Benambra Tailings Management Facility (TMF) Closure and Rehabilitation

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Presentation Content

- **TMF location and description**
- **Tailings geochemistry**
- **Current TMF status and status at closure**
- **Closure options**
- **Description of preferred option**
  - configuration
  - key issues
- **Relevant case studies**
  - Australia
  - International

TMF - Construction

TMF Current

TMF Diversion Drains

Geochemistry of Process Tailings

- **Stuart Miller & Associates EGI (1990, 1999)**
  - Massive sulphide
  - Extremely high net acid production potential
  - 35% S, NP 40 - 60 kg H_2SO_4/t (dolomite)
  - Net acid production potential 1,000 kg H_2SO_4/t
  - Store permanently underwater
  - Do not expose tailings for more than 80 days
  - acid production after 1 year
  - final net acid generation (NAG) pH of 2.5 (1.5 years)

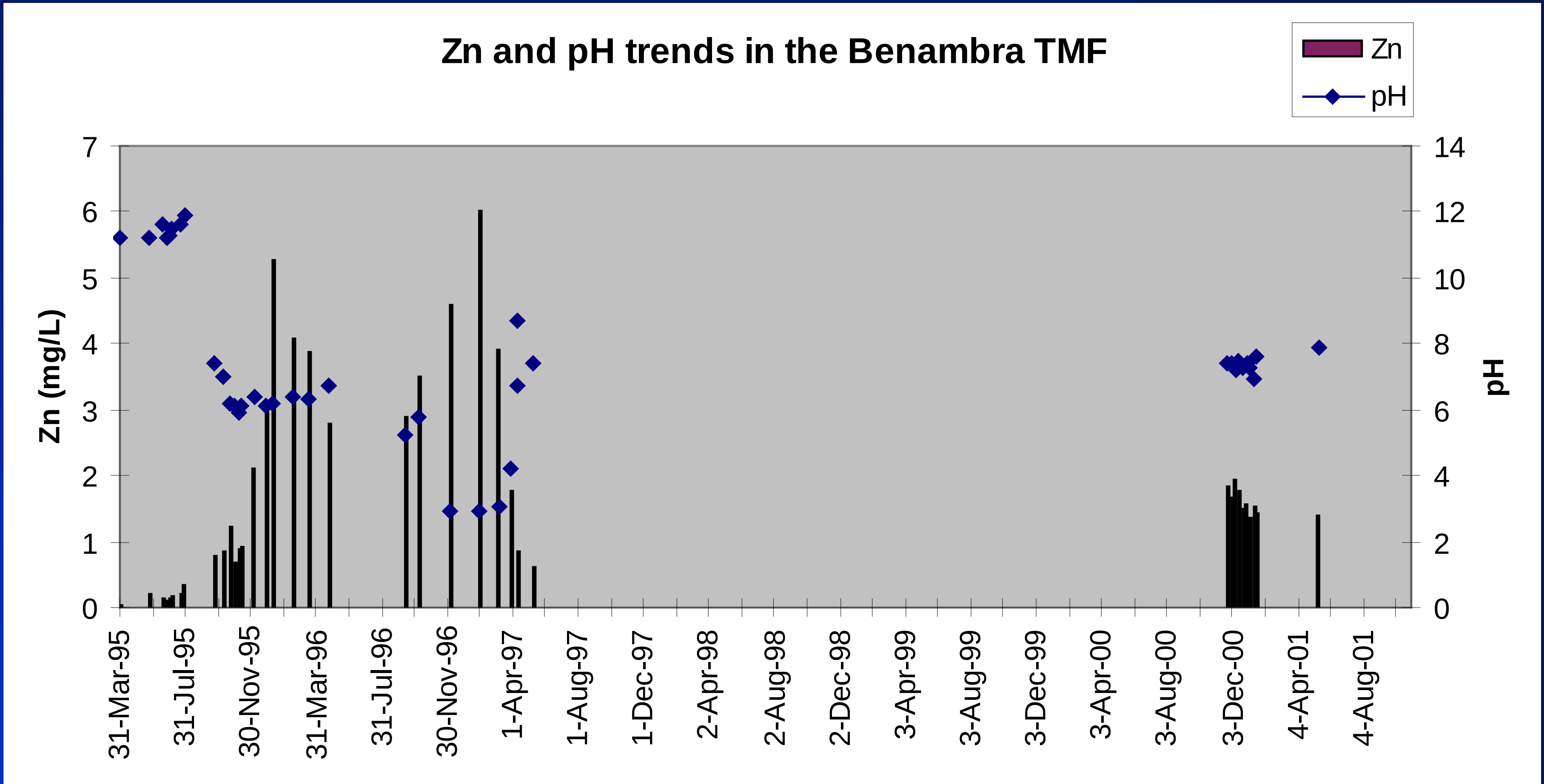
TMF – Current Status

- 700,000 tonnes of tailing producted 1992 - 1996 (Macquarie Resources)
- Tailings always submerged, 21 m high dam
- Acid generation presently is not a problem
- Current water quality close to regulatory criteria
- No active rehabilitation undertaken, yet reed beds and frogs are re-colonising the TMF
- Local wombats, wallabies, birds and other wildlife seen to inhabit and use facility

