Evaluation of Factors Controlling The
Evolution of Drainage Rates Through Surface Covers at the Hanford Site

G. V. Last
R. D. Mackley
G. W. Gee
S. W. Petersen (FH)

November 8, 2006

Introduction and Need:
One of the most sensitive parameters and a primary source of uncertainty in the long-term predictions of contaminant transport at Hanford is the time-varying estimates of recharge (deep drainage). Deep drainage rates of meteoric water through various soil cover (e.g. bare gravel surfaces, fine-grained soils with climax sage-steppe community) and protective barrier types as they evolve over time are key input parameters. One of the primary remediation strategies proposed for the Hanford Site is the use of surface barriers (caps) to prevent migration of waste due to infiltration and deep drainage of surface water. The design life for such barriers is typically estimated to range from 30 to 1000 years. Engineered surface barriers as with other soil covers and landforms, mature and evolve over time, in response to erosion, sediment deposition, climatic conditions, pedogenesis, hydrologic processes, vegetation, and biological processes (after Shafer et. al, 2004).

Environmental assessments at Hanford have used several different approaches for simulating the time-varying recharge (deep drainage) rates through various surface covers. These approaches vary from no change in recharge rates after design life to complete disappearance of the protective barrier immediately after design life. Inconsistencies between the recharge rates used by various Hanford assessments has raised concern over the technical defensibility of the assessments. Thus, an improved scientific basis is needed for predicting the long-term performance of surface barriers and for evaluating various scenarios for simulating long-term recharge (deep drainage) rates.

Purpose:
The purpose of this work is to develop the technical basis for simulating the long-term evolution and change in recharge (deep drainage) rates of various surface covers and engineered surface barriers. In general, there are three tools that can be applied to estimate the long-term performance of surface covers: monitoring, modeling, and natural analog studies (Waugh 2001). Numerical models can be used to simulate the aging/evolution of surface covers, and subsequent deep drainage rates, in response to complex environmental processes acting on that surface cover. Field characterization and monitoring of existing surface covers and engineered barriers provide data and information with which to calibrate/validate near term predictions from these models. Natural analog studies help identify and evaluate the important environmental processes (e.g. pedogenesis) and events (e.g. ecologic change) that could affect changes in the surface cover and how they should be incorporated into the numerical models.

There are ongoing efforts at the Hanford Site to estimate recharge from monitored lysimeter facilities, prototype barriers, and other deep drainage data such as chloride and other isotopic profiles in the vadose zone. There are also ongoing efforts to enhance/modify the STOMP (Subsurface Transport Over Multiple Phases) code to better model surface cover/barrier performance. The objective of this activity is to supplement these ongoing efforts with natural analog studies that can identify the processes and events controlling aging/evolution of surface covers, their components and materials, and the resulting deep drainage rates over hundreds to thousands of years.

Dry Creek Canyon is located approximately 10 km upstream from the proposed silt borrow site (Area C) for fine-grained material to be used in ET covers (surface barriers) to close waste disposal sites at Hanford (BHI-01551, D&D-25575). This canyon is approximately 3 km long and up to about 10 m deep. Mackley et. al. (2005) identified four soil chronosequences ranging in age from >13 kyr BP to <6.8 kyr BP. These fine-grained sediments are believed to be similar in age and physical/chemical properties to those at the silt borrow site. Due to their apparent similarity and proximity to the borrow area, the sediments exposed here have been used in an ad hoc fashion as a natural analog to how these ET barriers may evolve over time. The soil morphology, as it has developed over the last several thousand years, has been used to provide qualitative insights into how the barrier materials may perform over the long-term. However, Dry Creek Canyon has never been systematically and quantitatively evaluated to realize its full potential as an analog for long-term ET barrier maturation.

Approach:

This study will select time discrete analog sites within Dry Creek Canyon and other locations within or surrounding the Hanford Site, to provide qualitative and quantitative data that could demonstrate how ET barriers and other surface covers may evolve and perform over hundreds to thousands of years. Surface covers are landforms that will evolve in response to erosion, sediment deposition, climatic conditions, pedogenesis, hydrologic processes, vegetation, and biological processes (after Shafer et. al, 2004). To better understand how these coupled processes could affect the performance of surface covers over time, a series of detail study sites will be selected to evaluate changes to the surface soils between discrete time intervals. The fundamental assumption here is that looking back in time will provide a technical basis for predicting change in the future.

The primary objective or outcome from this study will be an improved scientific basis for evaluating various scenarios for modeling the long-term (after hundreds to thousands of years) behavior of barriers and other surface covers. For example, some of the scenarios currently used to model long-term barrier perform assume:

1) that the barriers effectively disappear after design life, or
2) that the barriers slowly evolve from an effective barrier, back to original pre-Hanford soil conditions, or
3) that the barriers do not substantially change, and remain effective essentially forever.

The three main issues to be addressed by this study are; 1) stability of the surface cover (e.g. erosion/deposition by water and/or wind) and capillary breaks (e.g. textural changes), 2) potential for animal burrows, plant roots, and soil development (e.g. jointing) to affect moisture migration (e.g. focused recharge) and deep drainage, and 3) the change in long-term drainage overtime, as it relates to soil development and climate. The focus of this study will be similar to that conducted by Shafter et. al. (2004).

Deliverables:

Detailed technical test plan
Preliminary test report
Final report

References:

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