LMS/RVT/S08542

Work Plan for the Enhanced Characterization of the Surficial Aquifer Riverton, Wyoming, Processing Site

June 2012

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Figure 1. Proposed Borehole Locations, Riverton, Wyoming, Processing Site 3

Appendix

Appendix A Laboratory Plan for 2012 Geoprobe Study, Riverton Site, June 5, 2012

Abbreviations

bgs	below ground surface
COC	constituent of concern
DOE	U.S. Department of Energy
ESL	Environmental Sciences Laboratory
ft	feet
g	grams
IDW	investigation-derived waste
JSA	Job Safety Analysis
K_d	distribution coefficient
µm	micrometers
mg/kg	milligrams per kilogram
mL	milliliters
mm	millimeters
NRC	U.S. Nuclear Regulatory Commission
PV	pore volume
SAP	Sampling and Analysis Plan
UMTRCA	Uranium Mill Tailings Radiation Control Act

1.0 Introduction

This plan describes the objectives, rationale, sampling and analysis activities, and specific quality assurance and quality control measures associated with the enhanced characterization of the surficial aquifer at the Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Riverton, Wyoming, Processing Site (Riverton site).

Initial groundwater characterization of the Riverton site was conducted in the 1990s, culminating with a Site Observational Work Plan in 1998 in which a natural flushing compliance strategy was recommended (DOE 1998a). The U.S. Nuclear Regulatory Commission (NRC) approved the natural flushing compliance strategy in the Ground Water Compliance Action Plan (DOE 1998b). Since 1998, verification monitoring has been conducted by the U. S. Department of Energy (DOE) to document site conditions and assess the progress of natural flushing; data collected during verification monitoring are reported annually in Verification Monitoring Reports. In addition, the Wind River Environmental Quality Commission has conducted studies and provided verification monitoring support during the verification monitoring period.

Results of the verification monitoring indicated that natural flushing was generally progressing as expected until June 2010, when significant increases in contaminant concentrations were measured in several wells. The June 2010 sampling event was conducted immediately after record flooding of the Little Wind River. During the flood, overbank flow was observed within a large area downgradient of the former mill site. The significant increases in contaminant concentrations occurred in monitoring wells where the flooding occurred. The spikes in contaminant concentrations are attributed to flood water mobilizing residual contamination in the unsaturated zone (DOE 2011) and potentially accelerating natural flushing.

The observations made in 2010 revealed that the existing site conceptual model and numerical groundwater computer modeling could not account for the spikes in contaminant concentrations observed in the surficial aquifer groundwater. Consequently, the site conceptual model needs to be updated and a revised groundwater flow and transport model must be developed to properly simulate natural flushing processes. This plan specifies the additional characterization work necessary to accomplish these goals.

1.1 Objectives

The purpose of this investigation is to obtain additional data to further characterize the surficial aquifer. Specific objectives of the investigation are to:

- Provide enhanced definition of contaminant plumes including the location of the centroid of each plume and the extent of groundwater contamination for each constituent of concern (COC).
- Provide a detailed distribution of contaminants for input into the updated groundwater computer model.
- Provide data that will guide placement of new monitoring wells outside of the contaminant plumes to monitor lateral plume behavior.
- Provide a detailed and updated baseline of groundwater contamination for tracking plume configuration, movement, and size over time. This will be used to assess the progress of natural flushing if this study is repeated in the future.

- Provide information on soil characteristics including leachability of uranium.
- Estimate the masses of uranium remaining in the unsaturated zone of the surficial aquifer, to gather data that can be used to develop appropriate contaminant source terms in the transport modeling. The resulting computer model will be capable of simulating the effects of periodic flooding of the Little Wind River.

2.0 Technical Approach

A Geoprobe Systems direct-push machine (Geoprobe Model 7720DT) will be used to install 120 boreholes along nine transects as shown in Figure 1. To optimize the mapping of contaminant plumes (which may be slightly different for each COC), these transects are oriented northeast approximately perpendicular to the known southeast direction of groundwater flow and to the axis of the currently known contaminant plume. Distance between transects is reduced and sampling density increased in the portion of the aquifer near the expected centriod of the contaminant plumes downgradient of the former mill site. This increase in sample density is designed to enhance definition of the centriod of the contaminant plumes and to provide for a higher density of soil data in the unsaturated zone in areas above the contaminant plumes where the Little Wind River has flooded in the past. Additional soil samples will be collected in the center of transects 1, 2, and 3 to compare non-flooded areas to flooded areas in order to examine the influence of surface infiltration.

