Progress Report: Grant No. NRC-27-10-1119

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Integrated Assessment of Uranium Mining Environmental Impacts

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Overview. This report summarizes progress made for Grant NRC-27-10-1119 over the second six-month period ending September 30, 2011. The total performance period for this grant is September 30, 2010 through September 30, 2013. As described in the scope of work, this research project comprises three main tasks: (1) Groundwater quality monitoring near future and closed in-situ recovery (ISR) uranium mining sites, (2) Development of a reactive transport model and radioisotope forensic methods, and (3) Recruitment of minority engineers interested in nuclear-related employment from the Kingsville, Texas vicinity. Progress towards completing these three tasks is summarized below.

## Task 1 – Groundwater quality monitoring near future and closed ISR mining sites

Analytical and field sampling methods development. Two graduate students have been trained for numerous laboratory analytical methods, including inductively coupled plasma mass spectrometry (ICP-MS) for analyses of U, Mo, Fe, Mn, Ca, Mg, Na, K, and Br, ion chromatography (IC) analyses for Br^-, F^-, Cl^-, NO_3^-, NO_2^-, SO_4^{2-}, and PO_4^{3-}, titrimetric analysis for alkalinity, colorimetric analyses for iron and sulfide, as well as field analytical methods including pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, groundwater level, GPS, and groundwater radon/thoron using a RAD7 electronic radon detector (Durridge Inc., Billerica, MA). The students have also been trained in groundwater sampling procedures following protocols in the USGS report *National Field Manual for the Collection of Water-Quality Data*. Standard methods are being followed for QA/QC.

Groundwater quality monitoring. To date, the graduate students have collected samples from 24 private groundwater wells (14 during the second six-month period) in the vicinity of active uranium exploration activity in Kenedy County, Texas, and performed the water quality analyses above. The students and PI attended a meeting with the Kenedy County Groundwater Conservation District (KCGCD) Board of Directors on May 18, 2011 and are now working in direct coordination with the KCGCD General Manager.[1] The students and PI also travelled to Austin, Texas, on May 24, 2011 to attend a meeting with a representative from Daniel B. Stephens & Associates (DBSA) to discuss coordination of this NRC-funded groundwater sampling program with an ongoing background groundwater quality assessment being performed

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[1] Kenedy County Groundwater Conservation District, http://www.kenedygcd.com/default.aspx.

by the KCGWCD at an active uranium exploration site.   The PI will also contact USGS to discuss the possible inclusion of the collected data into the *National Uranium Resource Evaluation* (NURE) database.[2] As Figures 1a and 1b illustrate, the KCGCD represents a significant data gap in the existing NURE database.
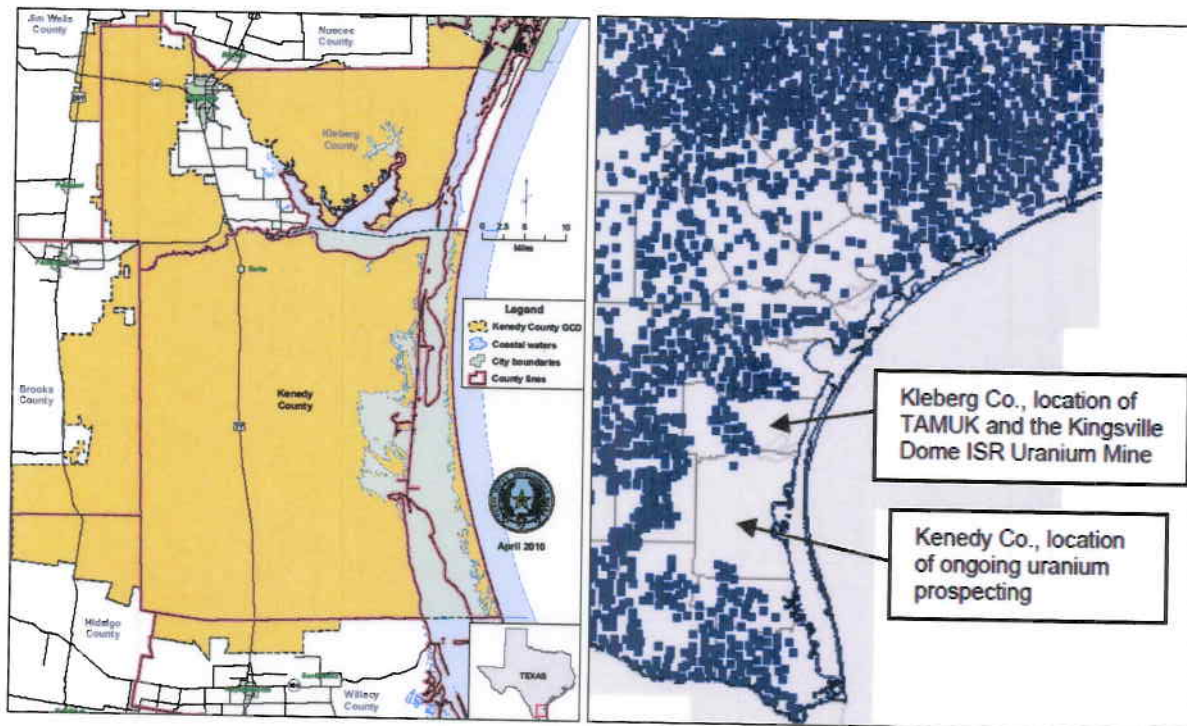
Figure 1: (a) Boundaries of the Kenedy County Groundwater Conservations District, and (b) location of wells with groundwater data currently in the USGS National Uranium Resource Evaluation (NURE) database.