TMF Status at Proposed Closure
(Austminex)

- Sub-aqueous storage behind 31m high dam
- Total tailings contained: 5.7 million tonnes
- Pond area: 10 hectares (8 currently)
- Tailings grind will be finer than current tailings
- Geochemistry same as current tailings

Water Quality



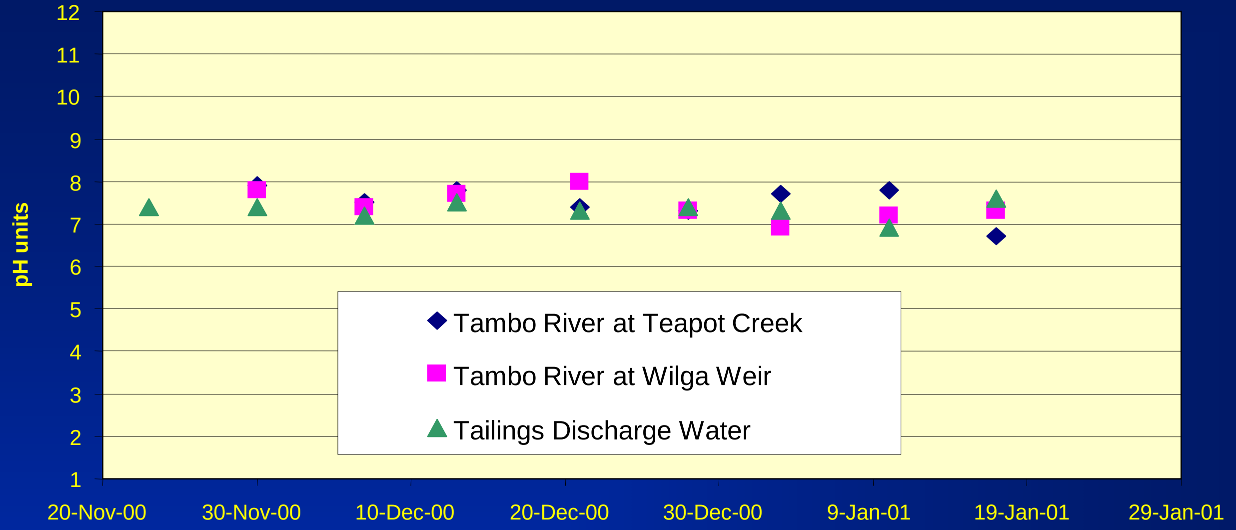
TMF Pond Discharges

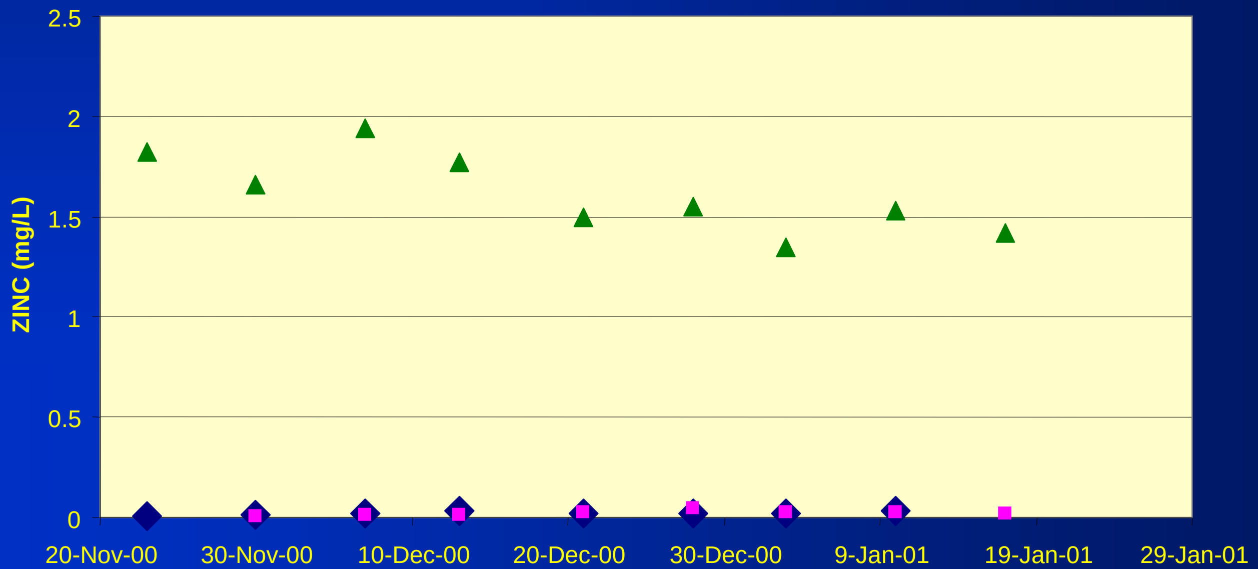
- **Two discharges:**
  - May-August 1999, 43.3 ML
  - Nov 2000-Jan 2001, 52.9 ML
- **Chemical sampling and biological surveys**
- **Macroinvertebrate surveys could not identify any impacts**

