Needs and Opportunities for Subsurface Contamination and Vadose Zone Research

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Chester Miller
Office of Basic and Applied Research
Office of Science and Technology

Purpose of the Workshop

- Continue information exchange between PIs and Hanford Site personnel
- Vadose Zone Contamination Issues
- Emphasis of chemical reaction and water migration processes (high/low level waste discharges)
- Assess Research Products
- Identify reporting structure useful to the DOE site personnel and contractors

Long-Term Research Agenda

- NAS/NRC study of Subsurface Contamination and Vadose Zone research needs and opportunities (Final report available)
- NAS/NRC report titled ”Science and Technology for Environmental Cleanup at Hanford” presents the successes and improvement areas of the science and technology program in the Hanford cleanup.
  - EMSP considered a model for research/site integration

NAS/NRC Recommendations for Focus of Subsurface Contamination/Vadose Zone Research

Subsurface Contamination and Vadose Zone Recommendations

- Long-term Research Agenda on Subsurface Contamination (*Research Needs in Subsurface Science*, March 2000)
  - Suggested research emphasis:
    - •Location and characterization of subsurface contaminants and characterization of the subsurface
    - •Conceptual modeling
    - •Containment and stabilization
    - •Monitoring and validation

Site Identified Needs

- In FY-2000 the sites through the Site Technology Coordination Groups identified 255 needs
- Over 50 of these were science needs

A full listing of the subsurface contamination area needs can be found at:
http://www.envnet.org/scfa/NeedsResps/SearchProc.asp

Problems to be Addressed

- Hanford, located in southeastern Washington State
  - encompasses 1450 square kilometers
  - nuclear weapons production from 1940 to 1989
    - several production reactors
    - chemical separations plants
    - solid and liquid storage sites
  - The unsaturated zone, on central plateau is 60-90 meters thick.
  - several trillion liters of contaminated water and supernatant liquid were discharged or gravity-settled via, basins, cribs, trenches, tanks, etc.
  - ground water and soil contamination from radionuclides (primarily, tritium, uranium, cesium-37, strontium-90, technetium-99, and iodine-129), metals (e.g. chromium), and DNAPLs (e.g. carbon tetrachloride)
  - recent conceptual and mathematical models indicate rapid migration potential to the groundwater.
  - Groundwater/Vadose Zone Integration Project, described at http://www.bhi-erc.com/vadose.vadose.htm
  - Subsurface Contaminations Technology Needs list at Http://www.pnl.gov/stcg/fy01needs/ss/index.stm

Problems to be Addressed

- Idaho National Engineering and Environmental Laboratory ,located west of Idaho Falls, Idaho
  - INEEL occupies 2,300 km^2 of semi-arid desert along the northern margin of the Eastern Snake River Plain
  - The site was established as a building, testing, and operating station for various types of nuclear reactors and propulsion systems
    - Spent fuel from the naval reactor program is also managed there
    - Low levels of plutonium have been found in ground water beneath the Radioactive Waste Management Complex (RWMC)–a disposal site that received low-level and transuranic waste beginning in 1952
    - Pit 9, a trench within the RWMC, received an estimated 7,100 m^3 of sludge and solids contaminated with plutonium and americium
  - The thick (60-240 m) unsaturated zone of volcanic strata was thought to impede contaminant migration to the underlying aquifers
    - Estimates today indicate travel times of tens of years, as opposed to thousands of years in the 50s and 60s
  - Interested investigators are referred to the INEEL Science and Technology Needs list at http//www.inel.gov/st-needs

