IMPLEMENTATION OF THE HANFORD SCIENCE AND TECHNOLOGY ROADMAP

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ABSTRACT

The U.S. Department of Energy (DOE) established the Groundwater/Vadose Zone Integration Project (Integration Project) in late 1997 to provide an innovative, new approach at DOE's Hanford Site for protecting the Columbia River. The Integration Project uses a roadmap to identify science and technology needs and to define activities to fill the gaps. The roadmap is the primary guide for planning science and technology research needed to address subsurface problems at the Hanford Site and to develop scientific understanding, information, and models needed to support Site milestones. The scheduling/sequencing of these activities in the roadmap, in turn, are coordinated with site milestones and decision points so that required new knowledge and information is available in time to be influential. Work scope identified in the roadmap is addressed by focused, site-specific investigations funded through the Integration Project and the Environmental Management Sciences Program (EMSP). The EMSP research has addressed a number of key scientific issues associated with the inventory of soil wastes at Hanford: tank waste source terms, the chemical speciation of tank wastes, water and contaminant fluxes through the vadose zone, and geochemical behavior of cesium-137 and chromium. The EMSP-Hanford Site partnership has been one of several recent activities at the Hanford Site that has created important, positive cultural changes among those involved in Hanford Site cleanup. The strong linkages between the EMSP program and the Hanford Site have been accomplished without compromise to the scientific spirit of the EMSP program.

INTRODUCTION

The Hanford Site was established during World War II to produce plutonium for the U.S. Army Corps of Engineers' Manhattan Project. From 1944 through the end of the Cold War, nine plutonium production reactors, along with nuclear fuel fabrication and processing facilities, were built and operated at the site. Hanford is now focused on management and cleanup of the legacy wastes from those days. The 560-square-mile site is located in southeastern Washington State (Fig. 1).

The U.S. Department of Energy (DOE) established the Hanford Groundwater/Vadose Zone Integration Project (Integration Project) in late 1997 to provide further assurance that cleanup actions and decisions at Hanford are protective of the Columbia River (1). The Integration Project, to be science-based, includes strong participation from national laboratories, universities, and private industry. In this way, the Integration Project provides the technical and scientific basis required to inform and influence important Hanford Site cleanup decisions.