Surface Water Quality Ranges
(November 2000 - January 2001)

	pH	Conductivity MS/cm	Zinc (T) mg/L	Copper (T) mg/L
Upstream	7.3 – 7.9	110 – 240	0.004 – 0.035	0.001 – 0.009
Water Cover	6.9 – 7.6	1600 – 1900	1.35 – 1.94	0.008 – 0.02
Downstream	6.9 – 8.0	250 - 480	0.01 – 0.043	0.002 – 0.006
EPA			0.5	0.2

TMF Pond Discharges





Current Approved Strategy

- **Dry cover (Work Plan 1992)**
  - Allow water to evaporate and tailings dry out
  - Spread lime
  - Place impermeable “clay” layer
  - Place waste rock cover
  - Beach inside embankment
  - Topsoil and vegetate
- **Work Plan stated that technology may improve over life of project**

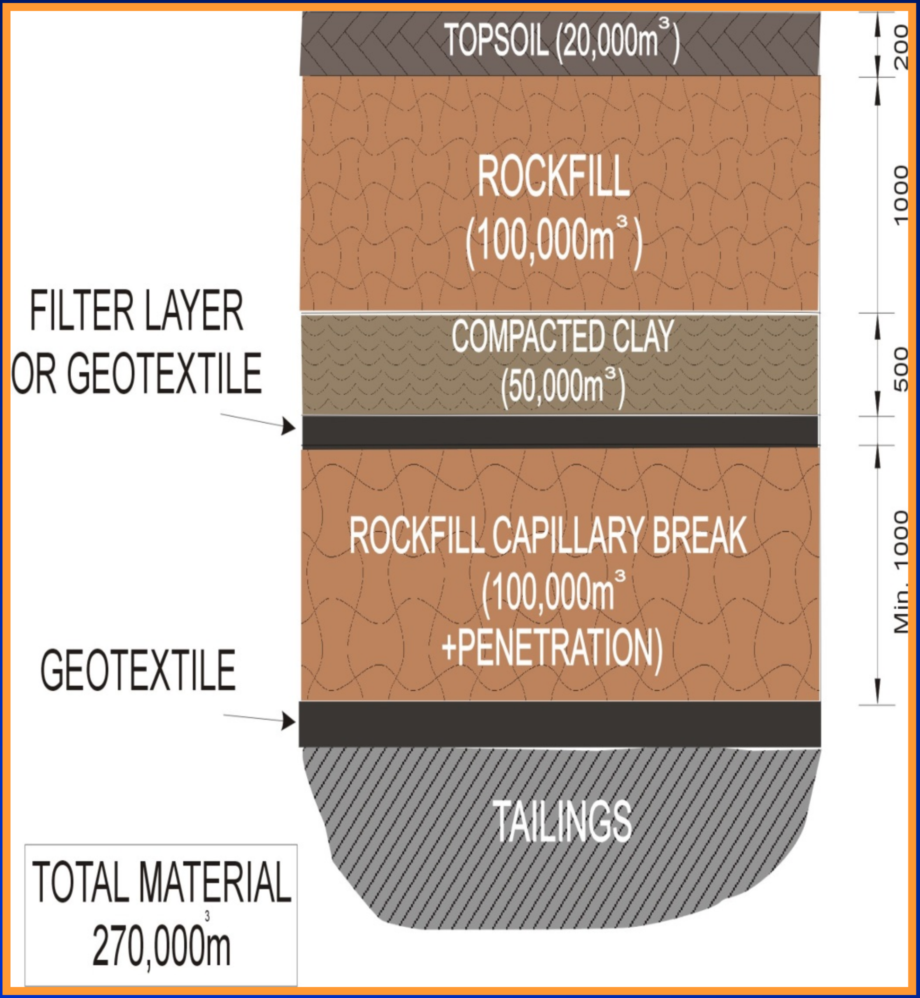
MEND Research - Canada

- **Equally funded by Mining Association of Canada and Natural Resources Canada**
- **1988 - present ($CAN17.5 million)**
- **Over 50 scientific reports and papers. Dry and wet covers.**
- *"…..permanent water cover remains one of the most effective approaches that can be applied to provide a stable geochemical environment for most sulphide tailings. Additional enhancement is accomplished at some tailings ponds through the use of sub-strata covers over the submerged tailings using oxygen consuming materials to reinforce reducing conditions in the sediments….."*(MEND 2001)

