Micro and Macro Scale Design and Performance of Dry Covers - Waihi, New Zealand

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Summary of methods for the prevention of mine drainage

(Ref. Global ARD Guide)
Waihi Climate

Air temperature: -5° to 28° C
Rainfall: 2100 mm a\(^{-1}\)
ET: 700 mm a\(^{-1}\)
Cover and Climate Types

General guidance on appropriate cover types

(Ref. Global ARD Guide)
Waihi Tailing Storage Facility
Storage 2 rehabilitation
Storage 2 rehab cover and land use
Objectives:

1. Restriction on generation of acid drainage in the short and long term
2. Rehabilitation of the downstream shoulder to pasture and native plantings
3. Surface water control to prevent ponding, infiltration and erosion

Achieved by:

Multi-layered cover system

1. Sealing layer - oxidation control and geochemical security
2. Soil layer – insulation & vegetation growth medium

Slope geometry – surface runoff and erosion control
Geochemical objectives & targets

Objectives
- minimise risk of adverse water quality effects
- minimum after-care and long term geochemical security

Targets

Mn – receiving water quality standard in consents is 2 g/m³
   Reduction in underdrainage flows rates < 1 L/s
pH = 6 for minimising Mn release and control of Al and Cu
SO₄ – 250 g/m³ recommended at closure (c. 10 kg/ha/d = double worst case estimate)

Primary method to achieve these targets is limestone addition to the waste rock

Sealing layer will reduce leachate flow rates
Cover design

Diagram showing a cover design for a tailings dam, with layers labeled Zone A (NAF), Zone B (NAF & PAF), Zone C, Zone D and E (NAF & PAF), Zone F (NAF & PAF), Zone G (NAF), Zone H (NAF), and Topsoil. Intermediate Sealing layers are indicated.

(NAF) Tailings
Storage 2 cover assessment

ANSTO study in 1994 – oxygen, temperature, and diffusion on waste rock and covers

Diffusion is the dominant $O_2$ transport mechanism in WRD

No advection or convection

Oxygen concentration < 1% at 2m depth from surface

No $O_2$ below 5m depth even in areas not covered
No oxidation at depth
Pyrite oxidation is not significant below 1-2m depth in uncovered areas
Some heating during construction of PAF waste areas

Sealing layer diffusion coefficients < 2.1 x $10^{-8}$ m$^2$/s

2-orders of magnitude lower than bulk waste rock
Important oxygen barrier

Sulphate generation rate - 93-99.5% reduction (to 5.5 kg/ha/d) with use of cover

ANSTO = Australian Nuclear Science & Technology Organisation
Zone G – sealing cover specifications

Diffusion coefficient is the critical factor determining the performance of zone G

\( De \) - function of moisture content or degree of saturation

90% degree of saturation (81-100% range) \( @ \ De = 2.1 \times 10^{-8} \text{ m}^2/\text{s} \)

zone G permeability < 1 \( \times 10^{-8} \text{ m/s} \)

Embarkment design and material specifications

Construction control - compact waste rock in 250mm thick layers – zone G

Field saturation levels – 85% minimum, 90% median
Construction Monitoring

Geotechnical testing of foundations and placed embankment fill

- Dry Density
- Air Voids
- Degree of saturation
- Scala Penetrometer
- Shear vane
- Particle Size Distribution
- Permeability – Triaxial Cell – zone G sealing layer
- Solid Density of Soil Particles

Failed tests result in re-compaction of finished areas and retesting
Sealing layer reduces leachate flows

Prevention of water ingress

Zone B – tails upstream barrier
Zone G – embankment cover

Graph shows performance for Storage 2 – L9 had the highest flows

Expected flows less than 0.25 L/s
Sulphate trends

250 g/m³ recommended at closure

Equiv. 10 kg/ha/d

= double worst case estimate
Storage 1A – slope geometry

**Slopes**
- 4:1 to 3.2:1 (horiz:vert)
- 10 m berms - reverse & longitudinal fall
- collector sumps and subsoil drainage
Pasture Productivity

Storage 2
dry matter (grass) production

18 embankment sites
6 control sites
-flat alluvials

Average = 15 kg/ha/d (range 9-23 kg/ha/d)

Performance target 80% - met in 2008
Successful Closure

Monitoring & inspection

Peer review

Receiving water quality standards for discharge & no adverse effects
Contributors

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