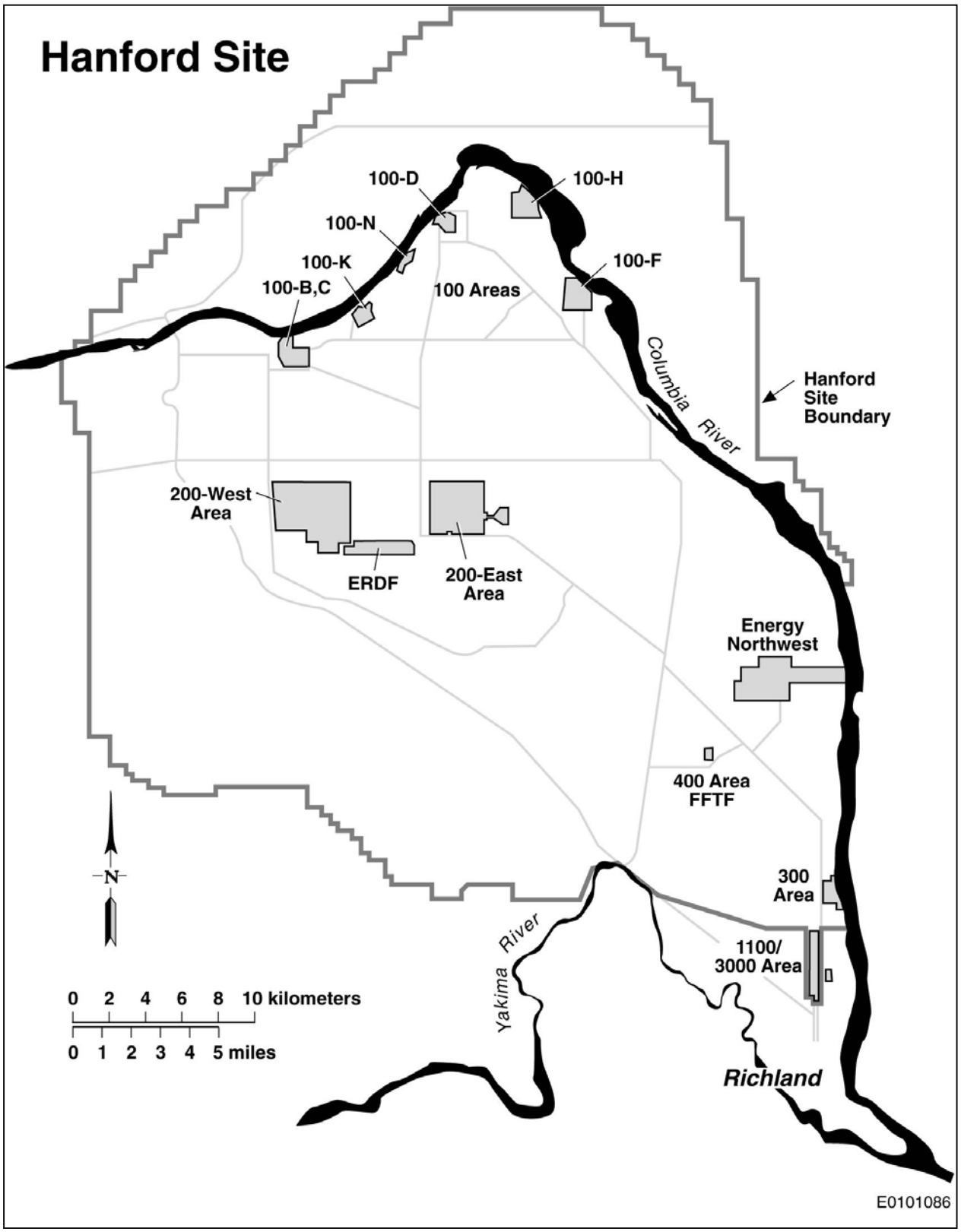

Fig. 1. Hanford Site Map

BACKGROUND

At Hanford, as with most complex waste management and cleanup efforts, there are multiple projects and organizations responsible for various aspects of the overall site mission. Two different DOE field offices, Richland Operations and the Office of River Protection, are responsible for managing the Site. DOE Richland operations are responsible for cleanup of the river corridor and central plateau. The Office of River Protection is responsible for remediation and closure of the high-level waste tanks at the Site, but the office is also responsible for characterization and assessment of the vadose zone beneath the tanks.

The Integration Project uses a roadmap to identify science and technology needs and to define activities to fill the gaps. The roadmap is the primary guide for planning science and technology research needed to address subsurface problems at the Hanford Site and to develop scientific understanding, information, and models needed to support Site milestones. The scheduling/sequencing of these activities in the roadmap, in turn, are coordinated with site milestones and decision points so that required new knowledge and information is available in time to be influential.

INTEGRATION PROJECT APPROACH

The Integration Project developed a science and technology roadmap during FY 1998 to 1999. Following review and evaluation by DOE and key Hanford regulators and stakeholders, the roadmap was published as Rev. 0 in June 1999 (1) and the first revision was released in 2000 (2). A third revision of the roadmap is now underway. The Integration Project uses the roadmap as a guide for planning science and technology scope needed to address subsurface problems at the Site. The roadmap describes the products on a schedule documenting linkages to core projects and other tasks on the Integration Project. These include a Characterization of Systems task, focused on integrating data and making it available for use and the System Assessment Capability, responsible for performing site-wide assessments of Hanford contamination. The roadmap identifies scientific studies or technology evaluations and development within each technical element (inventory, vadose zone, groundwater, Columbia River, and risk assessment). It provides a brief definition of each product, including project linkages and interactions, identification of the customer for the product, and projected startup and delivery dates. The document also includes a summary of budgets estimated for planning and executing activities.

Rev. 0 of the Integration Project science and technology roadmap was used to influence the FY 1999 call for proposals issued by the DOE Environmental Management Science Program (EMSP). The EMSP, which was established in 1995, is DOE's principal program for funding basic research to support environmental management. During FY99, the EMSP awarded 31 new grants (worth $25M in work scope over three years) that were directed at vadose zone problems. The scope of the research portfolio includes, among others, the following topical areas:

- Behavior of dense non-aqueous phase liquids (DNAPL) in the subsurface.
- Hydro-physical transport processes of high-level waste solutions in heterogeneous vadose zone sediments.
- Geochemical reaction processes of high-level waste solutions and entrained contaminants in vadose zone sediments.
- Geologic controls on water/waste migration in the vadose zone and geophysical methods for *in situ* characterization.

