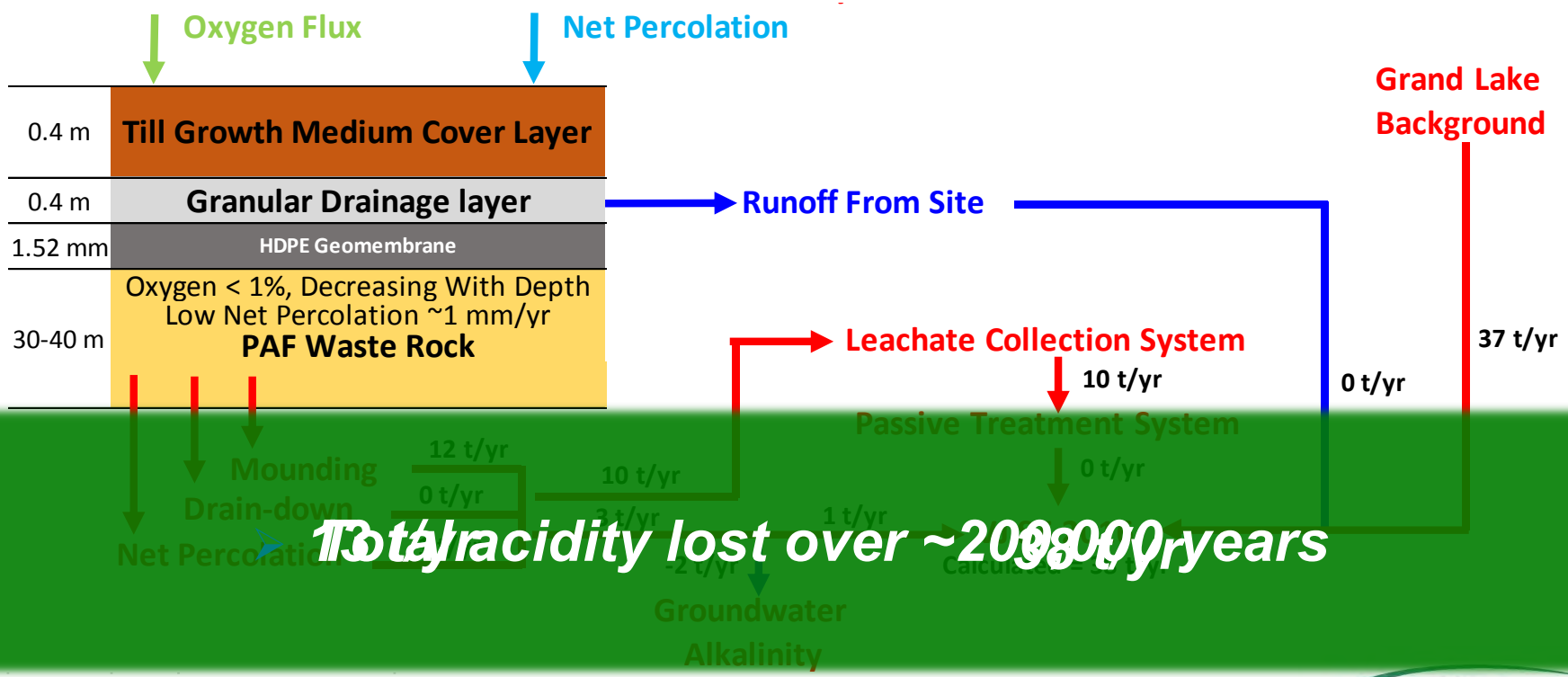
- Decommissioned groundwater collection system, reduction in treated load from 100 t/yr to 10 t/yr