Problems to be Addressed

- Nevada Test Site, became the primary location for atmospheric and underground nuclear testing in1951
  - The Test Site occupies 3,500 km^2 in southern Nevada, about 143 km north of Las Vegas
    - Surface and shallow soil are contaminated with americium, plutonium, depleted uranium, and metals from nuclear detonations, safety test shots, and rocket engine testing
    - Underground nuclear testing resulted in over 300 million curies of subsurface contamination including, tritium, plutonium, uranium, cesium, strontium, and fission products
    - Tritium plumes have been detected from testing locations because this radionuclide is very mobile in the water phase
    - Plutonium, once thought to be relatively immobile in groundwater due to low solubilities and strong sorption on mineral surfaces, was detected 1.3 km downgradient of the Benham test on Pahute Mesa, in a 600-m-deep monitoring well
  - Basic research in the mechanical and geochemical transport of plutonium is warranted
  - Other site-specific technology needs can be found at http://www.nv.doe.gov/programs/envmgmt/blackmtn/TDSTCGTechnologyNeeds.htm

Problems to be Addressed

- Oak Ridge Reservation, located about 10 km west of Knoxville, Tennessee,
  - Originally built to produce and chemically separate plutonium.
  - Later, produced isotopes and conducted isotopic and hazardous constituents research
  - Three main facilities:
    - Oak Ridge National Laboratory supported plutonium production R&D
    - Y-12 and K-25 Plants produced highly enriched uranium via magnetic separation and gaseous diffusion, respectively
  - Wastes were placed in burial grounds, that have subsequently caused soil and water contamination in the Melton Valley Watershed
    - strontium-90, tritium, cesium-137, and cobalt-60
  - Seepage from flooding of waste trenches caused migration of radionuclides
  - The sediments behind White Oak Dam are contaminated with radionuclides
  - White Oak Creek drains Melton Valley and the surface water contains tritium
  - Basic research is needed:
    - to better locate and characterize contamination hot spots in the burial grounds
    - to improve the site conceptual and mathematical models, which include fractured-bedrock flow and karst hydrology
  - Investigators are referred to the Technology Needs Database at http://www.em.doe.gov/techneed

Problems to be Addressed

- Rocky Flats Environmental Technology Site, located on the western side of Denver, Colorado
  - Encompasses 140 hectares
  - Operations ceased in 1989 after years of fabrication and components assembly for nuclear weapons production
  - Materials used in these activities included plutonium and enriched uranium metals and oxides
  - Poor storage and disposal practices resulted in surface and groundwater contamination on and offsite
    - principally, soil contamination with americium, plutonium, and uranium
  - Cleanup and closure actions include removal and stabilization of contaminated media, construction of caps and barriers, and long term monitoring and surveillance
  - Investigators are referred to the Rocky flats website at http://www.aimsi.com/rockyflat/

Problems to be Addressed

- Savannah River Site, established in 1950 near Aiken, South Carolina
  - Produced radioactive isotopes for use in nuclear weapons production
  - Encompasses 800 km^2
  - Site contains production reactors, chemical processing plants, and solid and liquid waste storage facilities
  - The Burial Ground Complex in the central part of SRS received low- and intermediate-level radioactive and mixed waste from 1952-1995
  - Closure of the Complex will include:
    - removal or stabilization of highly contaminated zones
    - an engineered and layered cover, possibly consisting of synthetic material
    - and long term monitoring and surveillance
  - 140 hectare DNAPL plume associated with manufacturing area in the northern portion of the site
    - From the 1950s to the 1980s, wastewater from fuel and target manufacturing seeped into the ground via an overflow basin, releasing solvents and heavy metals to the environment
    - A pump and treat system at the down gradient end of the plume controls spreading
  - Site engineers and scientists continue to look for new technologies and methods to better characterize, describe, and remediate the plume and its source(s)
  - Investigators are referred to the SRS website at http://www.srs.gov/general/srtech/stcg/home.htm