To obtain the sampling array displayed in Figure 1 in the field, coordinates based on the figure will be loaded into a portable GPS unit. Field crews will use the GPS unit to navigate to each location where a pin flag will be placed with the sample location number written on the flag. If a sample location is designated in an area where it will be difficult to install a borehole with the Geoprobe (e.g., roadway, dense vegetation, property issues, or underground utilities), or is within an environmentally sensitive area as discussed in Section 6.0, a sample location may be moved as much as 50 feet from the initial location.

2.1 Groundwater Sampling

To accomplish the objectives of this investigation, groundwater sampling will be conducted by driving steel rods with the Geoprobe to create a borehole for access to groundwater. Samples will be collected through the Geoprobe rods and holes will be abandoned after samples have been collected. A planned 120 locations will be sampled (Figure 1) and will be analyzed for the NRC-approved COCs (manganese, molybdenum, sulfate, and uranium), major cations (calcium, magnesium, potassium, and sodium), and additional major anions (chloride). In addition, field measurements of pH, specific conductance, temperature, oxidation-reduction potential, total alkalinity, turbidity, and dissolved oxygen will be obtained at each location.

Groundwater samples will be collected from the same depth at each location to facilitate a consistent and reproducible approach. The depth to groundwater typically ranges from 3 to 6 feet below ground surface (bgs). Geoprobe rods will be driven down to 12 feet bgs with a 3-foot slotted rod installed at the lower end. Poly tubing and a peristaltic pump will be used to collect samples through the rods, and tubing will be placed with the intake at the top of the water

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Figure 1. Proposed Borehole Locations, Riverton, Wyoming, Processing Site

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column. The midpoint of the slotted rod approximates the average midpoint of the screened intervals of wells in the current groundwater monitoring network. Procedures for operation, maintenance, and safe use of the Geoprobe are specified in *Procedure for Operation of the Geoprobe Model 7720DT* (LMS/PRO/S08578).

Groundwater sampling will be conducted according to the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (SAP) (LMS/PLN/S04351), with the following exceptions. Purging will be accomplished by pumping 8 liters of water from each rod prior to sample collection. Tubing intake will be placed at the top of the water column during purging. This represents approximately 3 casing (steel rod) volumes (1.5-inch i.d. rods with 8 feet of water in the rod). No parameter stability is required prior to sampling, and there is no maximum flow-rate requirement during the purging process. Geoprobe rods will be decontaminated by physically removing all visible soils from the exterior of the rods and rinsing the interior and exterior of the rods with tap water from a known source before moving to the next location. If sample tubing is re-used, decontamination will be accomplished as specified in the SAP, which is a detergent/deionized water rinse followed by a deionized water rinse.

After completion of sampling, steel rods will be pulled, the depth to the top of the collapsed material in the hole will be measured, and the borehole will be abandoned by slowly filling the hole with bentonite pellets or chips to ground surface. If it appears that bridging of the bentonite is occurring during filling of the hole, the bentonite will be slowly poured into the hole in 2-foot lifts. After completion of each lift, the bentonite will be tamped to help eliminate any potential bridging and to ensure that a good seal is obtained. The total volume of bentonite used at each hole will be recorded. All boreholes will be abandoned as soon as possible after removing the steel rods, and in all cases within 2 hours of removing the rods from the hole. GPS data will be collected to document the actual sample location.

2.2 Soil Sampling

Soil sampling will be conducted at 30 locations in the area of the contaminant plume on and southeast of the former mill site and 3 locations upgradient of the former tailings pile, as shown in Figure 1. Two samples will be collected at each location using the Geoprobe with a 5-foot rod with a disposable plastic liner. Each 5-foot section of soil will be split into two samples—one from 0 to 2.5 feet and one from 2.5 to 5 feet bgs. Samples will be labeled with a depth-specific suffix to indicate the depth interval. For example, soil samples collected from location T05-02 will be labeled as T05-02-0-2.5 and T05-02-2.5-5.