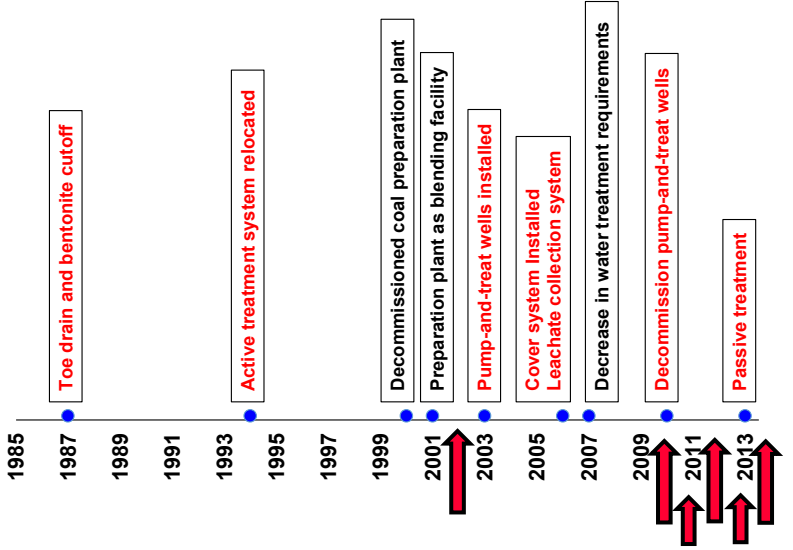
VJ – Acid Load Phase 3

100 years post-cover system prediction w/ passive treatment

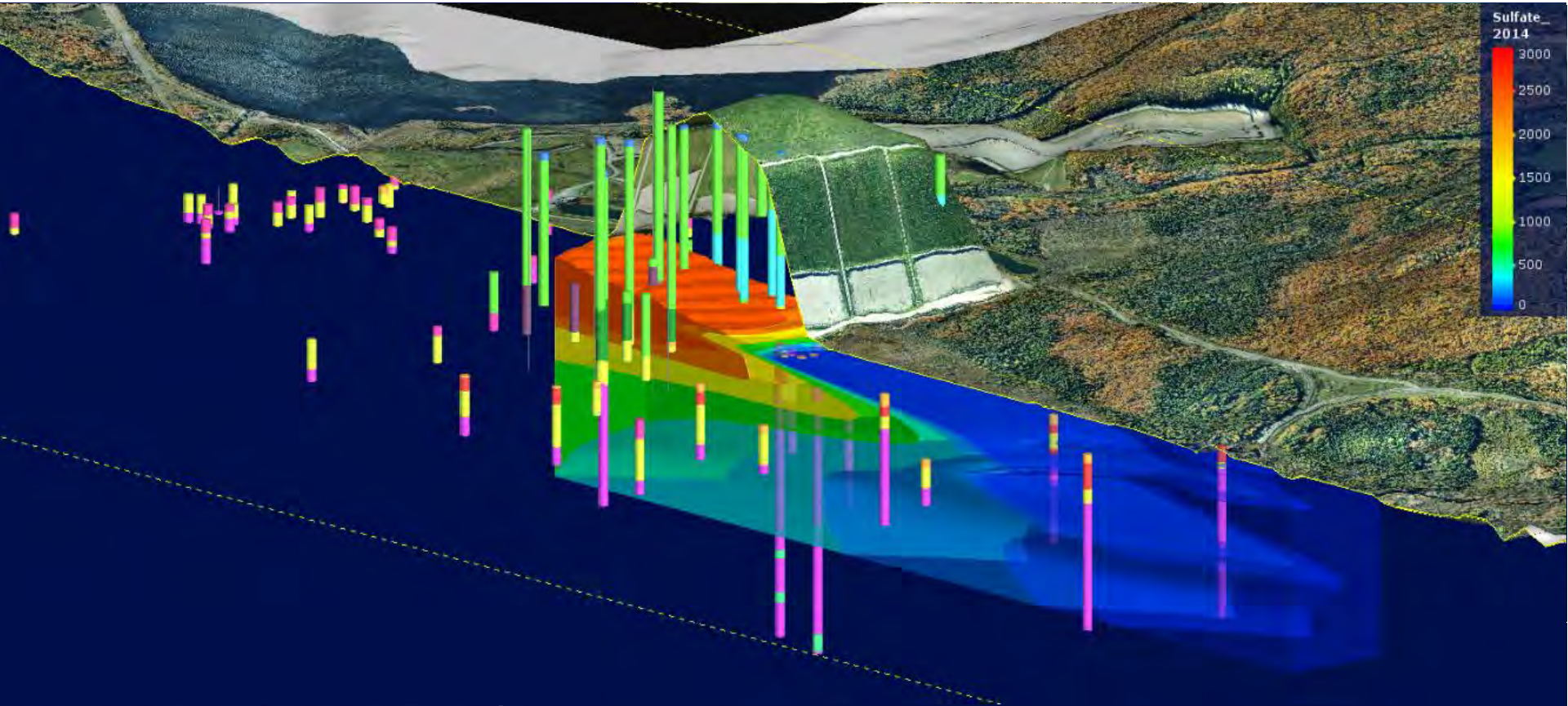
- ***Mounding** contributes **largest load***
- ***Total acid load reduced** to ~38 t/yr*
- ***Understanding for long-term loading and outcomes without numerical simulations***



