Field Hydrologic Performance of Earthen Covers for Uranium Mill Tailings Disposal Sites on the Colorado Plateau

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Cover Strategy:
Resistive Barrier vs. Water Balance Covers

Conventional Cover

- Surface Layer
- Geomembrane
- Clay Barrier
- Interim

Water Balance Cover

- Storage Layer
- Capillary Break
- Interim

Conventional Cover  Water Balance Cover
Validate Performance with ACAP Lysimeter

ACAP lysimeters used to confirm a design meets performance goal by directly monitoring percolation and to understand, when necessary, the hydrologic processes controlling percolation.

Armored Cover at Cheney Disposal Facility

- Elevation: 1500 mm
- Precipitation: 230 mm
- Climate: Seasonal semi-arid
- Cover Thickness: 1.4 m

Armored Cover at Cheney Disposal Facility

- Riprap: 300 mm
- Bedding: 150 mm
- Frost Protection: 450 mm
- Clay Radon Barrier: 450 mm
- Tailings
• Most precipitation becomes ET
• Perc much higher later in record.
• Subtle variation in soil water storage.
• Very little runoff.
• Bedding and frost protection layer vary seasonally
• Radon barrier saturated at end of record
• Increase in water content of sand consistent with percolation
Cheney Annual Water Balance

- ET largest fraction, but usually < precip
- Perc relatively low, except during wetter years.
- Perc tied directly to integrity of clay radon barrier.

Note: Y2 scale 10x < than Y1
Most of precipitation becomes ET.

Perc much higher during wetter years.

Barrier integrity critical for managing wet conditions.
Water Balance Cover at Monticello Disposal Facility

Elevation: 2150 mm
Precipitation: 370 mm
Climate: Seasonal semi-arid
Cover Thickness: 2.0 m
Monticello Water Balance Record

- Nearly all precip becomes ET
- Storing & releasing water each year
- Runoff very small fraction (minimal erosion)
- Avg percolation rate < 0.5 mm/yr
Monticello Water Content Record

- High frequency variation near surface.
- Dampens with depth.
- Runoff very small fraction (minimal erosion).
- Avg percolation rate < 0.5 mm/yr.
Monticello Annual Water Balance

- ET largest fraction, ≈ precip
- Perc very low, elevated only during wettest year

Note: Y2 scale 100x < than Y1
Monticello: Percolation & Precipitation

- Nearly **ALL** of precipitation becomes ET
- Perc elevated in very wet year **only**. Not dependent on magnitude of precipitation.
White Mesa Mill Tailings Facility

**Elevation:** 1900 m  
**Precipitation:** 360 mm  
**Climate:** Seasonal semi-arid  
**Cover Thickness:** 2.0 m
White Mesa Water Balance Record

- Large seasonal change in soil water storage
- Vegetation being established, allowing longer residence of water in profile
- Perc, lateral flow, and runoff very low. Little erosion potential
Lessons Learned

• Water balance covers very effective in managing water balance at semi-arid sites for broad range of conditions. Percolation typically < than 0.5 mm/y on average.

• Water balance covers consistent with natural ecological setting, promoting long-term sustainable performance with minimal maintenance.

• Armored resistive barrier functions well with modest precipitation, but long-term integrity of the barrier layer critical to proper functioning.

• At higher precipitation, percolation from cover with resistive earthen barriers increases substantially.