

# Evaluating Performance of Cover Design for Remedial Options Analysis of Mine Closure



Cantung Mine Site, NT

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Government  
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## Overview of Presentation

- Location and History of the Cantung Mine
- Investigation Scope and Rationale for Cover Design
- Overview of the Five Tailings Ponds on Site
- Review of Mine Tailings Geochemistry
- Discussion of Geochemistry Investigation and Cover Design Remedial Options Analysis
  - Discussion of Existing Cover on TP1/2
  - Seepage and Oxygen Transport Modelling
  - Geochemical Controls in the Cover
- Next Steps and Ongoing Work
- Discussion and Questions

# Site Location



## Cantung Mine Background



- Prospectors discovered the Cantung Mine tungsten deposit in 1954
- Production commenced in 1962 from an open pit at the rate of 300 tons per day (tpd)
- The discovery of the E Zone orebody in 1971 led to underground development to access this zone
- From 1974 onwards, ore production was predominantly from underground with seasonal mining of the open pit after 2013
- Cantung at one time produced 5% of the world's tungsten.

## Current Status of Cantung Mine

- Cantung Mine currently owned by North American Tungsten Corporation Ltd.
  - Currently under creditor protection with Alvarez & Marsal as Court appointed monitor
- Site is under Care and Maintenance, with funding provided by the Government of Canada



## Ongoing Investigation Program

- Tetra Tech currently undertaking the following programs:
  - Phase III Environmental Site Assessment (ESA)
  - Human Health and Ecological Risk Assessment
  - Tailings Geochemistry and Cover Assessment
  - Borrow Source Assessment
  - Geotechnical Stability Assessments for the Pit, Underground, and Tailings Ponds
  - Site-wide Remedial Options Analysis and Liability Estimate
- Focus of this presentation is on the ongoing evaluation of closure alternatives for the five tailings ponds facilities, as it relates to geochemical considerations

## Rationale for Cover Design Investigation

- Tailings material is classified as potentially acid generating and has potential for elevated metal leaching
- Covering the tailings facilities is one option for mitigating the potential for acid rock drainage and metal leaching (ARD/ML)



## Rationale for Cover Design Investigation

- The cover placed on TP1/2 has performed sufficiently to prevent the development of ARD/ML within the tailings and associated poor water quality discharges from these tailings piles
  - These covers were not “engineered” and the reasons for their success are not clearly understood
- Evaluate why the closure of TP1/2 has been successful and if the same closure approach can be applied to TP3/4/5





## Cantung Mine Geologic Context

- Tungsten mineralization at Cantung occurs as scheelite associated with massive replacement pyrrhotite in calc-silicate gangue within limestone
- Tailings were deposited in 5 surface tailings storage facilities with waste rock either being back hauled underground or stored within surface waste rock piles