VJ – Solute Transport (Sulfate)

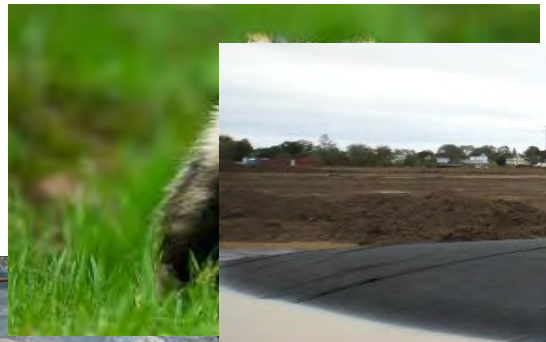


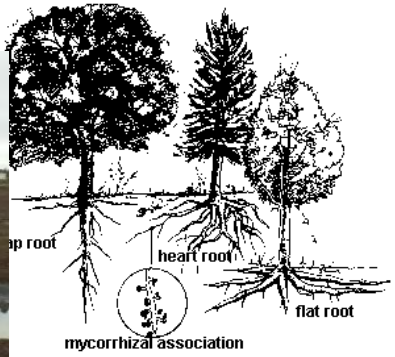
2014



Risk – Holes In Geomembrane

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

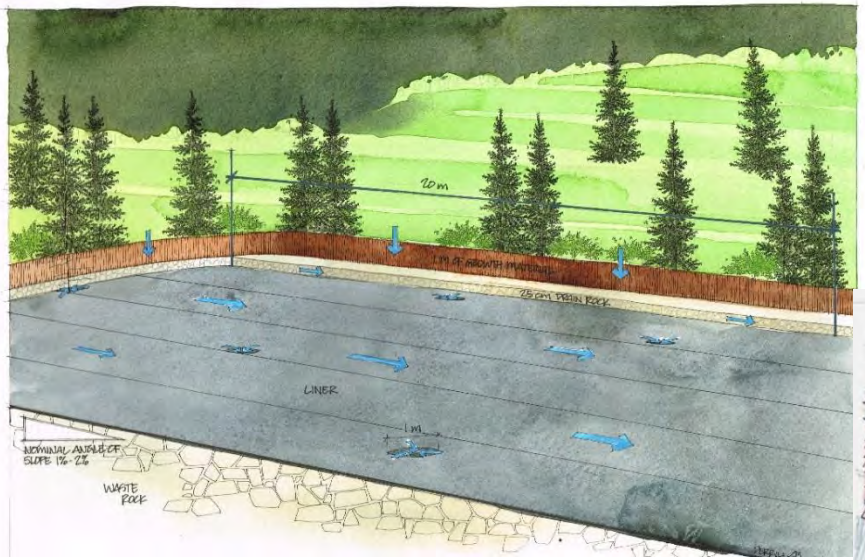




http://heapsolutions.com/applications/heap-liner-leak-detection/

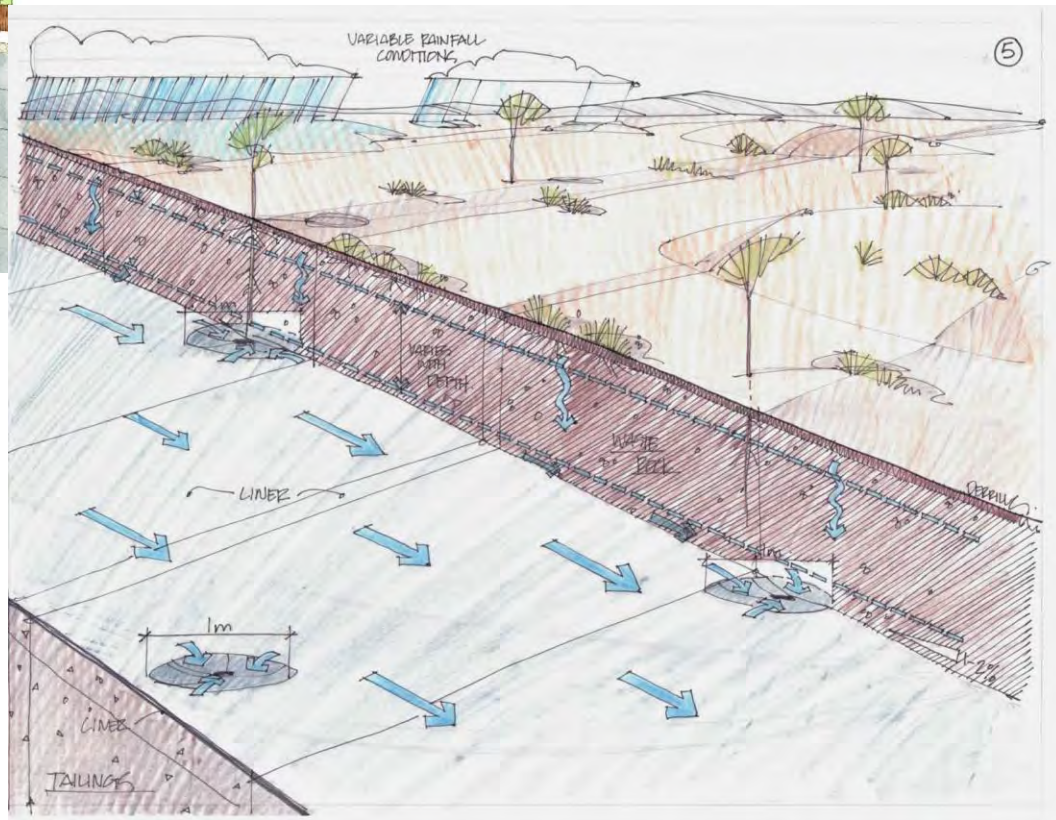
O'Kane and Meiers 2014

Risk – Influence of Holes



- ***Very Good Lateral Drainage Capacity:***
  - ***… extend timeline***
- ***Service Life of Geomembranes?***
  - ***e.g. Benson et al 2011:***

55-125 yrs



O'Kane and Meiers 2014

Costs and Loading… and Risk

Discount Rate (%)	Collection and Treatment NPV	Cover System NPV
1.0	$ 29.5M	$ 16.1M
2.5	$ 17.0M	$ 14.6M
4.0	$ 11.2M	$ 13.8M

Groundwater Collection System Only Captured 40% of Basal Load

Summary Discussion Points

- Conceptual model used to develop understanding of loading from WRP
- Unique site – heavily monitored
- Strong conceptual model requires sufficient site information
- Transition to passive treatment, load to receiving environment reduced.
- Risk with long term performance
  - Geomembrane lifespan, holes
  - Minimize effect of holes with adequate lateral drainage.
  - NPV should be a tool to evaluate risk

Thank You!

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Habitat for Humanity Initiative – El Salvador

Rainbow of HOPE for Children