Rehabilitation Options

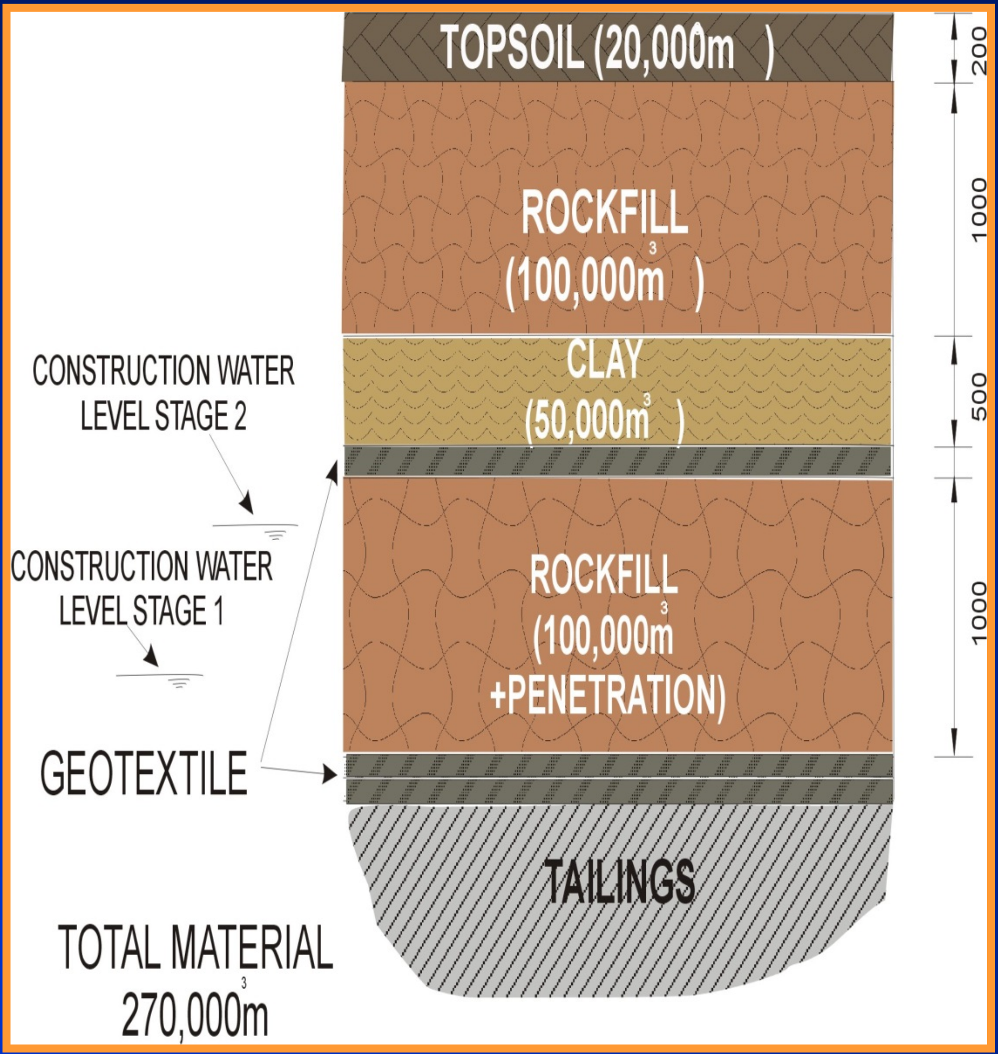
- **Potential Options**
  - Underground disposal, relocation not feasible
  - Dry Cover
  - Wet Cover
    - Saturated Soil
    - Shallow water cover
    - Naturally generating wetland

Dry Cover



- **Dewater TMF and water treatment**
- **Disturbance of tailings from construction**
- **Oxidation of tailings is likely during slow construction**
- **Sourcing of vast amount of cover materials**
- **Long term erosion of cover material inevitable which opens pathways for exposure and oxidation of tailings**
- **Maintenance of a capillary break layer is doubtful due to settlement**