Future Subsurface Contamination-Vadose Zone Solicitations

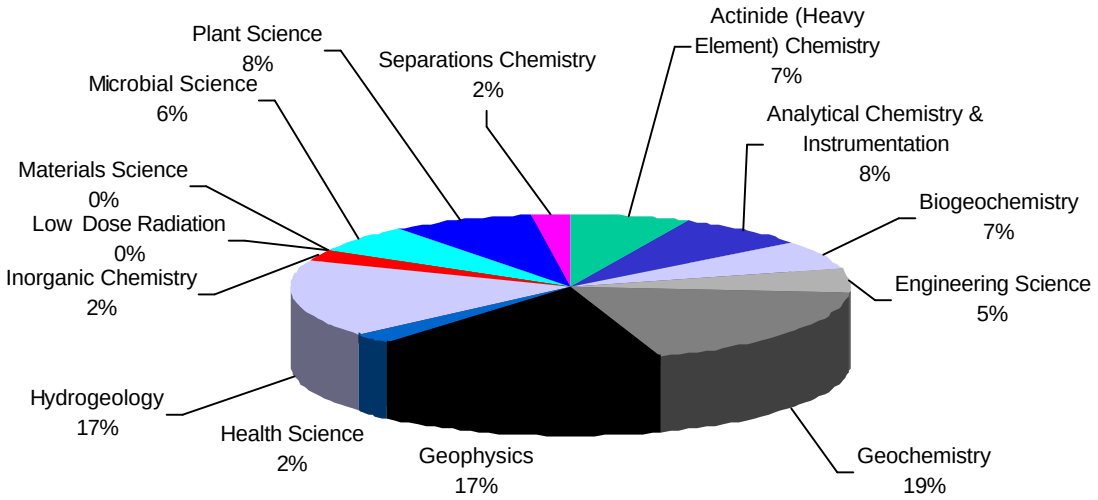
- Office of Basic and Applied Research (EM-52)
  - In the process of preparing a Notice for FY 02 for basic research related to the subsurface contamination and the vadose zone

Subsurface Contamination/Vadose Zone Projects

132 Projects funded to date

1996	1997	1998	1999	2000	2001
72	11	0	31	18*	0

Actinide (Heavy Element) Chemistry	9
Analytical Chemistry & Instrumentation	10
Biogeochemistry	9
Engineering Science	7
Geochemistry	24
Geophysics	22
Health Science	3
Hydrogeology	23
Inorganic Chemistry	3
Low Dose Radiation	0
Materials Science	0
Microbial Science	8
Plant Science	11
Separations Chemistry	3



* Renewal of 1996 or 1997 projects

EMSP Projects

FY 1999 Projects

Project Number: 70010

Project Title: Spectroelectrochemical Sensor for Technetium Applicable to the Vadose Zone

Lead PI: Dr. William R. Heineman, University of Cincinnati

Co-PI(s): Dr. Samuel G. Bryan, Pacific Northwest National Laboratory

Project Number: 70012

Project Title: Complex Electrical Resistivity for Monitoring DNAPL Contamination

Lead PI: Dr. Stephen R. Brown, New England Research, Inc.

Project Number: 70035

Project Title: DNAPL Surface Chemistry: Its Impact on DNAPL Distribution in the Vadose Zone and its Manipulation to Enhance Remediation

Lead PI: Dr. Susan E. Powers, Clarkson University

Co-PI(s): Dr. Miles E. Denham, Westinghouse Savannah River Company

Project Number: 70045

Project Title: Investigation of Pore-Scale Processes which Affect Soil Vapor Extraction

Lead PI: Dr. Albert Valocchi, University of Illinois at Urbana-Champaign

Project Number: 70050

Project Title: Novel Optical Detection Schemes for In-Situ Mapping of Volatile Organochlorides in the Vadose Zone

Lead PI: Dr. S. Michael Angel, University of South Carolina

Co-PI(s): Dr. Bill W. Colston, Jr., Lawrence Livermore National Laboratory

EMSP Projects

Project Number: 70052

Project Title: Material Property Estimation for Direct Detection of DNAPL Using Integrated Ground-Penetrating Radar Velocity, Imaging, and Attribute Analysis

Lead PI: Dr. John Bradford, Boise State University

Project Number: 70054

Project Title: Phytoremediation of Ionic and Methyl Mercury Pollution

Lead PI: Dr. Richard B. Meagher, University of Georgia

Project Number: 70063

Project Title: Biodegradation of Chlorinated Solvents: Reactions Near DNAPL and Enzyme Function