3.0 Analytical Program

3.1 Field Measurements

Field measurements made on all groundwater samples will include temperature, oxidation-reduction potential, dissolved oxygen, specific conductance, pH, turbidity, and total alkalinity. Procedures for conducting field measurements and calibration/operational checks of field instrumentation are found in the SAP.

3.2 Laboratory Analysis

Groundwater samples will be analyzed for manganese, molybdenum, sulfate, uranium, calcium, magnesium, potassium, sodium, and chloride by an approved subcontracted laboratory using analytical methods and associated detection limits specified in the SAP.

Soil samples will be analyzed at the Environmental Sciences Laboratory (ESL). Samples will be sieved and only the fraction less than 2 millimeters will be analyzed. This finer fraction of material typically contains most of the leachable constituents because of the large surface area compared to the larger fractions. Sieve analysis will be conducted in the field at a representative outcrop along the Little Wind River to estimate particle size distribution in the unsaturated zone, which will be used to normalize results to represent the entire unsaturated zone. An extraction process using water with a chemistry similar to the Little Wind River will be used on soil samples collected from all 33 locations (66 samples) to simulate leaching in the unsaturated zone during flood events. The Batch Test Procedure specified in Appendix A, which incorporates a high water-to-rock ratio, will be used to simulate the flood events that would remove uranium. The leachate will be analyzed for uranium by the ESL using analytical method AP(U-2), *Uranium Determination by Chemchek.*

A fraction of the 16 soil samples collected from 8 locations (T01-05, T02-07, T03-10, T04-10, T05-02, T06-10, T07-04, and T-08-03) will be used for column tests designed to estimate the total uranium source materials remaining in the unsaturated zone. A relatively simple mode of one-dimensional flow and transport will be used to match data collected during the column testing, which will in turn produce an estimate of the uranium distribution coefficient (K_d). The column tests will be conducted using the Column Test Procedure specified in Appendix A. These soil sampling locations were selected because they are along a flow path that will include locations upgradient of the former tailings pile, locations on the former mill site, and locations downgradient where groundwater contaminant concentrations spiked after the Little Wind River flooded in June 2010.

In addition to batch leaching and column tests, kinetic experiments will be conducted to examine the rate of uranium partitioning between the liquid-solid interface. Kinetic tests will be conducted on samples collected from 4 locations (8 samples) and will be conducted according the Kinetic Test Procedure specified in Appendix A. Kinetic tests will be conducted on samples collected from locations T01-05, T03-10, T05-02, and T-08-03 unless other locations are selected based on field observation of the soils.

4.0 Quality Assurance

Quality assurance and quality control requirements, which are specified in the SAP, apply to this plan. These include procedures for sample collection, calibration and operational checks of field instrumentation, collection of quality control samples, documentation of sampling activities, decontamination of sampling equipment, training, use of approved laboratories and analytical methods, and data validation and qualification.

5.0 Health and Safety

Field activities will be conducted in compliance with the health and safety requirements specified in the *Health and Safety Manual* (LMS/POL/S04321). Task-specific health and safety requirements for the sampling activities are specified in the Job Safety Analysis (JSA) for *Water Sampling and Minor Well Maintenance at LM Sites*. Safety requirements for operation of the Geoprobe are specified in *Procedure for Operation of the Geoprobe Model 7720DT*. The Plan of the Day will be discussed at daily tailgate safety meetings to highlight safety hazards that may be encountered during each day's work and to highlight the associated precautions that will be taken to mitigate the potential hazards.

6.0 Environmental Compliance

Environmental compliance considerations include the ones described below.