Wet Cover - Saturated Soil



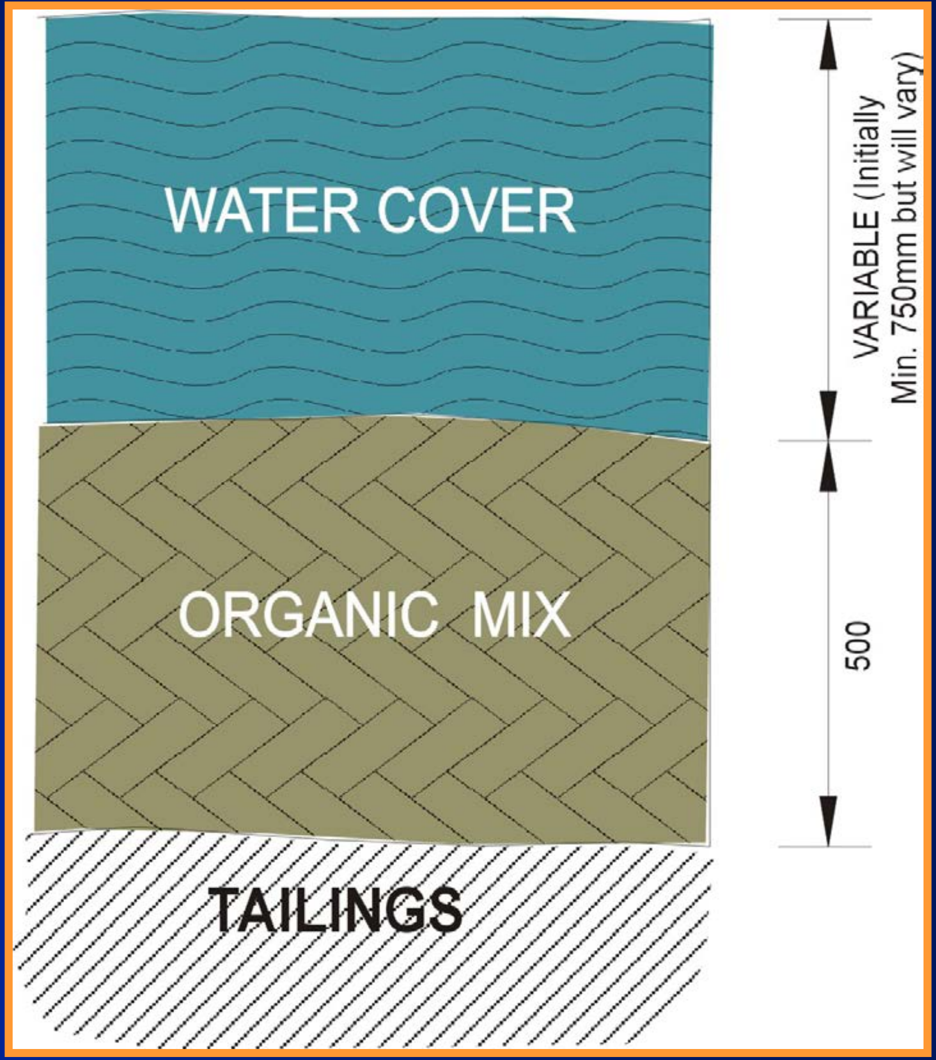
- Partial Dewatering of TMF and water treatment
- Disruption to tailings from construction
- Specialised construction equipment required
- Survivability of geotextiles
- Slow construction - exposure to weather and storm erosion risk
- Sourcing of cover materials
- Final cover surface is dry and subject to erosion

Wet Cover - Shallow Water Cover

- No need to dewater TMF
- No disturbance or oxidation of tailings
- Resistant to erosion
- No need to source vast amounts of cover materials
- Long term re-creates the original swamp environment i.e. self-sustaining system
- Consistent with MEND conclusions

Wet Cover - Naturally Generating Wetland

- No need to dewater TMF
- No disturbance or oxidation of tailings from construction
- Resistance to erosion
- No need to source vast amounts of cover materials
- Natural replenishment of the organic/sediment from the catchment (5-25mm/year without any organics)
- Re-creates original swamp environment i.e. self-sustaining system



Water Inflow

Full Catchment

Case	Estimated additional water volume presenting to the TMF per annum (ML)	
	Wulgulmerang Rainfall	Benambra Rainfall
Average Year	260	251
Wet Year	531	481
Dry Year	64	62