INTERACTIONS WITH EMSP INVESTIGATORS

When the EMSP selected the 31 grants, they also provided funding to the Integration Project to facilitate interaction with the EMSP principal investigators and to incorporate their results into meaningful activities that would have an impact at the Hanford Site (EMSP Linkage Project). The EMSP program instructed the Integration Project to influence and guide, but not to direct, the vadose zone EMSP projects. The Integration Project established and maintained linkages with the EMSP investigators through a series of three focused workshops that were held at the Pacific Northwest National Laboratory at the Hanford Site. These workshops paired EMSP investigators with Hanford Site remediation contractors. EMSP investigators first presented their research plans, and in subsequent years, presented their evolving research results and their implications to Hanford. Site personnel, in turn, identified critical scientific issues and key information needs, updated yearly by results of field investigations of contaminated sites, and suggested minor modifications to research scope to enhance benefit. Considerable mutual understanding and collaboration developed between these parties over the 3-year period with the important result that many of the EMSP research results and findings are immediately applicable to issues resolution and technology needs at the site.

In addition to hosting the workshops, the Integration Project provided contaminated and uncontaminated samples of sediments to EMSP investigators and facilitated access to the Hanford Site to conduct research. Uncontaminated samples were obtained from the placement of new compliance-driven monitoring wells while contaminated samples have been obtained from several different tank farms (S-SX, B-BX-BY) and past practices crib sites (TW-1/TW-2). These samples were carefully selected by Integration Project personnel and tailored to the scope/hypotheses of the requesting EMSP project so that the results obtained with them would have maximal potential scientific and Site benefit. In select cases, funding from the EMSP Linkage Project was used to augment EMSP projects to perform specific, state-of-science analyses, consistent with project objectives and scope, on high-visibility Hanford samples. This approach was used to obtain sophisticated chemical speciation measurements of chromium (S-SX tank farm), uranium (B-BX-BY tank farm), and plutonium (TW-1/TW-2) at DOE user facilities as needed for determining corrective/remedial actions.

EMSP principal investigators also participated directly in several field-transport experiments performed at the Integration Project's Vadose Zone Test Facility. In these studies, coordinated by Integration Project staff, dilute and saline fluids have been injected into the vadose zone to test hypotheses on geologic controls on unsaturated fluid flow. Moisture and tracer plumes have been characterized and tracked using different subsurface geophysical methods offered by EMSP investigators and other participants. A reactive tracer experiment is currently being planned.

EMSP CONTRIBUTIONS TO HANFORD INVESTIGATIONS

To a large degree, the full impact of the EMSP-Hanford Site partnership is only now emerging as the FY 1999 EMSP projects complete their 3-year term, and results are published and delivered to users and the scientific community in "final" form. The following example scientific benefits have already been realized.

- EMSP projects have performed advanced experiments and analyses and have developed new models that have improved Hanford's ability to describe past cesium-137 and chromium migration events in the vadose zone beneath leaked single-shell tanks and to predict future transport as required for remedial assessment (Fig. 2).
- New conceptual models have been developed through experimentation that describe the complex geochemical and hydrologic behavior of high-level waste solutions in the vadose zone. The effects of high salt and caustic are now sufficiently understood to speculate on migration behavior of hot, dense, high-level waste supernatant in the Hanford vadose zone and to develop improved reaction/transport models.
- A collaborative team involving EMSP investigators has performed field experiments at the Hanford Site that have shown that subtle changes in sediment texture can induce lateral spreading of moisture plumes and contaminants in the vadose zone (Fig. 3). These observations have provided a conceptual framework to interpret the complex contaminant distribution patterns noted in the tank farms and an impetus to upgrade vadose zone transport models to incorporate this key effect.

