Groundwater Research Report
WR06R005

# EFFECTIVENESS OF ENGINEERED COVERS: FROM MODELING TO PERFORMANCE MONITORING

**Craig Benson**

2009

Project Number WR06R005

# Effectiveness of Engineered Covers: From Modeling to Performance Monitoring

Craig Benson
University of Wisconsin-Madison

2009

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# Completion Report

**Submitted By:** Craig Benson
**Submitted:** 6/1/2009

**Start Date:** 12/1/2006
**End Date:** 2/28/2009

## Project Title

WR06R005: Effectiveness of Engineered Covers: From Modeling to Performance Monitoring

## Project Investigators

Craig Benson, University of Wisconsin-Madison

## Results

The objective of this project was to gather information needed to project the long-term performance of final covers and to interpret the performance of the landfill final cover test sections that were constructed and monitored as part of the Alternative Cover Assessment Program (ACAP). This information was gathered as we exhumed 24 of the 27 ACAP test sections along with two full-scale final covers at operating landfills.

Field and laboratory testing has shown that the hydraulic properties of final cover soils change in response to pedogenic processes that affect soil structure. These changes occur fairly rapidly (within 3-5 yr) and their magnitude is a function of the initial structure of the soil (larger changes in hydraulic properties occur for soils that are denser and less conductive when initially placed). An overall loosening of the soil occurs, which results in an increase in saturated hydraulic conductivity, as well as a change in soil water storage capacity. In addition, the hydraulic properties converge to a relatively narrow band after several years of weathering. In particular, regardless of the initial condition, the saturated hydraulic conductivity ultimately falls within 10-5 to 10-3 cm/s, van Genuchten's alpha parameter falls within 0.01-0.1 kPa-1, and van Genuchten's n parameter falls within 1.2-1.5.

These findings have two important practical implications for alternative covers. First, the universally narrow ranges for the hydraulic properties reduce the uncertainty in predictions of long-term cover performance and build confidence in alternative cover technology. Second, the findings suggest that alternative cover soils should not be densely compacted, and should be constructed with less plastic fine-textured soils when possible. Adopting both of these recommendations for cover soil selection and placement will result in covers that undergo smaller changes in hydraulic behavior over time, and therefore will exhibit more uniform performance over time.

Changes in the properties of geosynthetic materials have been less significant (except for geosynthetic clay liners). Wide-width tensile strengths, melt flow indices, and oxidation induction times of the geomembranes have remained essentially unchanged during the ACAP study. Small reductions (2x) in the transmissivity of geocomposite drainage layers have been observed. The permittivity of the overlying and underlying geotextiles in geocomposite drainage layers has also diminished modestly (2-3x) due to intrusion of fines. These changes are not significant enough to affect performance in the near term. However, performance may be affected over decades or centuries, which can be important for wastes with very long life spans (e.g., radionuclides). Interface shear strengths have remained essentially unchanged. However, appreciable reductions in the ply adhesion of

geocomposite drainage layers have been observed at several sites, which may have implications for long-term stability.

Significant increases in the hydraulic conductivity of geosynthetic clay liners (GCLs) have been observed in some cases, even if the GCL is covered by a geomembrane. The increases in hydraulic conductivity are due to replacement of native Na in the bentonite with divalent cations (predominantly Ca, but also Mg) combined with dehydration of bentonite surfaces or lack of sufficient hydration prior to cation exchange. For most sites where the GCL is covered by a geomembrane, low hydraulic conductivity can be maintained by ensuring the subgrade water content is at least 10% and that the total cation charge per mass (TCM) in the subgrade is less than 0.8 cmol+/kg. However, this recommendation does not ensure universal success. At two sites where the GCL was covered with a geomembrane, preferential flow was observed in GCLs even though they were sufficiently hydrated. The preferential flow paths appear to form in response to cation exchange in bentonite surrounding bundles of needle-punching fibers.

## Impacts

**No answer has been submitted for this question.**

## Most Significant Benefit/Application

**No answer has been submitted for this question.**

## Follow-Up

A draft final report for this project has been submitted. After review and revision, the final report needs to receive widespread dissemination.

The findings from the study need to be published in peer-reviewed journals. Six journal manuscripts have been drafted from this project and will be submitted for review and publication.

A webinar series should be developed to present the findings from this study to a broad audience.

