Quantifying Vadose Zone Flow and Transport Uncertainties Using a Unified, Hierarchical Approach

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Research Objectives

This project recognizes the difficulties in predicting field-scale vadose zone transport raised by the small-scale variability of vadose zone flow and transport properties and the large scale of the typical contamination problems facing DOE. We are developing and demonstrating a general approach to parameterize models of flow and transport in the heterogeneous vadose zone that is practical at the field scale. Scientific goals include: investigating the application of recent advances in indirect measurement of soil properties to the conditional simulation of flow and transport in the heterogeneous vadose zone; determining the relationships between the type of data used in the conditional simulation, the quantity of data available, the scale of measurement, and the uncertainty in predictions of flow and transport; and developing guidance for the effective application of the model parameterization and conditional simulation approach at field scales common to DOE vadose zone contamination problems.

This investigation is being conducted using data from large-scale, controlled field experiments conducted on the Hanford Site. Because the scale of these experiments is comparable to the scale of DOE’s contamination problems, we will be able to elucidate relationships between the quantity and spatial extent of characterization data and the accuracy and uncertainty of flow and transport predictions. We envision that this research will demonstrate a systematic approach for cost effectively parameterizing spatially variable models of the vadose zone and that the results will provide guidance for allocating vadose zone characterization resources.

Research Progress and Implications

This report summarizes work after five months of a three-year project. The project is developing and demonstrating a vadose zone parameterization method using data from a field experiment conducted in 1980-81 in the 200 East area of the Hanford Site (the Sisson and Lu Site). Additional data from this site was subsequently collected in 1995 using detailed geophysical borehole logging. As part of the Hanford Site Science and Technology Program, an additional infiltration/tracer experiment is being planned for the Sisson and Lu Site. This experiment will be conducted during the spring/summer of this year and will include advanced geophysical measurements (such as electrical resistivity tomography and cross-borehole ground penetrating radar) as well as more conventional measurements of soil moisture and matric potential and tracer concentrations. This project has been collaborating with the Hanford Science and Technology Program in their planning of this additional experiment. This has involved attendance at planning workshops and review of the test plan. Relevant data and the results of analyses will be shared freely between this project and the Hanford program. All data from the Sisson and Lu Site will be used in the analyses conducted under this project. The primary work under this project will be conducted after the Hanford experiment has been conducted and
additional data needed for our analyses (soil hydraulic property measurements at the Sisson and Lu
Site) have been collected.

This project is using pedotransfer functions derived from neural network analyses to determine
the utility of such indirect measurements in large-scale predictions and to examine the effect on
uncertainty in transport predictions from using indirect measures of soil hydraulic properties. To
develop the pedotransfer functions we have assembled the relevant unsaturated hydraulic property
data from the Hanford Site and are currently in the process of analyzing this data.

**Planned Activities**

Core samples will be obtained from the Sisson and Lu Site upon completion of the Hanford Science
and Technology Program experiment at the site. This activity is scheduled for the latter half of June.
Samples will be analyzed at the U.S. Salinity Lab for water retention, unsaturated hydraulic
conductivity, and physical properties. Sample analysis is anticipated to take approximately two months.
The hydraulic properties are required for the scaling analysis used in the parameterization/conditional
simulation approach. Data analysis will be conducted in collaboration with the Hanford Site
researchers. Scaling and geostatistical analyses using the newly-obtained hydraulic data will be
conducted by this project. These analyses will be initiated in August or September. The neural network
analyses using the currently available Hanford Site data will continue. The additional data will be
included in the analysis when it becomes available. The simulation activities to be conducted under
this project will commence in FY01.