6.1 Waste Management

Investigation-derived waste (IDW) will include purge water, equipment calibration waste, excess sample material (both water and soil), decontamination rinsate, and solid waste (tubing, soil sampling liners, disposable gloves, disposable pipettes, paper towels, visqueen, etc.). The Geoprobe push-rod method obviates the generation of drill cuttings, so excess soil IDW will be limited to very small quantities; these will be collected to the extent practicable, and placed back in the borehole prior to abandoning the hole. All excess liquid IDW will be dispersed broadly to the ground surface in the vicinity of the borehole. IDW may not be discharged to the ground surface in suspected wetland areas nor may it be discharged to places where it could be washed away such as in dry washes (see discussion below). Solid waste will be collected and disposed of at a municipal landfill. Waste samples generated by the ESL may be sent to the Grand Junction, Colorado, Disposal Site for disposal provided that it meets the site's waste acceptance criteria.

6.2 Land Disturbance

Efforts must be taken by all members of the field crew to minimize impacts and disturbances to the land surface caused by project-related activities. Specifically:

- Unnecessary use of vehicles in the field will be avoided.
- Vehicle travel, including that of the Geoprobe and support vehicles, will occur on paved or established roadways to the maximum extent possible. This will require preplanning of travel routes and may entail traveling extra distances to avoid crossing undisturbed land areas along the transects. When off-road travel is necessary, all vehicles will travel along the same path to minimize the total area of land impacted. Vehicles will park along the transect path when working at a sample location to minimize impacts to the land surface.
- Storage and equipment lay-down areas will be minimized to the extent practicable.
- Work on wet ground surfaces caused by rain will not be allowed if doing so causes unnecessary disturbance to the land surface. If wet ground conditions occur, work should be shifted to areas where land disturbances cannot occur, or activities must be delayed until the ground surface is dry.

- The project supervisor is responsible for assessing land disturbances to determine if possible sediment is mobilizing offsite or into a wash during a storm event. If this occurs, storm-water control measures, such as the installation of straw bales or silt fencing, must be installed at the latest by the end of the work day.
- The Environmental Compliance project lead must be contacted if storm-water management controls are installed, or if it appears that excessive amounts of land disturbance are occurring.

6.3 Dust Control

To minimize the potential for dust generation, all vehicles will adhere to a maximum travel speed of 15 miles per hour when traveling off road or on dirt roads.

6.4 Suspected Wetlands and Dry Washes

Work restrictions, as described below, apply to suspected wetland areas and dry washes. Wetland areas are not expected to be encountered during the project activities; however, this section is included as a protective measure. For the purpose of this work plan, the term "suspected wetlands area" is generically defined as an area having any of the following characteristics:

- The presence of surface water (including channels with surface water)
- The presence of saturated or inundated soils, including muddy soils
- The presence of vegetation that is substantially different than that in the surrounding area (such as more dense or greener vegetation that may include cattails, willows, etc.)

All suspected wetland areas will be avoided and left undisturbed during this Geoprobe characterization effort. Specifically:

- Vehicles, including the Geoprobe, will not be allowed to drive through any portion of a suspected wetland area (unless on a developed road)
- Work in a suspected wetland area is prohibited (including the staging of equipment and supplies, and refueling of equipment and vehicles)
- IDW may not be discharged to the ground surface in a suspected wetland area

Extra care will be taken by the occupants of the lead vehicle when driving into lower lying areas that could be muddy, areas near the Little Wind River, and dry washes to ensure that suspected wetland areas are identified and avoided. It may be helpful to scout a suspect area on foot before bringing in a vehicle. The following Geoprobe locations, and the routes to these locations, will be carefully evaluated: T03-01, T04-02 and -03, T06-01 through -03, T06-15 and -16, T08-05 through -08, and T09-01 through -05.

Vehicles can be driven into and across dry washes and Geoprobe work can be conducted in these areas. However, IDW may not be discharged to the ground surface in such places or where it could be washed away.

6.5 Cultural Resources

A cultural resources inventory has been completed by a qualified archaeological services company of all potentially impacted, previously undisturbed areas. No cultural resource sites were identified in the inventory, and the DOE Office of Legacy Management (LM) will submit the results to the Wyoming State Historic Preservation Office, the Northern Arapaho and Eastern Shoshone Tribal Historic Preservation Officers, and the U.S. Bureau of Indian Affairs for concurrence and approval of the determination.

During the field investigation, if any unanticipated cultural resource discoveries are identified, the following protocol will be followed and the following language, called a "discovery clause," will be included in any field documents (e.g., Plan of the Day, Plan of the Week).