Lead PI: Dr. Perry L. McCarty, Stanford University

Project Number: 70069

Project Title: Fast Flow in Unsaturated Coarse Sediments

Lead PI: Dr. Tetsu K. Tokunaga, Lawrence Berkeley National Laboratory

Project Number: 70070

Project Title: Reactivity of Primary Soil Minerals and Secondary Precipitates Beneath Leaking Hanford Waste Tanks

Lead PI: Dr. Kathryn L. Nagy, University of Colorado

Co-PI(s): Steven B. Yabusaki, Pacific Northwest National Laboratory

EMSP Projects

Project Number: 70081
Project Title: Immobilization of Radionuclides in the Hanford Vadose Zone by Incorporation in Solid Phases
Lead PI: Dr. Samuel J. Traina, Ohio State University
Co-PI(s): Dr. Calvin C. Ainsworth, Pacific Northwest National Laboratory
Dr. Gordon E. Brown, Jr., Stanford University

Project Number: 70088
Project Title: Interfacial Reduction-Oxidation Mechanisms Governing Fate and Transport of Contaminants in the Vadose Zone
Lead PI: Dr. Baolin Deng, University of Missouri at Columbia
Co-PI(s): Dr. Edward C. Thornton, Pacific Northwest National Laboratory

Project Number: 70108
Project Title: Effects of Fluid Distribution on Measured Geophysical Properties for Partially Saturated, Shallow Subsurface Conditions
Lead PI: Dr. Patricia A. Berge, Lawrence Livermore National Laboratory

Project Number: 70115
Project Title: The Use of Radar Methods to Determine Moisture Content in the Vadose Zone
Lead PI: Dr. Rosemary J. Knight, Stanford University
Co-PI(s): Dr. Paul Smith , University of British Columbia

Project Number: 70121
Project Title: The Influence of Calcium Carbonate Grain Coatings on Contaminant Reactivity in Vadose Zone Sediments
Lead PI: Dr. John M. Zachara, Pacific Northwest National Laboratory
Co-PI(s): Dr. Gordon E. Brown, Jr., Stanford University
Dr. Carrick M. Eggleston, University of Wyoming

EMSP Projects

Project Number: 70126

Project Title: Collaboration: Interfacial Soil Chemistry of Radionuclides in the Unsaturated Zone

Lead PI: Dr. Jonathan Chorover, Pennsylvania State University

Co-PI(s): Dr. R. Jeffrey Serne, Pacific Northwest National Laboratory

Dr. Appathurai Vairavamurthy, Brookhaven National Laboratory

Project Number: 70132

Project Title: Speciation, Mobility and Fate of Actinides in the Groundwater at the Hanford Site

Lead PI: Dr. Ken O. Buesseler, Woods Hole Oceanographic Institute

Co-PI(s): Dr. John F. Wacker, Pacific Northwest National Laboratory

Project Number: 70135

Project Title: Colloid-Facilitated Transport of Radionuclides Through the Vadose Zone

Lead PI: Dr. Markus Flury, Washington State University

Project Number: 70146

Project Title: Spectroscopic and Microscopic Characterization of Contaminant Uptake and Retention by Carbonates in Soils and Vadose Zone Sediments

Lead PI: Dr. Richard J. Reeder, State University of New York at Stony Brook

Co-PI(s): Dr. Wayne P. Hess, Pacific Northwest National Laboratory

Project Number: 70149

Project Title: The Dynamics of Vadose Zone Transport: A Field and Modeling Study Using the Vadose Zone Observatory

Lead PI: Dr. Charles R. Carrigan, Lawrence Livermore National Laboratory

EMSP Projects

Project Number: 70163

Project Title: The Aqueous Thermodynamics and Complexation Reactions of Anionic Silica Species to High Concentration: Effects on Neutralization of Leaked Tank Wastes and Migration of Radionuclides in the Subsurface

Lead PI: Dr. Andrew R. Felmy, Pacific Northwest National Laboratory

Co-PI(s): Dr. Gregory Choppin, Florida State University

Project Number: 70165

Project Title: Integrated Field, Laboratory, and Modeling Studies to Determine the Effects of Linked Microbial and Physical Spatial Heterogeneity on Engineered Vadose Zone Bioremediation