The details of these general findings have been incorporated directly into the recently completed Field Investigation Report for the S-SX Tank Farm (S-SX FIR), a Tri-Party Agreement (TPA)-mandated milestone dealing with tank farm corrective actions. This is the first time that EMSP research has been used in direct support of a Hanford regulatory milestone. The Integration Project is tracking and awaiting other scientific contributions of the EMSP research that may contribute to other impending milestones, such as the Field Investigation Report for the B-BX-BY Tank Farm, to be assembled in late FY 2002. The collective scientific accomplishments of the FY 1999 EMSP projects and the implications and utility of this research to the Hanford site will be summarized at the end of FY 2002 in report form as an activity within the EMSP Linkage Project.

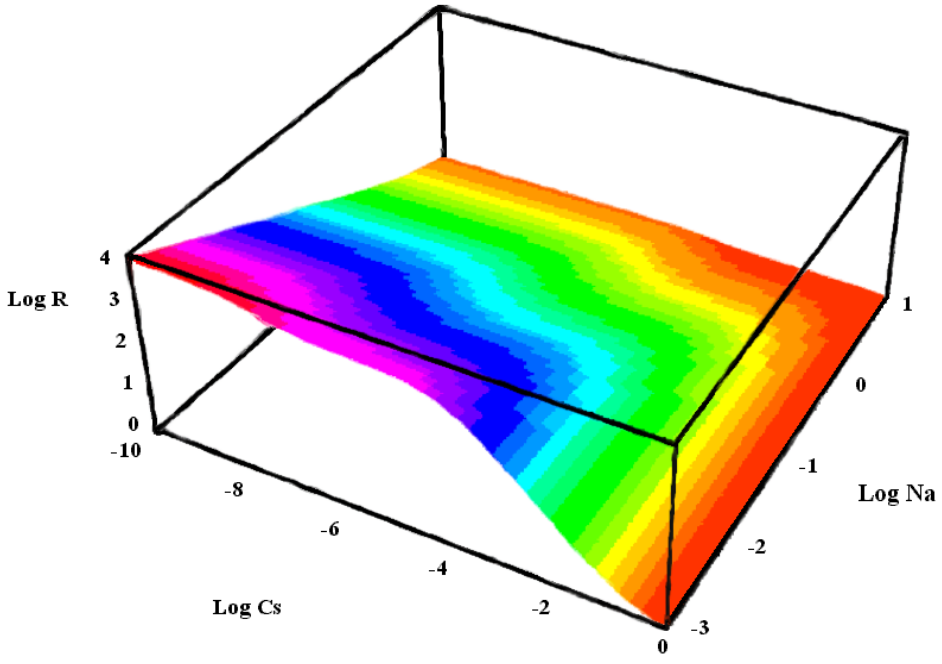

Fig. 2. Retardation Factor (R) for Cesium (Cs) Exchange with Sodium (Na)

The results from the Vadose Zone Transport Field Study experiments have demonstrated that subtle changes in sediment texture can induce lateral spreading of moisture plumes and contaminants in the vadose zone. The subtle changes in texture may be more important in vadose zone transport than previously thought (Fig. 3). In addition, assessment of the strontium-87/strontium-86 isotopic ratios in core materials from Hanford by an EMSP project indicated an average water infiltration flux of 300±200 mm/y to the vadose zone over the past 100 to 1000 y.

CONCLUSIONS

The FY 1999 awards represented the first time that EMSP projects and principal investigators were linked with specific site problems and that mechanisms were put in place to foster the linkages. As a result, a broad range of scientific knowledge and expertise is being applied to solve problems at the Hanford Site through partnerships with EMSP investigators at DOE national laboratories, universities, and private industry. The EMSP-Hanford Site partnership has been one of several recent activities at the Hanford Site that has created important, positive cultural changes among those involved in Hanford Site cleanup. The remediation contractors now view scientists as partners in the clean-up process as their research is contributing to issues resolution in a timely manner through the coordinative benefit of the roadmap and the workshops. Regulators (Washington State Department of Ecology) have endorsed the infusion of science into regulatory documents, such as the S-SX FIR, to enhance product credibility. Regulators are requesting copies of scientific publications and want to participate in future scientific planning with anticipation that their own key scientific concerns may be alleviated, in

part, by this research. These strong linkages between the EMSP program and the Hanford Site have been accomplished without compromise to the scientific spirit of the EMSP program. Results of scientific accomplishment through both the EMSP program and the Integration Project are being published in peer-reviewed journals.