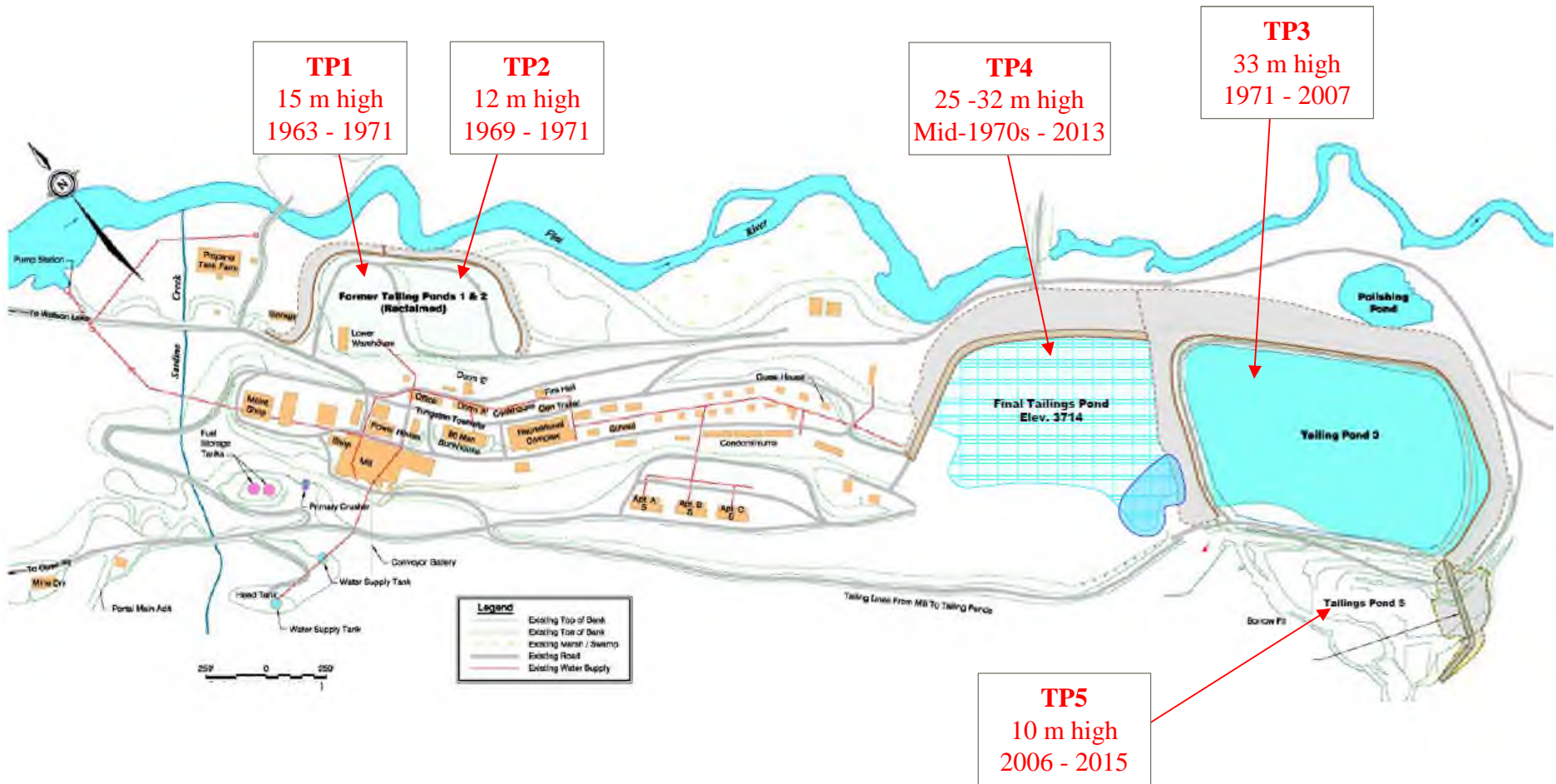
# Site Plan



# Physical Setting

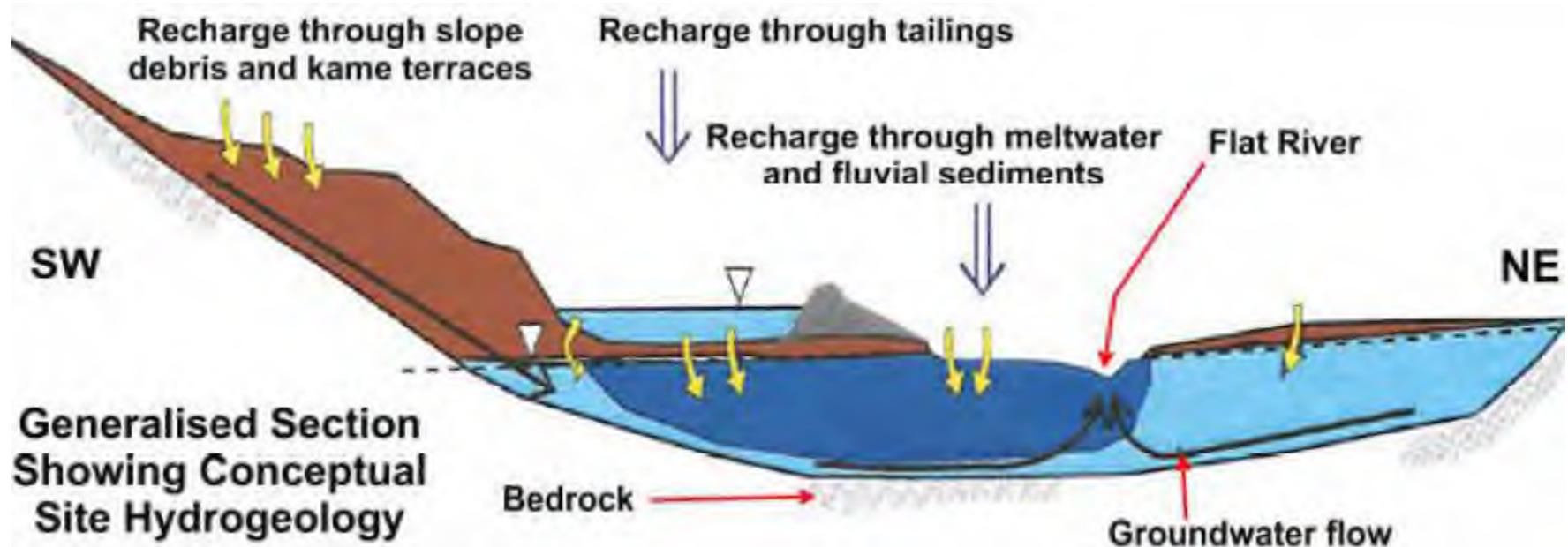


# General Layout of Tailings Ponds



# Conceptual Site Model

- Used historical information and data from 2017 field program to develop (physical) Conceptual Site Model (CSM).



## TP1 and TP2 Overview

- Tailings cover placed around 1971
- Used as a storage area for equipment and unused machinery
- The surfaces of both facilities are flat and densely compacted to permit the traffic and laydown of heavy equipment



# TP1, TP2



# TP3, TP4, TP5







# TP4



## Geochemistry of the Tailings

- Primary mineralogy consisting of quartz, pyroxene, amphiboles, scheelite, muscovite, pyrrhotite (primary sulphide mineral/source of acidity) and carbonates – dolomite and calcite (primary source of neutralization capacity).
- Elevated in Bi, Cd, Co, Cu, Fe, Hg, S and W, with occasionally marginally elevated As, Ag, and Zn
- Humidity cell testwork indicated that under lab conditions, the onset to acidic conditions in the cell was 212 weeks or ~4 years
  - However, scale-up of the data to local conditions suggested that it could take on the order of hundreds of years for the tailings on location to become acidic

# Geochemistry of Tailings

	Paste pH	Total Sulphur (S%)	Sulphate Sulphur (S%)	Sulphide Sulphur (S%)	Sobek NP (kgCaCO <sub>3</sub> /t)	Total Inorganic Carbon (%)	Carbonate NP (kgCaCO <sub>3</sub> /t)	Sobek NP/AP	Carb NP/AP
<b>Minimum</b>	2.5	0.01	0.01	0.04	-47.7	0.01	0.8	-0.1	0.005
<b>Maximum</b>	8.6	21.2	2.5	17.7	539.3	8.9	737.5	276.5	1706.7
<b>Median</b>	7.7	5.2	0.2	5.4	200.4	1.5	128.3	1.2	1.0

Based on 213 samples from TP1, TP2, TP3, TP4



### TP2



- The till cover placed on TP1/2 was typically 1.5 to 3 m thick and consisted dominantly of silicates minerals (quartz, muscovite) and lesser carbonates (calcite and dolomite) with minor feldspars and accessory minerals
- The cover material consistently classifies as non-PAG and has maintained neutral to slightly alkaline pH conditions