Lead PI: Dr. Fred J. Brockman, Pacific Northwest National Laboratory

Co-PI(s): Dr. John S. Selker, Oregon State University

Project Number: 70176

Project Title: Transuranic Interfacial Reaction Studies on Manganese Oxide Hydroxide Mineral Surfaces

Lead PI: Dr. Heino Nitsche, Lawrence Berkeley National Laboratory

Co-PI(s): Dr. R. Jeffrey Serne, Pacific Northwest National Laboratory

Project Number: 70177

Project Title: Technetium Attenuation in the Vadose Zone: Role of Mineral Interactions

Lead PI: Dr. Nancy J. Hess, Pacific Northwest National Laboratory

Co-PI(s): Dr. Steven D. Conradson, Los Alamos National Laboratory

Project Number: 70179

Project Title: Radionuclide Sensors for Water Monitoring

Lead PI: Dr. Jay W. Grate, Pacific Northwest National Laboratory

Co-PI(s): Dr. Timothy A. DeVol, Clemson University

EMSP Projects

Project Number: 70187

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

Lead PI: Dr. Philip D. Meyer, Pacific Northwest National Laboratory

Project Number: 70193

Project Title: Influence of Clastic Dikes on Vertical Migration of Contaminants in the Vadose Zone at Hanford

Lead PI: Dr. Christopher J. Murray, Pacific Northwest National Laboratory

Co-PI(s): Dr. John L. Wilson, New Mexico Institute of Mining & Technology

Project Number: 70206

Project Title: Calcite Precipitation and Trace Metal Partitioning in Groundwater and the Vadose Zone: Remediation of Strontium-90 and Other Divalent Metals and Radionuclides in Arid Western Environments

Lead PI: Dr. Robert W. Smith, Idaho National Engineering and Environmental Laboratory

Co-PI(s): Dr. F. Grant Ferris, University of Toronto

Dr. Anna-Louise Reysenbach, Portland State University

Project Number: 70219

Project Title: Fate and Transport of Radionuclides Beneath the Hanford Tank-Farms: Unraveling Coupled Geochemical and Hydrological Processes in the Vadose Zone

Lead PI: Dr. Philip M. Jardine, Oak Ridge National Laboratory

Co-PI(s): Dr. Calvin C. Ainsworth, Pacific Northwest National Laboratory

Dr. Scott Fendorf, Stanford University

Project Number: 70220

Project Title: High Frequency Electromagnetic Impedance Imaging for Vadose Zone and Groundwater Characterization

Lead PI: Dr. Gregory A. Newman, Sandia National Laboratories - Albuquerque

Co-PI(s): Edward Nichols, ElectroMagnetic Instruments, Inc.

EMSP Projects

Project Number: 70267

Project Title: A Hydrologic-Geophysical Method for Characterizing Flow and Transport Processes within the Vadose Zone

Lead PI: Dr. David L. Alumbaugh, University of Wisconsin at Madison

Co-PI(s): James R. Brainard, Sandia National Laboratories - Albuquerque

FY 2000 Projects

Project Number: 73731

Project Title: Automating Shallow Seismic Imaging

Lead PI: Dr. Don W. Steeples, University of Kansas

Project Number: 73732

Project Title: Migration and Entrapment of DNAPLs in Heterogeneous Systems: Impact of Waste and Porous Medium Composition

Lead PI: Dr. Linda M. Abriola, University of Michigan

Project Number: 73745

Project Title: Permanganate Treatment of DNAPLs in Reactive Barriers and Source Zone Flooding Schemes

Lead PI: Dr. Frank W. Schwartz, Ohio State University

Project Number: 73758

Project Title: Fixations Mechanisms and Desorption Rates of Sorbed Cs in High Level Waste Contaminated Subsurface Sediments: Implications to Future Behavior and In-Ground Stability