> *If cultural artifacts or skeletal remains are unearthed or uncovered during construction operations, activities in the vicinity of the cultural resources shall cease, and the LM Environmental Program Manager shall be notified. The onsite manager shall protect the items discovered and allow no further site-disturbing activities until LM makes a decision concerning the disposition of the items and provides written notification to the onsite manager to proceed with work.*

The Environmental Compliance project lead must also be notified if any unanticipated discoveries are made.

6.6 Migratory Birds

All applicable requirements will be adhered to regarding disturbances of migratory birds. All requirements will be identified before field work is initiated. It is likely that the requirements will affect the project work schedule.

6.7 Threatened and Endangered Species

Based on an evaluation of federally listed vegetation and wildlife species, there should not be any threatened or endangered species affected by the Geoprobe characterization activities. However, it is unknown at this time whether the tribes have a more extensive listing of protective or sensitive species. All applicable requirements will be identified and adhered to prior to initiating the Geoprobe characterization.

6.8 Refueling

Refueling the diesel engine that drives the Geoprobe will be primarily conducted at a gas station in Riverton. Some refueling of the Geoprobe will take place in the field by using a portable gas can. No refueling will be allowed in the Supplemental Standards areas located on the former processing site (Figure 1). Precautions for refueling the Geoprobe are specified in the *Water Sampling and Minor Well Maintenance at LM Sites* JSA. All other vehicles and equipment, besides the Geoprobe, will be refueled at a gas station in Riverton.

6.9 Well or Borehole Permits and Abandonment Notifications and Reports

Well or borehole permits, abandonment pre-notifications, and abandonment reports are not required for this field activity because the boreholes will not be completed as groundwater monitoring wells. The borehole abandonment method presented in this work plan is considered a best management practice.

7.0 Reporting

A trip report will be generated at the conclusion of the field investigation. The report will describe the logistics of the investigation, any variance from this plan, and additional information that might be needed for interpretation of the data.

Upon receipt of the laboratory data, a data summary report will be prepared that will include plume maps for each contaminant of concern, tables displaying all data, and tables or charts displaying summary statistics.

8.0 Access

Access to tribal land is granted through a cooperative agreement with the Northern Arapaho and Eastern Shoshone Tribes.

Access to the former mill site is granted through a quitclaim deed that was associated with the sale of the property to Chemtrade Refinery Services.

Access to private land will be granted through access agreements established with each property owner.

9.0 References

DOE (U.S. Department of Energy), 1998a. *Final Site Observational Work Plan for the UMTRA Project Site at Riverton, Wyoming*, U0013801, U.S. Department of Energy, Grand Junction Office, February.

DOE (U.S. Department of Energy), 1998b. *Final Ground Water Compliance Action Plan for the Riverton, Wyoming, Title I UMTRA Project Site*, attached to letter from DOE to NRC of September 22, 1998, U.S. Department of Energy, Grand Junction Office.

DOE (U.S. Department of Energy), 2011. *Verification Monitoring Report for the Riverton, Wyoming, Processing Site, Update for 2010*, LMS/RVT/S07202, U.S. Department of Energy, Grand Junction, Colorado, February.

Health and Safety Manual, LMS/POL/S04321, continually updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

Procedure for Operation of the Geoprobe Model 7720DT, LMS/PRO/S08578, prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, May 2012.

Sampling and Analysis Plan for U. S. Department of Energy Office of Legacy Management Sites, LMS/PLN/S04351, continually updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

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Appendix A

Laboratory Plan for 2012 Geoprobe Study, Riverton Site, June 5, 2012

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Batch Test Procedure: Geoprobe soil cores for batch testing will be collected at 33 locations from the site. Each core will be separated into two samples (0 to 2.5 feet [ft] and 2.5 to 5 ft depths) for a total of 66 samples. Samples will be delivered to the ESL in plastic zip-lock bags. A test solution will be prepared from reagent-grade chemicals to simulate the major-ion composition of the Little Wind River water – site personnel will provide a composition of major ions for this water (Ca, Na, K, Mg, SO_4, Cl, NO_3, pH, total alkalinity). For each sample the following procedure (following ESL procedure CB(BT-1)) will be used:

1. Air dry and sieve to < 2 millimeters (mm).
2. Weigh the < 2 mm and > 2 mm fractions. Use the < 2 mm fraction for testing.
3. Combine 100 milliliters (mL) of test solution with 2 grams (g) of solids, split between two 50 mL plastic centrifuge tubes. Agitate end-over-end for 4 hours.
4. Centrifuge until clear. Decant into a 200 mL volumetric flask.
5. Repeat with second 100 mL of test solution. Fill to volume with test solution.
6. Centrifuge until clear. Decant into the same 200 mL volumetric flask.
7. Filter the 200 mL flask through a 0.45 micrometers (μm) pore-size filter.
8. Analyze filtrate for U.
9. Calculate soil concentration of U in milligrams per kilogram (mg/kg).

Kinetic Test Procedure: Geoprobe soil cores for batch testing will be collected at four locatios from the site (8 samples). Samples will be delivered to the ESL in plastic zip-lock bags. The same test solution that was used for batch testing (simulated Little Wind River water) will be used for the kinetic tests. The procedure is similar to the Batch Text Procedure (following ESL procedure CB(BT-1)) and is as follows:

1. Air dry and sieve to < 2 mm enough sample for 10 tests (10 g). Homogenize the sample sufficiently so that splits can be taken with equivalent chemical compositions.
2. For each test, combine 50 mL of test solution with 1 g of solids. Agitate end-over-end for the prescribed times: 5 minutes, 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, 8 hours, 16 hours, 48 hours, and 96 hours (10 tests for each sample).
3. Quickly centrifuge until clear and filter. Decant into a 50 mL volumetric flask. Fill to volume with test solution.
4. Analyze filtrates for U.
5. Calculate soil concentration of U in mg/kg.

Column Test Procedure: Geoprobe soil cores for column testing will be collected at eight locations (16 samples) from the site. Enough sample will be collected so that the < 2 mm fraction will fill a column (about 25 mL). Samples will be delivered to the ESL in plastic zip-lock bags. The same test solution that was used for batch testing (simulated Little Wind River water) will be used for the column tests. For each sample the following procedure (following ESL procedure CB(CT-1)) will be used:

1. Air dry and sieve to < 2 mm.
2. Weigh the < 2 mm and > 2 mm fractions. Use the < 2 mm fraction for testing.
3. Fill a 22 mL OMNI glass chromatographic column with a split of the < 2 mm fraction.
4. Determine the weight of the sediment used in the column by weighing the < 2mm fraction remaining after the split and compute the difference.

5. Pump test fluid from bottom to top using a peristaltic pump at a flow rate of 10 mL/minute. Minimize the tubing volume.
6. Record the time needed to fill the column, and record the flow rate (measured after column is filled). Use those values to determine the pore volume (should be about 10 mL).
7. Collect effluent (use fraction collector if desired) approximately every pore volume (PV) until U values stabilize (use at least 5 PVs). Record all volumes and calculate "true" flow rates.
8. Analyze for U.
9. Extract residual sediment from the column into one or more 50 mL centrifuge tubes. Add exact volume of Davis's (Davis and Curtis 2003[1]) "labile test" solution to each tube (labile test" solution is 14.4 millimolar of $NaHCO_3$ and 2.8 millimolar of Na_2CO_3 at pH 9.39). Use a volume that will allow good agitation. Agitate end-over-end for 3 weeks.
10. Centrifuge and filter (0.45 µm). Analyze for U.
11. Calculate total U mass and concentration in the solid sample.
12. Calculate and plot the K_d values in mL/g.
13. If desired, we could conduct a 1-D surface complexation model using PHREEQC that would estimate the density of surface complexation adsorption sites.

[1] Davis, J.A., and G.P. Curtis, 2003. *Application of Surface Complexation Modeling to Describe Uranium (VI) Adsorption and Retardation at the Uranium Mill Tailings Site at Naturita, Colorado*, NUREG/CR-6820, prepared by the U.S. Geological Survey for the U. S. Nuclear Regulatory Commission, December.