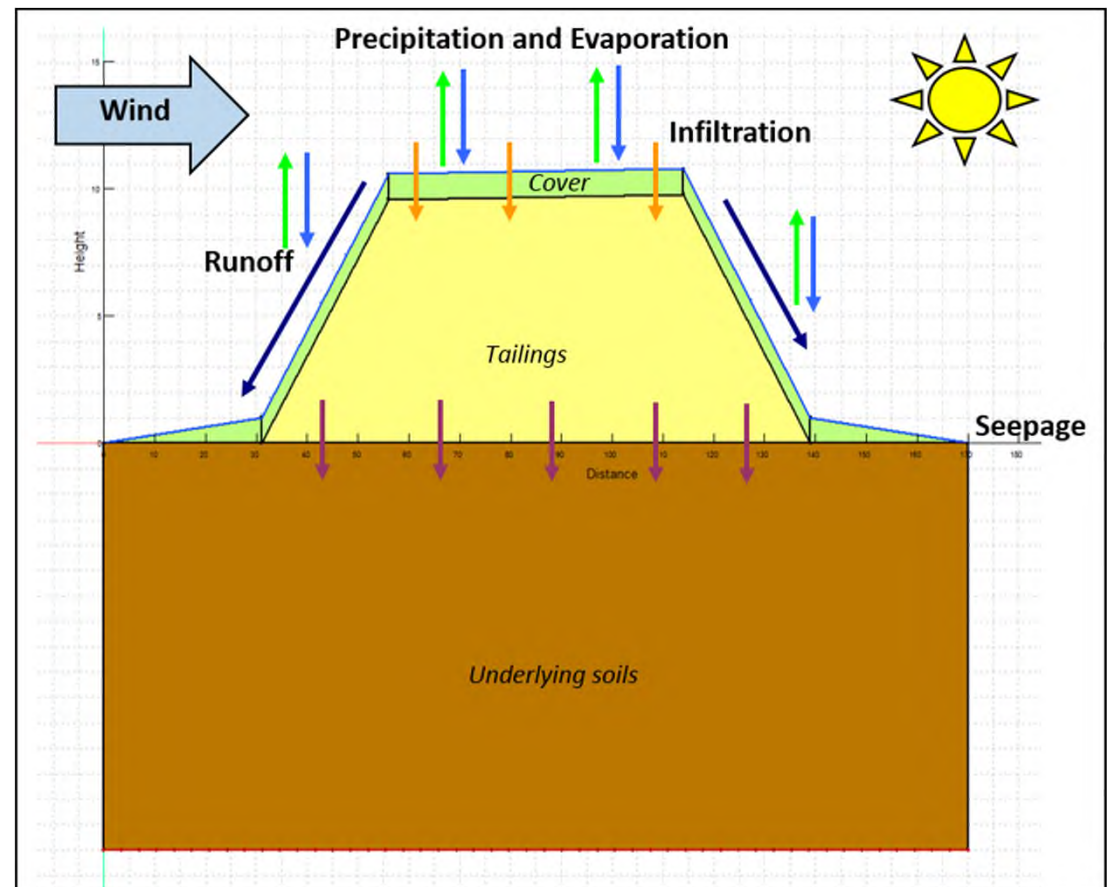
## Tailings Oxidation at Cover-Tailings Interface

- Preliminary oxidation confined to the tailings cover- interface
- In TP1, frozen tailings were observed within 0.10m of tailings-cover contact
- In TP2, partially frozen tailings were within 2m of tailings-cover interface
- Unknown total depth of freezing
- Future investigations to capture full profile