Lead PI: Dr. John M. Zachara, Pacific Northwest National Laboratory

EMSP Projects

Project Number: 73773

Project Title: Isotopic Tracers for Waste Fluid Tracking and Fluid-Soil Interactions: Hanford, Washington

Lead PI: Dr. Donald J. DePaolo, Lawrence Berkeley National Laboratory

Project Number: 73775

Project Title: Colloid Genesis/Transport and Flow Pathway Alterations Resulting From Interactions of Highly Reactive Waste Solutions and Sediments in the Vadose Zone

Lead PI: Dr. Jiamin Wan, Lawrence Berkeley National Laboratory

Project Number: 73776

Project Title: High Frequency Electromagnetic Impedance Measurements for Characterization, Monitoring and Verification Efforts

Lead PI: Dr. Ki-Ha Lee, Lawrence Berkeley National Laboratory

Project Number: 73784

Project Title: Microbially Mediated Immobilization of Contaminants Through In Situ Biostimulation: Scale up of EMSP project 55267

Lead PI: Dr. Philip M. Jardine, Oak Ridge National Laboratory

Co-PI(s): Dr. Scott Fendorf , Stanford University

Project Number: 73793

Project Title: Biofiltration of Volatile Pollutants: Solubility Effects

Lead PI: Dr. Brian H. Davison, Oak Ridge National Laboratory

Co-PI(s): none found

EMSP Projects

Project Number: 73808

Project Title: Microsensors for In-Situ Chemical, Physical, & Radiological Characterization Mixed Waste

Lead PI: Dr. Thomas G. Thundat, Oak Ridge National Laboratory

Project Number: 73812

Project Title: Physics of DNAPL Migrations and Remediation in the Presence of Heterogeneities

Lead PI: Dr. Stephen H. Conrad, Sandia National Laboratories - Albuquerque

Project Number: 73819

Project Title: Plutonium Speciation, Solubilization, and Migration in Soils

Lead PI: Dr. Mary P. Neu, Los Alamos National Laboratory

Co-PI(s): Dr. Richard G. Haire, Oak Ridge National Laboratory

Project Number: 73830

Project Title: Seismic Surface-Wave Tomography of Waste Sites

Lead PI: Dr. Timothy L. Long, Georgia Institute of Technology

Project Number: 73836

Project Title: Induced Polarization with Electromagnetic Coupling: 3D Spectral Imaging Theory and Field Tests

Lead PI: Dr. F. Dale Morgan, Massachusetts Institute of Technology

EMSP Projects

Project Number: 73843

Project Title: Mechanisms of Heavy Metal Sequestration in Soils: Plant-Microbe Interactions and Organic Matter Aging

Lead PI: Dr. Teresa W. M. Fan, University of California at Davis

Project Number: 73858

Project Title: Chlorinated Hydrocarbon Degradation in Plants: Mechanisms and Enhancement of Phytoremediation of Groundwater Contamination

Lead PI: Dr. Stuart E. Strand, University of Washington

Project Number: 73914

Project Title: Reductive Immobilization of U(VI) in Fe(III) Oxide- Reducing Subsurface Sediments: Analysis of Coupled Microbial-Geochemical Processes in Experimental Reactive Transport Systems

Lead PI: Dr. Eric E. Roden, University of Alabama

Project Number: 73962

Project Title: Advanced High Resolution Seismic Imaging, Material Properties Estimation and Full Wavefield Inversion for the Shallow Subsurface

Lead PI: Dr. Alan R. Levander, Rice University

Points of Contact for EMSP

Mark Gilbertson
Phone: (202) 586-7150
Email: MARK.GILBERTSON@em.doe.gov

Roland Hirsch
Phone: (301) 903-9009
Email: ROLAND.HIRSCH@science.doe.gov

Yevgeny Macheret
Phone: (208) 526-2708
Email: MACHERY@id.doe.gov

Chester Miller
Phone: (202) 586-3952
Chester.Miller@em.doe.gov

OST Homepage
ost.em.doe.gov

EMSP Homepage
emsp.em.doe.gov