## Awards, Honors & Recognition

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|---|---|
| **Title** | J. James Croes Medal |
| **Event Year** | |
| **Recipient** | |
| **Presented By** | ASCE |
| **Description** | |

## Committees, Memberships & Panels

| | |
|---|---|
| **Group Name** | US Department of Energy |
| **Description** | Chair, Independent Technical Review Committee for On-Site Disposal Facilities |
| **Start Date** | |
| **End Date** | |

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|---|---|
| **Group Name** | ASTM |

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|---|---|
| **Description** | D18 Executive Committee |
| **Start Date** | |
| **End Date** | |

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|---|---|
| **Group Name** | Geo Institute |
| **Description** | Board of Governors |
| **Start Date** | |
| **End Date** | |

## Interactions

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| **Description** | This project is a collaborative effort between the US Nuclear Regulatory Commission, US National Science Foundation, US Department of Energy, US Environmental Protection Agency, and the Environmental Research and Education Foundation. The Desert Research Institute of Reno, NV and California Polytech University are collaborators |
| **Event Date** | |

## Other Project Support

| | |
|---|---|
| **Source** | Multilple Agencies |
| **Dollar Value** | $1 |
| **Description** | This project is benefiting from funding being provided by the following agencies as part of a collaborative effort to understand the temporal evolution of the characteristics of landfill final covers: US National Science Foundation, US Nuclear Regulatory Commission, US Department of Energy, US Environmental Protection Agency, and the Environmental Research and Education Foundation. |
| **Start Date** | |
| **End Date** | |

## Partners

| | |
|---|---|
| **Name/Organization** | William H. Albright |
| **Affiliation** | Desert Research Institute |
| **Affiliation Type** | |
| **Email** | bill@dri.edu |
| **Description** | Co-PI |

## Presentations & Public Appearances

| | |
|---|---|
| **Title** | Design and Construction of Alternative Covers |
| **Presenter(s)** | Craig H. Benson, and William H. Albright Presentation Type: Workshop Event Name: Event location: Event Date: February 2008 Target Audience: Audience Size: 100 Description: |
| **Presentation Type** | |
| **Event Name** | Design and Construction of Alternative Covers |
| **Event Location** | Portland, OR |

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|---|---|
| **Event Date** | 2/1/2008 |
| **Target Audience** | |
| **Audience Size** | 100 |
| **Description** | 3-d workshop for engineering consultants, state regulators, and federal regulators |

## Students & Post-Docs Supported

| | |
|---|---|
| **Student Name** | Matthew Bennett |
| **Campus** | University of Wisconsin-Madison |
| **Advisor Name** | Craig Benson |
| **Advisor Campus** | University of Wisconsin-Madison |
| **Degree** | Masters |
| **Graduation Month** | December |
| **Graduation Year** | 2009 |
| **Department** | and Environmental Engineering |
| **Program** | Geo Engineering |
| **Thesis Title** | |
| **Thesis Abstract** | |

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|---|---|
| **Student Name** | Seunghak Lee |
| **Campus** | University of Wisconsin-Madison |
| **Advisor Name** | Craig Benson |
| **Advisor Campus** | University of Wisconsin-Madison |
| **Degree** | Post Doc |
| **Graduation Month** | April |
| **Graduation Year** | 2009 |
| **Department** | Civil and Environmental Engineering |
| **Program** | Geo Engineering |
| **Thesis Title** | |
| **Thesis Abstract** | |

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|---|---|
| **Student Name** | A. Hakan Oren |
| **Campus** | University of Wisconsin-Madison |
| **Advisor Name** | Craig Benson |
| **Advisor Campus** | University of Wisconsin-Madison |
| **Degree** | Post Doc |

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|---|---|
| **Graduation Month** | August |
| **Graduation Year** | 2009 |
| **Department** | Civil and Environmental Engineering |
| **Program** | Geo Engineering |
| **Thesis Title** | |
| **Thesis Abstract** | |

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|---|---|
| **Student Name** | Joseph Scalia |
| **Campus** | University of Wisconsin-Madison |

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|---|---|
| **Advisor Name** | Craig Benson |
| **Advisor Campus** | University of Wisconsin-Madison |

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|---|---|
| **Degree** | PhD |
| **Graduation Month** | May |
| **Graduation Year** | 2010 |
| **Department** | |
| **Program** | |
| **Thesis Title** | |
| **Thesis Abstract** | |

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|---|---|
| **Student Name** | Paul Schlicht |
| **Campus** | University of Wisconsin-Madison |

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|---|---|
| **Advisor Name** | Craig Benson |
| **Advisor Campus** | University of Wisconsin-Madison |

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|---|---|
| **Degree** | Masters |
| **Graduation Month** | December |
| **Graduation Year** | 2009 |
| **Department** | Civil and Environmental Engineering |
| **Program** | Geo Engineering |
| **Thesis Title** | |
| **Thesis Abstract** | |