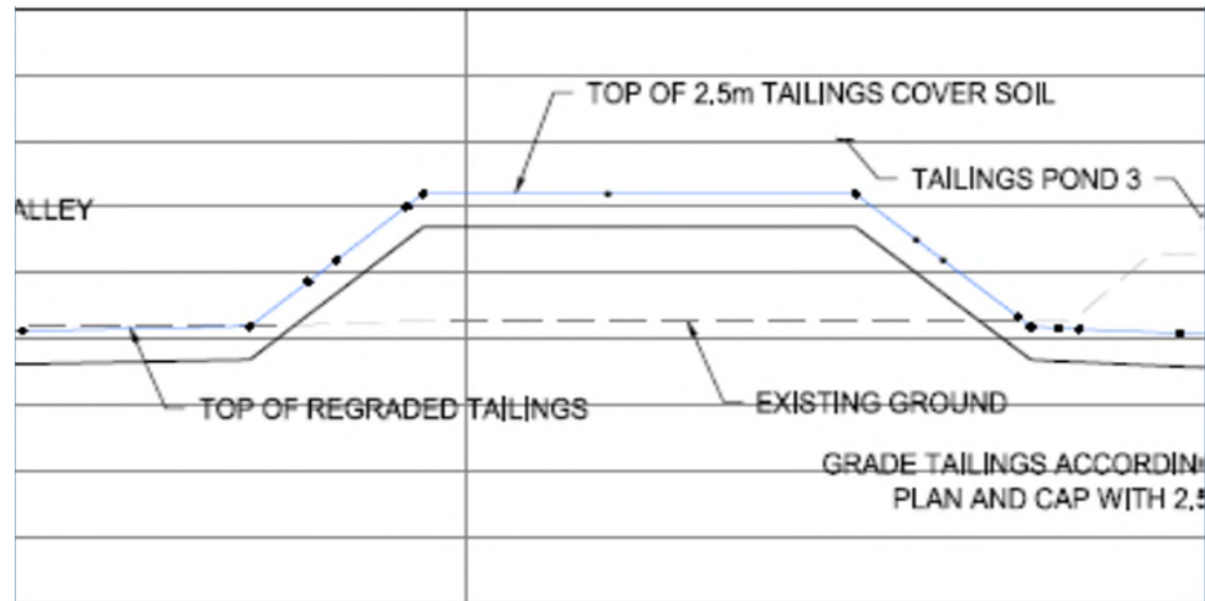
# TP1/2 Existing Cover and Design Basis for TP3/4/5 Cover

- Conducted steady state and transient seepage modelling for one representative cross section of the tailings ponds to determine how cover is performing with respect to prevention of infiltration of precipitation and transport of oxygen through the cover



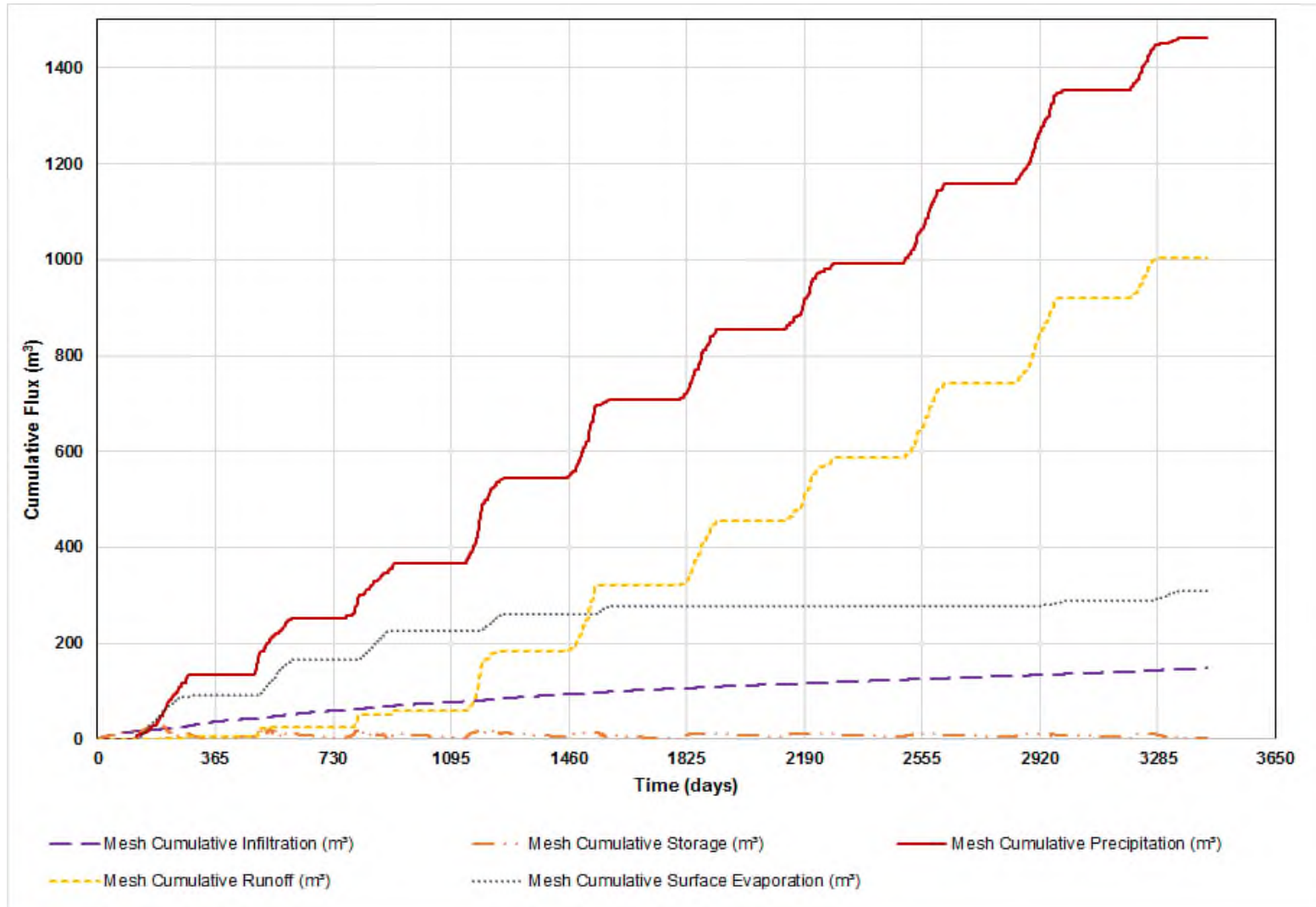
## Seepage and Oxygen Transport Modelling

