WHITE PAPER

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Geoenvironmental Research Experience:

My research interests focus primarily on the experimental and numerical modeling of flow and contaminant transport processes in geologic systems. Currently, my activities center around understanding the transport behavior of contaminants in soil and fractured rock, and determining the effectiveness of *insitu* remediation strategies for the clean-up of hazardous waste sites. For much of my work, I combine numerical and physical modeling using a geotechnical centrifuge to provide guidelines for use in this field. In addition, I have interest and experience in the design of disposal sites for the storage of waste materials.

Within the past 5 years, I have supervised or co-supervised 5 undergraduate theses, 17 master's theses and 5 PhD theses, with 2 still in progress, in the geoenvironmental area. The research projects covered include investigations of:

- Mechanisms for subsurface NAPL entrapment.
- Unstable flow and fluid transport in the vadoze zone.
- The insitu remediation technology of air sparging.
- DNAPL transport in fractures.
- Alternative technologies for landfill design and operation.
- The effects of groundwater levels on wooden pile stability.
- Contaminant transport in wetland soils.
- Subsurface colloid transport.
- Factors limiting aerobic microbial activity in saturated media.
- Use of information technology in preliminary site assessment.

Geoenvironmental Teaching Experience:

During the past 5 years, I have taught or co-taught the following courses:

- Waste Containment and Site Remediation Technology (Graduate Course).
- Environmental Geotechnics: Sub-module on Contaminant Transport and Remediation (Graduate Course).
- A Web-Based System for Preliminary Investigation at Hazardous Waste Sites (M.Eng. Project).
- Groundwater Impacts from the Plainville Landfill (M.Eng. Project).
- Boston Groundwater Depletion and Foundation Problems (Senior Design Project).

- Human Health, Pollution and the Environment (Freshman Seminar).
- Pollutant Transport in Natural Water Systems (Short-Course for K-12 Teachers).
- Grungy Groundwater (Hands-on Laboratory Activity for Grade 5 Students).
- Groundwater Pollution Curriculum Guide (Curriculum Material Developed for 5-12 Students and Teachers).

Geoenvironmental Consulting Experience:

My geoenvironmental consulting experience during the past five years has included:

- Technical assistance for Plainville Citizen's Group. Provided advice on the design of remediation activities for the Plainville Landfill Plume.
- Technical Advisor for EPA Regions 1&2 TOSC program. Provided advice on contaminant plume detection and remediation at the Army National Guard's Massachusetts Military Reservation.

Appraisal of Geoenvironmental Research, Education and Practice:

Geoenvironmental engineering has developed over the past 20 years into a recognized field of research, practice and education. Research in geoenvironmental engineering has contributed to the development of new landfill technologies, as well as new hazardous waste site investigation and remediation technologies. Geoenvironmental engineering education is now a part of the civil engineering curriculum at many universities, while geoenvironmental engineering practice is routinely carried out by a large number of civil engineering firms. These achievements are significant for the time in which they have come about, and should be valued by the geoenvironmental community.

Several challenges now lay ahead for the community. Some of these include:

- *Develop a better understanding of the risks that wastes actually pose to human health and the environment*. At present, the field is very much driven by regulations that have evolved without this understanding. The community needs to examine whether the goal of protecting society from its waste is being met, and at a reasonable cost.

- *Change the focus of remediation from clean-up to remediation and stewardship*. It is technically not feasible to clean-up many of the hazardous waste sites that threaten public and environmental health. Strategies for dealing with such sites, possibly over multiple generations, need to be considered in tandem with remediation decisions. Means of communicating risks, monitoring wastes and containment facilities, and revisiting decisions over long time periods need to be developed.

- *Better integrate research and practice*. There is a larger disconnect between geoenvironmental research and practice than is good for the field. This is especially true for geoenvironmental problems that involve subsurface flow. Models developed to describe contaminant transport and remediation in research often require parameters that are not typically measured in practice. Furthermore, they frequently assume that the

properties of the subsurface are known in a detail not known in practice. For this reason, tools for predicting contaminant transport and remediation generated through research often remain "research tools", while practice too frequently relies on out-dated models and the extrapolation of measurements from pilot test cells.

- *Examine alternatives to landfill design and operation*. The dry-tomb approach to landfilling MSW needs to be reconsidered. Aerobic and anaerobic bioreactor landfills should be more widely investigated as alternatives. Consideration should also be given to the productive end use of land when landfill design is approached, perhaps leading to alternative cover designs.

- *Increase involvement in areas traditionally viewed as "hydrology"*. Water management, including groundwater management, has traditionally been viewed as the territory of hydrologists. The geoenvironmental community needs to increase its decision making role in this area. For example, plans to extract groundwater for drinking from confined aquifers are often feasible from a hydrological standpoint, but neglect the impact of pumping on the mechanical behavior of soils. Geoenvironmental expertise can improve many water management decisions.

- *Expand the education of geoenvironmental engineers*. The problems tackled in this area are multidisciplinary. Courses developed by instructors with a traditional engineering background may need to be expanded to reflect this fact. The development of integrated courses with instructors having backgrounds in, for example, biological, chemical and social sciences, should be considered.

- *Develop means of dealing with low level, wide spread contamination*. Contaminated river and harbor sediments and lead contaminated roadside soils are two examples of wide-spread contamination that require alternative approaches to remediation that are easily applicable over large areas, and are also cost effective.

- *Maintain the viability of practice.* As CERCLA funding vanishes and contaminated land issues receive less and less public attention, geoenvironmental engineering practice, especially in the area of remediation, could shrink. Alternative expertise, such as stewardship services at sites that pose an on-going hazards, should be invested in.

- *Maintain the viability of research*. The funding base for geoenvironmental engineering research needs to be expanded beyond traditional sources such as the NSF, EPA and State Governments. A broad vision, and "strategic plan", for the field might provide a basis for opening alternative avenues of funding.

Perspective on Emerging Geoenvironmental Issues and Technologies:

Some perspective on emerging geoenvironmental issues is provided above. Emerging technologies that merit further development and/or implementation in practice include:

- Bioreactor landfills.

- Alternative landfill cover designs, e.g., capillary barriers.
- Permeable treatment walls.
- Optimization models for “pump-and-treat” remediation.

Challenges that require further knowledge/ research include:

- Remediation of fractured bedrock.
- Long-term (inter-generational) performance of containment systems.
- Integration of long-term processes (e.g., climate change) in predictive models.
- Better and cheaper sensors.
- Containment schemes for radioactive wastes.
- Subsurface disposal of non-traditional wastes, such as CO_2.