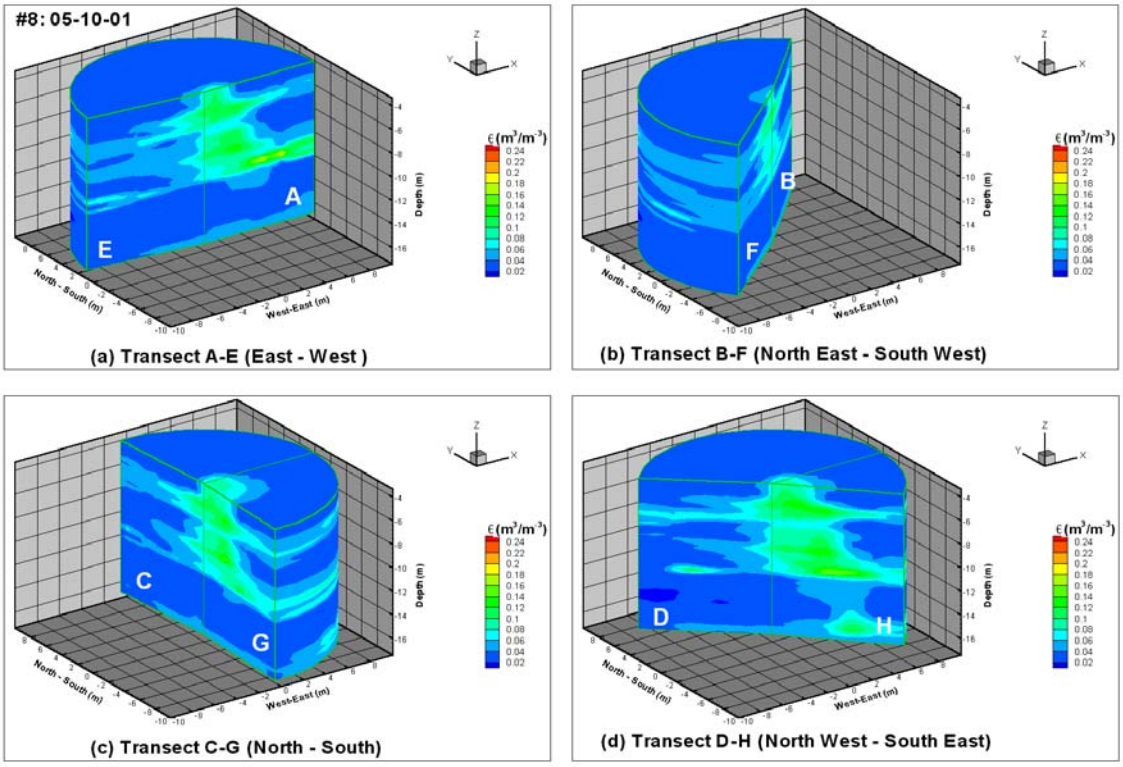

Fig. 3. Moisture Distribution for Saline Plume after 30,000-L Sodium Thiosulfate Injection

The workshops with the EMSP investigators were useful in establishing and maintaining linkages with the Integration Project and core projects. In these workshops, information was freely exchanged and opportunities for collaboration were identified. Many of the interactions continued outside of the workshops and Integration Project.

Providing sediment samples to the EMSP investigators ensured that the experiments that were performed were relevant to Hanford. The interactions ensured that research results were transferred to and used by the Hanford Site projects.

The experiment initiated with the FY 1999 EMSP call has been successful. A new, effective model has been established for DOE Environmental Management to develop targeted, fundamental science that can enhance the credibility of clean-up decisions and, hopefully, expedite site closure while providing full protection to the Columbia River.

REFERENCES

1. U.S. Department of Energy (DOE). 1999. *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*. DOE/RL-98-48, Vol. III, Rev. 0, U.S. Department of Energy, Richland Operations, Richland, Washington.

2. U.S. Department of Energy (DOE). 2000. *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*. DOE/RL-98-48, Vol. III, Rev. 1, U.S. Department of Energy, Richland Operations, Richland, Washington.