- Modeling was completed using VADOSE/W (GEO-SLOPE, 2014), a two dimensional variably saturated zone modeling program within the GeoStudio software suite.
- No quantification of the seepage rate or volume was determined from this modeling effort.

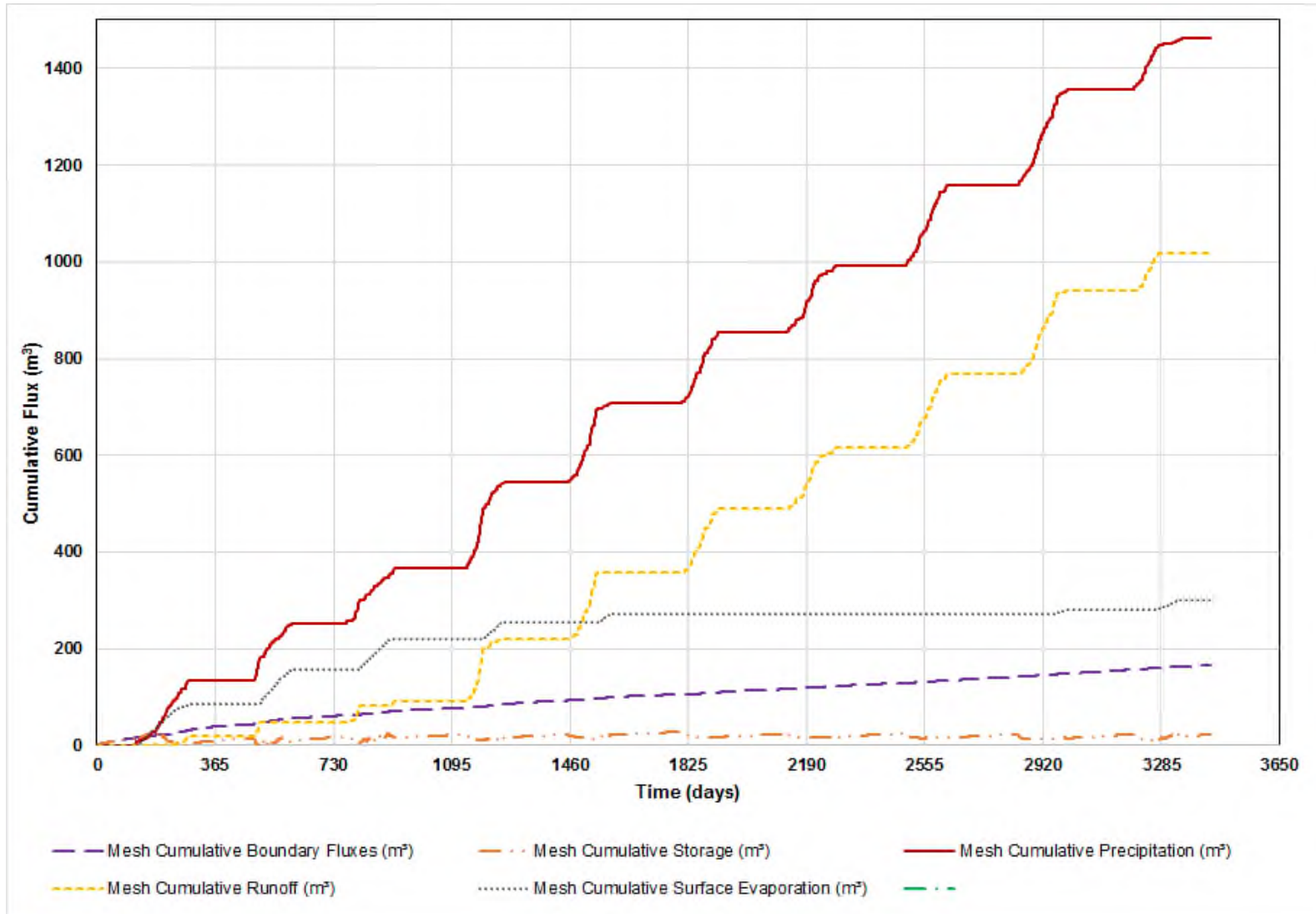


**Cross Section Simulated to Evaluate Cover Performance**





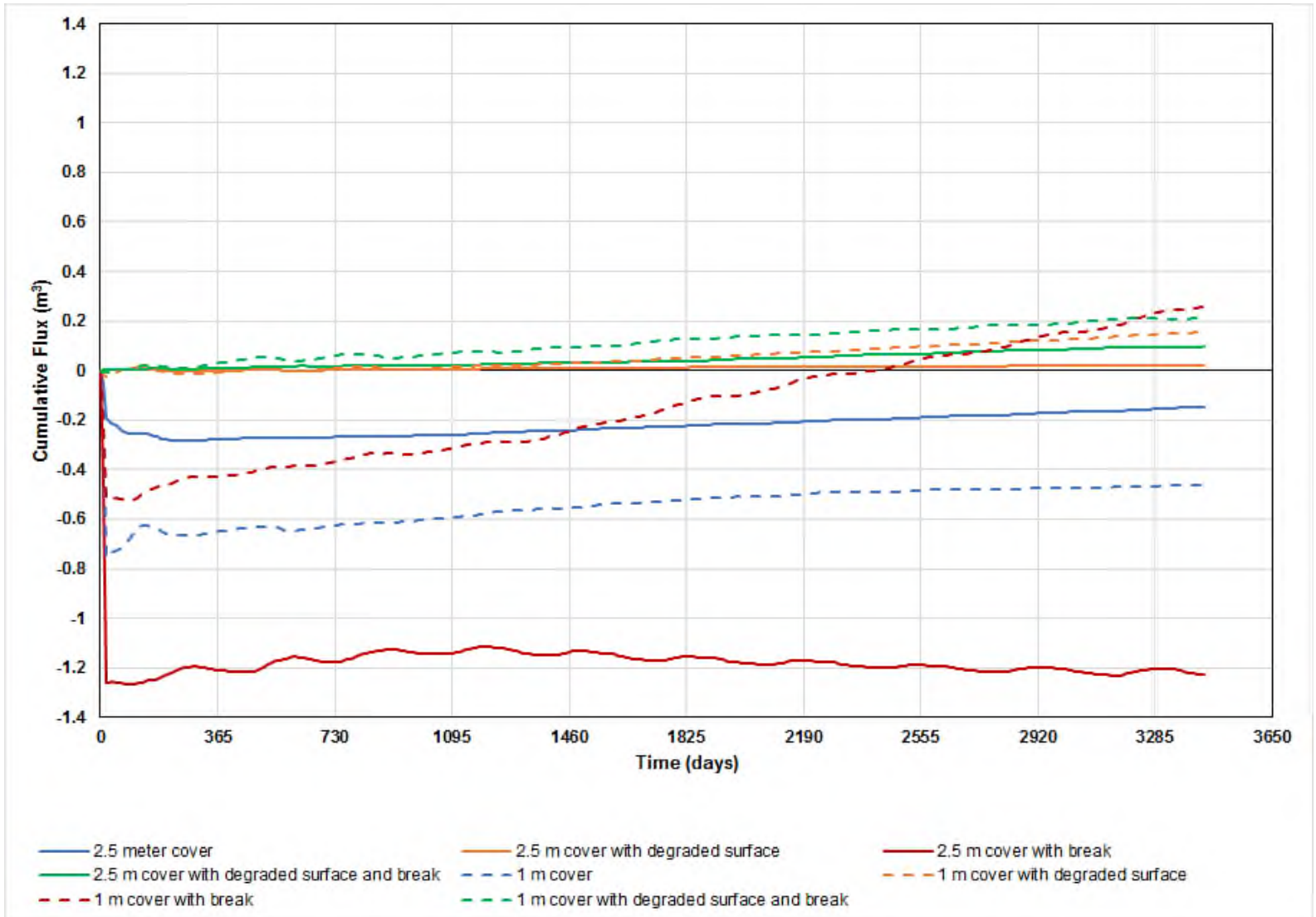
## Water Balance – 2.5 Meter Thick Cover



