Objectives and Design Solutions of a 1000-year Evapotranspiration-Capillary Surface Barrier System

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What’s Next for Reclamation? April 9 - 13, 2017
Background - Surface mining

- Alters the vegetation, soils, bedrock, and landforms
- Changes the surface hydrology, groundwater, and flow paths

- Changes ecology of the site
Surface Mining - Problems

- **Surface**
  - Loss of vegetation
  - Loss of soil
  - Erosion
  - Runoff
  - Stream pollution

- **Subsurface**
  - Acid drainage
  - Groundwater contamination
Surface Barrier (Cover, Cap)

- covers the exposed rocks
- isolates rockpile/tailing
- reduces erosion
- provides a medium for vegetation growth
- reduces drainage
Soil covers for tailings impoundments, waste rock piles, backfilled pits and heap leach pads (Rykaart et al. 2006)

<table>
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<tr>
<th>Continent</th>
<th>Country</th>
<th>Number of Cases</th>
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<td><strong>Total</strong></td>
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Barrier Design Challenges

Regulatory requirements

- Compliance
- Rules
- Regulations
- Guidelines

Recharge Control

Wind Erosion

Water Erosion

Animal Intrusion

Plant Intrusion

Human Intrusion

Waste isolation

Maintenance
Objectives

- Introduce performance objectives and the design solutions for a long-term (1000 yr) surface barrier
- Evaluate the performance of the surface barrier after a demonstration of 20 years

The 2000-Year-Old Man-Made Grave Creek Mound in the Ohio River Valley, WV

10000-Year–Old Iceberg Deposited Mound (Berggmounds)
Performance Objectives of a Surface Barrier over a Nuclear Waste Site

Objectives

#1 Meet or exceed RCRA criteria
#2 Function in a semiarid to subhumid climate
#3 Limit drainage to less than 0.5 mm yr\(^{-1}\)
#4 Limit runoff
#5 Minimize erosion
#6 Minimize biotic intrusion
#7 Have a design life of 1000 years
#8 Be maintenance free
Objective #1: Meet or exceed RCRA criteria
- thickness > 0.91 m;
- design life: 30 years;
- conductivity: <32 mm/yr

Design Solution
- thickness of 4.5 m;
- design life of 1000 year;
- drainage rate < 0.5 mm/yr
- containing a coated asphalt concrete (AC)
Objective #2:
- Function in a semiarid to subhumid climate

Design Solution:
- Use a ETC barrier with 2-m-thick silt loam
- The compacted clay barrier may not work

AI = P/PET

<table>
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<tr>
<th>Classification</th>
<th>Aridity Index</th>
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<tbody>
<tr>
<td>Hyperarid</td>
<td>AI &lt; 0.05</td>
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<tr>
<td>Arid</td>
<td>0.05 &lt; AI &lt; 0.20</td>
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<tr>
<td>Semi-arid</td>
<td>0.20 &lt; AI &lt; 0.50</td>
</tr>
<tr>
<td>Dry subhumid</td>
<td>0.50 &lt; AI &lt; 0.65</td>
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</table>
Objective #3:
- Minimize drainage rate to <0.5 mm/yr

Design solution:
- 2-m thick ET barrier
- Capillary break
- 2% slope of barrier surface
Objective #4: Limit runoff

Design solutions

- Use soil with sufficient large permeability

Warden silt loam

\[ K_s = 36 \text{ mm/hr} \]
Objective #5: Minimize erosion

Design solution

- 15% gravel mix
- vegetation
Objective #6: Minimize biotic intrusion

Design solutions

- 1.5-m riprap layer
- asphalt concrete layer
Objectives and Solution - 7

- **Objective #7**: Have a design life of 1000 years
- **Objective #8**: Be maintenance free

**Design solution**

- **Use natural materials for barrier construction**: soil and rock
- **Establish a natural ecological system**: ETC Barrier
- **Include protective side slopes**
Barrier Design: 3D

Structure of the Prototype Hanford Barrier
Functions of Barrier Components

Silt Loam + Gravel:
- Vegetation growth
- Precipitation storage and release
- Erosion control

Riprap Side Slope:
- Intrusion control

Riprap layer:
- Intrusion control

Drainage Gravel:
- Promote lateral drainage

Compacted Soil
- Settlement control

Asphalt Concrete
- Drainage interception
- Noxious gas control

In Situ Soil

216-B-57 Waste Crib

2X vertical exaggeration
Tests

➢ Treatability test
  ▣ Irrigated the north section to about 3x the average precipitation (3x160 = 480 mm/yr)

➢ Controlled burn
  ▣ The north section was burned in Sept. 2008

➢ Monitoring: 1994 to 2013
Results: Soil Water Content Dynamics (10/95-3/96, irrigated)

- Soil became wetter
- Top 0.7 to 1 m was very wet
- Lower portion was still moist in late spring
- Water was diverted away from the center line

Click to play video
Soil Water Content Dynamics (4/96-10/96, irrigated)

- Soil became drier spring/summer
- Entire-soil profile became dry
- ET used up all the stored water

Click to play video
Summary - Design Barriers for Mine Lands

Determine barrier objectives

- Regulatory Requirements
  - Federal
  - State
- Functionality Requirements
  - Climate
  - Maximum drainage rate
  - Runoff control
- Longevity Requirements
  - Design life
  - Erosion control
  - Maintenance

Design surface barriers to achieve the objectives

- Type, Complexity