Bindi driest year on record (100yrs): +7 ML

Benambra driest year on record (50yrs): +32 ML

Natural Wetland - Role of Organic Layer

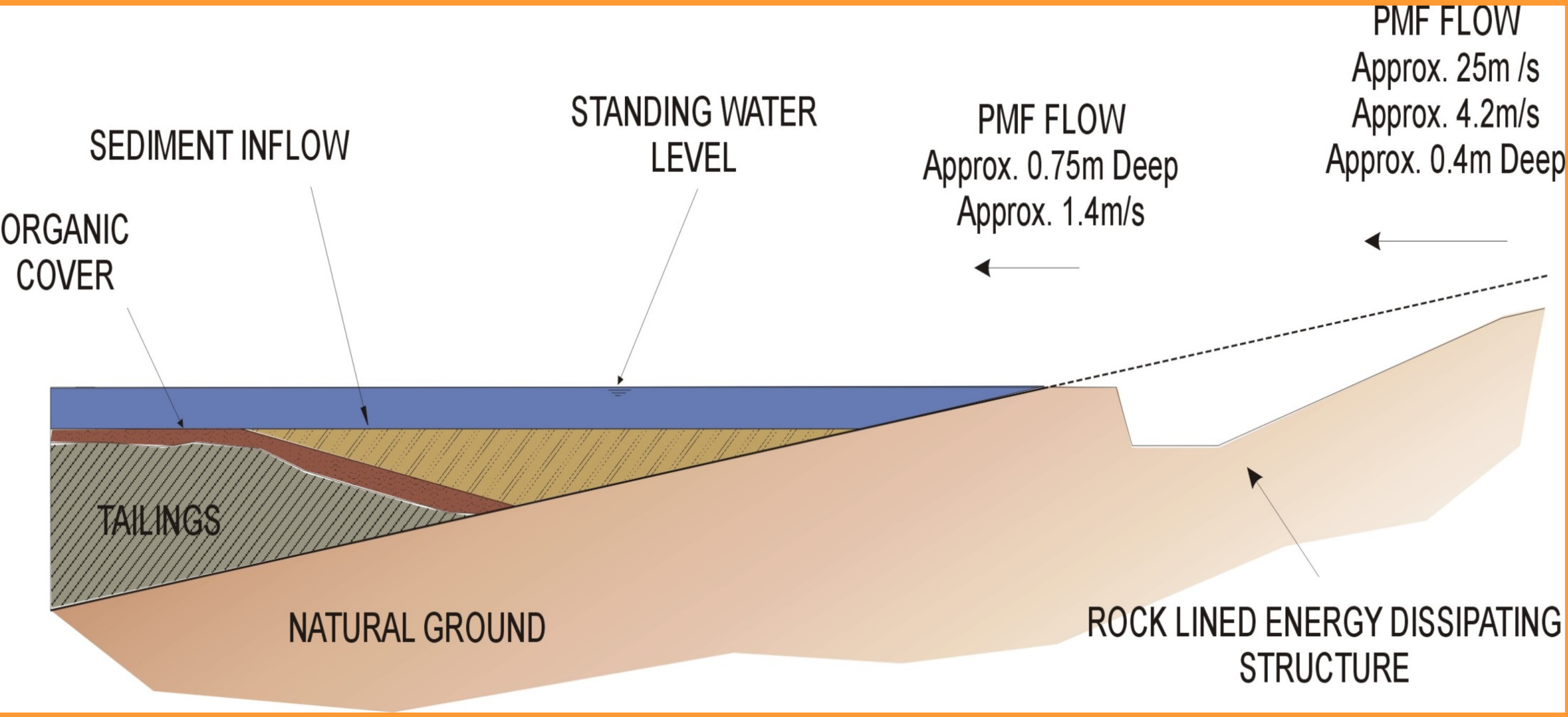
- **Is not essential as oxygen barrier but create multiple barrier system. Water is oxygen diffusion barrier**
- **Provides oxygen consumption layer below water cover**
- **MEND Studies:**
  - East Sullivan, Ascot, Eustis and Clinton, Falconbridge, Canada
  - Organic decomposition has:
    - a higher de-oxygenation rate than tailings i.e. preferential consumption of oxygen
    - creates anaerobic conditions at base
    - residues act to physically encapsulate tailings
  - Limited life due to consumption
- **Will be consumed over time (up to 30-40 years in exposed areas - expect longer below water)**
- **Replenishment will occur (demonstrated now in TMF)**

Organic Material

- **Paper mill belt presses**
  - classed as fill material
  - saturated
  - large quantities available
- **Sawmill or forestry**
  - may be limited supply, requires saturation
- **Stabilised sewerage sludge**
  - Readily available eg. Carrum
  - Currently rehabilitating Braeside (EPA WA)

PMF Flood Control

- Inlet erosion control



- Spillway discharge

Other Issues

- **Quality of long term discharges**
  - current conditions
  - organics
  - self - regulation
- **Minimum water depth**
  - geochemical
  - wave
  - flood erosion