**Water Balance – 1 Meter Thick Cover**

## Summary of Water Balance Parameters as Percentage of Precipitation

	<b>Infiltration</b>	<b>Storage</b>	<b>Precipitation</b>	<b>Runoff</b>	<b>Surface Evaporation</b>
2.5 m compacted till cover	10%	0%	100%	69%	21%
0.5 m uncompacted + 2 m compacted till	10%	2%	100%	71%	21%
2.5 m compacted till cover + 0.5 m capillary break	21%	11%	100%	68%	21%
0.5 m uncompacted + 2 m compacted till + 0.5 m capillary break	29%	19%	100%	69%	21%
1 m compacted till cover	11%	2%	100%	70%	21%
0.5 m uncompacted + 0.5 m compacted till	8%	2%	100%	73%	21%
1 m compacted till cover + 0.5 m capillary break	17%	12%	100%	73%	21%
0.5 m uncompacted + 0.5 m compacted till + 0.5 m capillary break	16%	12%	100%	75%	21%



**Cumulative Vapor Flux through Base of Cover**

## Geochemical Controls in the Cover

- Silicate-dominated mineralogy
- Oxygen consumption and carbon dioxide production
- Saturation limiting the transport of oxygen through the cover
- Silicate weathering
  - Consume carbonic acid and water
  - Result in the formation of clay minerals, bicarbonate, dissolved silica, and dissolved ions
  - Bicarbonate provides a source of neutralization capacity
  - Dissolved ions can also further reduce acidity by binding with hydroxides which will precipitate out of solution at near neutral pH
- Source of iron oxide could also be iron released from silicate mineralogy which is then oxidizing and being precipitated from solution

## Next Steps and Ongoing Work

- Testpitting and sampling conducted in July 2018 on all 5 tailings ponds
- Measurement of hydraulic conductivity, in situ moisture content, and visual observations of oxidation front



## Next Steps and Ongoing Work

- Evaluate samples collected from the TP1 and TP2 cover and equivalent borrow source material to determine if chemical reactions have changed the cover material over the last 50 years
- Update model based on measured conditions (moisture content, particle size analysis, hydraulic conductivities)





**TETRA TECH**

Thank you – discussion and questions

