The DOE Vadose Zone Science and Technology Roadmap and Vadose Zone Science and Remediation Initiatives

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Abstract: Three research initiatives at the Idaho National Environmental and Engineering Laboratory (INEEL) are aimed at advancing the state-of-the-art of vadose zone characterization, monitoring and modeling science and technology that can be of benefit to site operations. Interdisciplinary, multi-institutional research focused on Department of Energy (DOE) field problems is being proposed to develop the right data necessary for monitoring contaminant migration, building computer simulations, and, to adequately model and predict contaminant behavior and fluid flow in the vadose zone. These, when combined, will provide an improved scientific basis, bounding uncertainty, for environmental decision-making with respect to the vadose zone.

A basic relationship used in determining the need for remedial actions in the subsurface is:

Risk = Contaminant Concentration + Contaminant Exposure + Contaminant Toxicity

Regulators generally set the contaminant exposure parameters and the health profession deals with identifying contaminant toxicity. The subsurface research community can best affect the risk equation by bounding the uncertainties associated with predicting and measuring contaminant concentrations (i.e., what are you leaving in the ground, where is it, and, where is it going and how is it changing). This is a daunting task in the vadose zone due in part to the complex (as opposed to complicated) nature of non-linear, coupled, vadose zone biological, hydrological and chemical processes.

GAO observations and follow-on National Research Council reports make evident the need for increased investment in vadose zone Research and Development (R&D). All these reports reach the same general conclusion that there is a need to improve our ability to predict contaminant fate and transport in the vadose zone if we are to make key environmental decisions with reduced uncertainty.

Three initiatives at the Idaho National Engineering and Environmental Laboratory (INEEL) are aimed at addressing these issues and designed to forge links between R&D and site operations: The Vadose Zone (VZ) Science and Technology Roadmap, the Subsurface Science Initiative (SSI) and the Subsurface Geoscience Laboratory (SGL).

The Roadmap is a strategic planning effort to develop a national response to vadose zone science and technology issues. It provides a structure for understanding the context of remedial and long-term stewardship decision-making by the DOE. It addresses the

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components that contribute to an improved scientific input to these decisions and a discussion of the critical research necessary to realize the vision of a sound scientific basis for making public policy and regulatory decisions. It envisions decades of research and infrastructure development aimed at making continuous improvements and order of magnitude (as opposed to incremental) advances in underlying science understanding.

The SSI is envisioned to enhance substantially the scientific and engineering underpinnings of the DOE environmental remediation programs at the INEEL and across the Complex. This will provide better opportunities to focus collaborative, interdisciplinary and multi-institutional efforts on the most vexing problems surrounding remediation, monitoring and long-term stewardship of contaminated sites.

The SGL will be a DOE user facility located at the INEEL that will allow researchers to perform a full range of interdisciplinary, three-dimensional, meso-scale (pilot) experimental campaigns that include work with radioactive components. It will be a critical element in support for experiments that bridge the gap between the laboratory and field scales. It will be a facility unique for its collection of equipment and instrumentation.

These research initiatives will support DOE's complex-wide needs while simultaneously advancing the state-of-the-art of vadose zone characterization, monitoring and modeling science and technology. Interdisciplinary research focused on DOE problems and coordinated to integrate and communicate results is critical if the vadose zone research community is to move forward in pace with DOE's need to understand the basic processes at work in the vadose zone. There is a need to possess the right data necessary for monitoring contaminant migration and building computer simulations, and to adequately model and predict contaminant behavior and fluid flow in the vadose zone. These, when combined, will provide an improved scientific basis for decision-making with respect to the vadose zone.

Some of the more pertinent questions relating to vadose zone remediation issues include:

- Are the type and application of VZ models supporting risk assessment technically viable and defensible.
- Are the existing and planned VZ data of sufficient quality and quantity to support the risk assessment remedial alternative selection and implementation.
- Do the existing and planned VZ data provide a foundation for long-term monitoring.
- Are the scientific and technical underpinnings for the possible VZ solutions to be implemented correct.
- Are the VZ scientific and technical underpinnings, and proposed solutions reasonable and defendable under applicable regulatory requirements and interagency agreements.

The quality of EM cleanup and long-term stewardship decisions in the vadose zone is directly related to the uncertainty in the scientific basis on which the decision process rests. The scientific efforts proposed in these initiatives will dramatically reduce the uncertainties of key decision parameters. Specifically, the expected scientific results will

provide greater accuracy and confidence in risk statements concerning the potential of public health and environmental impacts from contaminants present or released to the subsurface.

This research will provide more sophisticated mathematical models for critical risk drivers. Not only will EM be able to model processes for which algorithms do not now exist, but will also be able to understand and describe critical processes affecting contaminant transformation and movement in the subsurface. These scientific contributions will provide the basis for more effective development and application of remedial technologies.

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