Naturally Generating Wetland: Closure

Naturally Generating Wetland: Intermediate

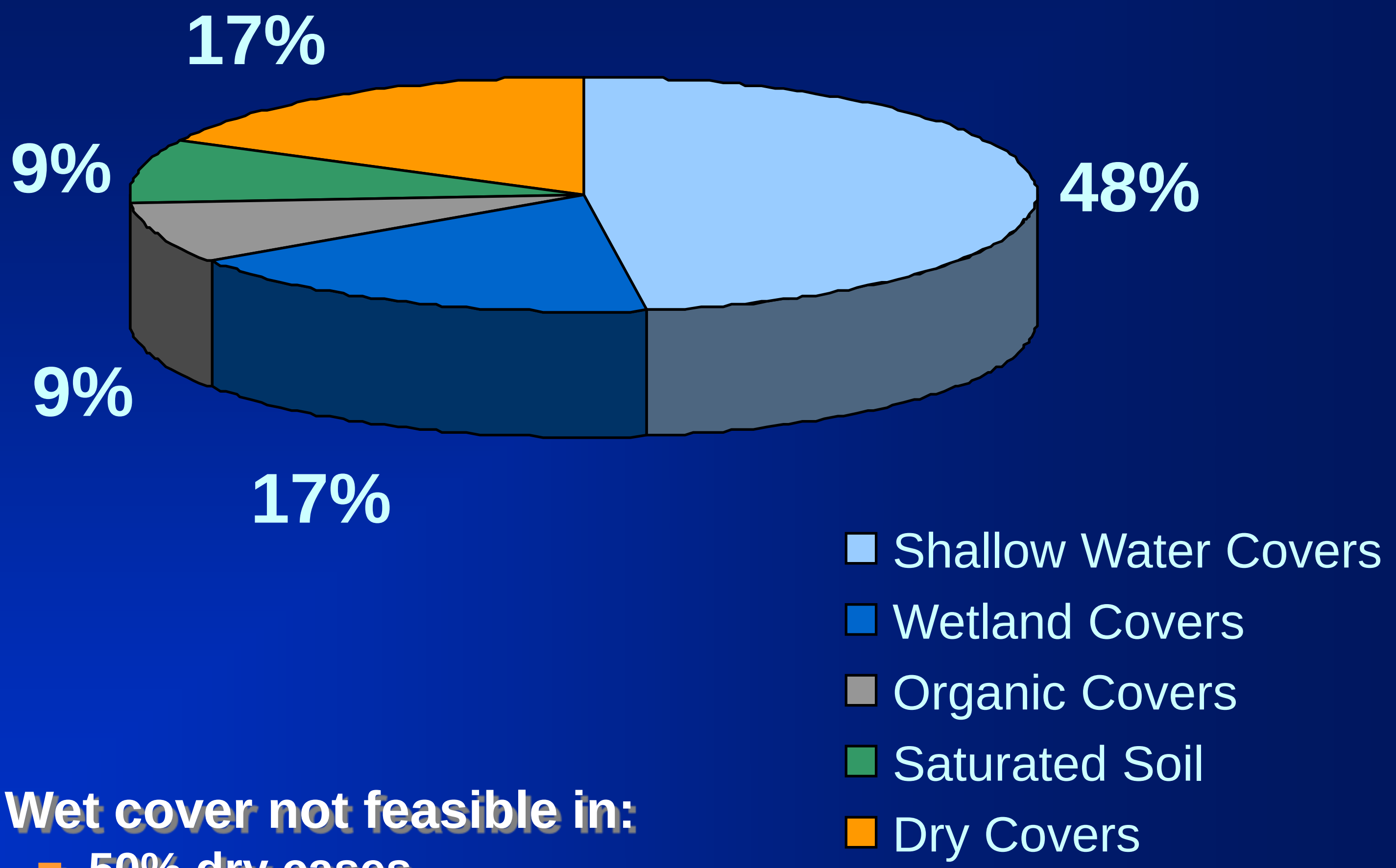
Naturally Generating Wetland: Long Term

Case Studies of Sulphidic TMF Closures

TMF Case Studies

- **Australia**
  - Captains Flat
  - Mt Lyell
  - Rum Jungle
  - Rosebery
  - Renison Bell
  - New Zealand
  - Golden Cross
- **Canada**
  - Equity
  - Quirke
  - Falconbridge
  - Louvicourt
  - Solbec
  - Waite Amulet/Millenbach
  - Sullivan
  - Panel wetlands
  - Les Auriferes Terrain
  - Denison
  - Brenda/Heath steel
  - Spanish American
  - Mattabi
  - Strathcona
  - Stanleigh
- **Sweden**
  - Saxberget
  - Kristineburg
  - Gaigebert
  - Stekeniokk
- **Ireland**
  - Lisheen
- **Norway**
  - Lokkenn
- **Peru**
  - Lago Junin

Summary of all Case Studies



- **Wet cover not feasible in:**
  - **50% dry cases**
  - **60% saturated soil**

Captains Flat (ACT) / Rum Jungle (NT)