Task 2 – Development of reactive transport model and radioisotope forensic methods

Coupled reactive transport modeling. The two graduate students have been trained to use the PHREEQC geochemical software package to simulate one-dimensional groundwater contaminant transport.[3] The students will be using PHREEQC to model uranium , molybdenum and radon migration from uranium ISR mining sites. The students have recently applied PHREEQC to simulate the experimental results obtained from a previous aquifer sediment column study that involved supplying hydrogen and ethanol as electron donor substrates to stimulate microbial reduction and immobilization of uranium and molybdenum (Figure 2). The PI is currently learning the PHT3D reactive multicomponent transport model that links the

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[2] USGS National Geochemicial Database, http://pubs.usgs.gov/of/1997/ofr-97-0492/.

[3] USGS, *PHREEQC – A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations,* http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/.

PHREEQC geochemical modeling software with the three-dimensional groundwater flow and transport simulators MODFLOW and MT3DMS (using the *Processing Modflow 8* graphical user's interface).[4] The PI and one graduate student attended a four-day "Reactive Transport Modeling with PHT3D" short course this summer.
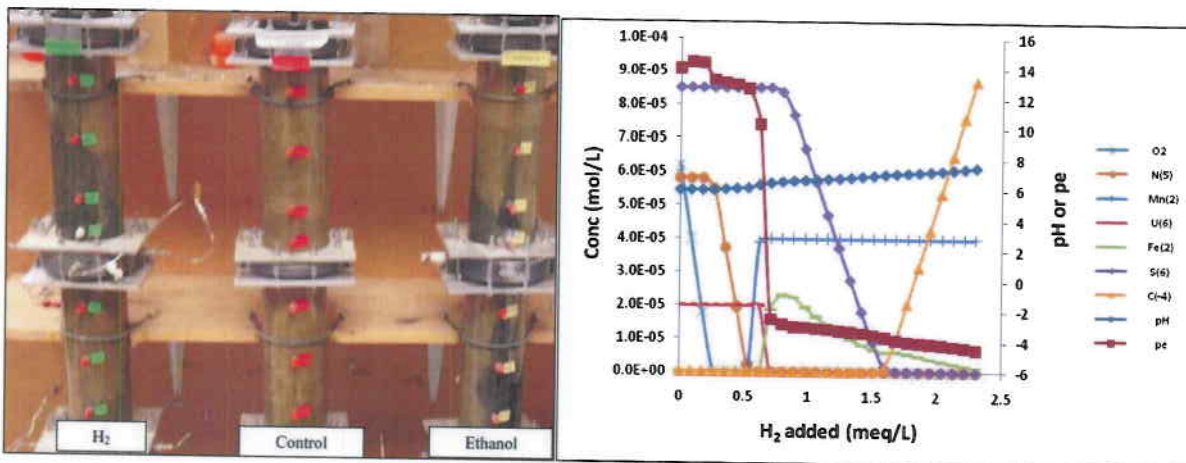

Figure 2. (a) Lab-scale sediment columns packed with contaminated sediments and supplied with hydrogen (left) or ethanol (right) as electron donors for stimulating microbial reduction and immobilization of uranium and molybdenum (from a completed previous study), and **(b)** example of PHREEQC model simulation (from this research project).

Radiogenic isotope forensic modeling. The objective of this task is to develop a geochemical forensic modeling approach to use short-lived radiogenic isotopes (particularly radon) as reactive tracers for distinguishing between naturally elevated concentrations of uranium and its progeny in groundwater from anthropogenic contamination. The graduate students are making progress incorporating simultaneous radon transport and decay into a one-dimensional PHREEQC model.

Task 3 – Recruitment of minority engineers interested in nuclear-related employment

Two enthusiastic graduate students (both U.S. citizens) were hired as research assistants to perform the research tasks described above. Because the funding was not available until six weeks after the start of the fall semester (2010), both students were hired at the start of the spring semester in 2011. An African-American Ph.D. student (Muhammad Ibrahim) will take the doctoral qualifying exam in May 2012. A Caucasian domestic student (Daniel Heuston) is on target to graduate by August 2012. The PI will contact the NRC's MSIP program for clarification on the six-month nuclear-related employment agreement. The PI is currently working on recruiting another M.S. research assistant to replace Daniel in the summer of 2012. All these students will be from the South Texas region and will reflect local demographics.

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[4] Simcore Software, *Processing Modflow 8*, http://www.simcore.com/pm8.