Captains Flat

dry/saturated soil cover resulted in AD in local Creek

Rum Jungle

Failed dry/saturated soil cover

Mt Lyell - Tasmania

Mt Lyell - Tasmania

- **Pilot TMF**
  - Tailings pH 7-8 below 1 cm
  - Overlying water pH 4-5 (natural). Average Cu 0.02mg/L, Pb 0.02
  - Appears natural waters mobilising metals
  - Natural vegetation establishment / wildlife

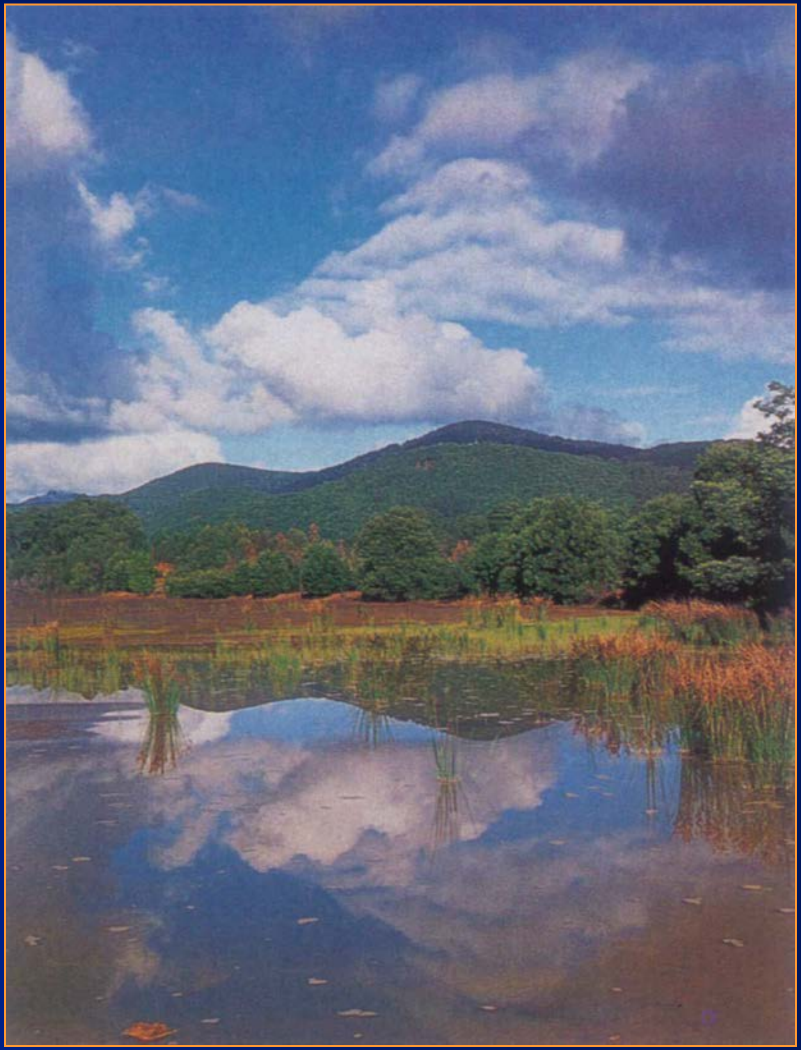
- **Princess Creek >60 metres final embankment**
  - sub-aqueous, lake closure
  - inflows up to 200 L/s
  - Two spillways for long term discharge and flood handling
  - Long term min water cover of 1 metre
  - DPIW&E approval

Rosebery - Tasmania

- **Poor water quality from exposed tailings**
- **Approved closure is free water and wetland**
- **Found that vegetation establishment inconsistent**
- **Modified Closure Strategy-**
    - lower water to 300-500mm, lime dose, raw sewerage in top pond
- **DPIW&E and West Coast Council/National Heritage Council approval**

Renison Bell - Tasmania

- Major CSIRO study
- Combined free water wetland
- Creation of organic rich anaerobic surface layer



Lisheen, Ireland

- New mine
- Laboratory and test plots for wetland closure very successful.
- Approved closure is 1 metre slurried peat directly over tailings. Originally proposed limestone layer but not necessary
- Wetland will have free water areas and water level controlled by spillway
- Design based on water and organic material inhibiting tailings oxidation
- BATNEEC - Irish EPA

Golden Cross, NZ

- Mining since 1893, very wet climate
- 9 million cubic metres tailings and waste rock
- Water/wetland cover proposed with spillway to control level
- In areas where tailings exposed a soil cover up to 4 metres thick placed over very soft tailings
- Long term discharge to trout fishery in high quality stream
- results to date good, excess water will be discharged untreated to Creeks.

Summary

- Dry closure not feasible
- Maintenance of water cover feasible
- International best practice is for permanent water cover
- MEND research program demonstrates effectiveness of permanent water cover closure