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REV. 0

WORK PLAN FOR MONITOR WELL INSTALLATION WATER AND SEDIMENT SAMPLE COLLECTION AQUIFER TESTING AND TOPOGRAPHIC SURVEYING AT THE RIVERTON, WYOMING, UMTRA PROJECT SITE

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Prepared for
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LIST OF ACRONYMS

Acronym	Definition
ASTM	American Society for Testing and Materials
DCA	data collection activity
DCO	data collection objective
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
MSDS	material safety data sheet
QA	quality assurance
SAP	sampling and analysis plan
SNL/NM	Sandia National Laboratories/New Mexico
SOP	standard operating procedure
SOWP	site observational work plan
UMTRA	Uranium Mill Tailings Remedial Action

1.0 INTRODUCTION

1.1 PURPOSE

Investigations conducted during preparation of the site observational work plan (SOWP) at the Uranium Mill Tailings Remedial Action (UMTRA) Project site (Figure 1) support a proposed natural flushing ground water compliance strategy, with institutional controls. However, additional site-specific data are needed to reduce uncertainties in order to confirm the applicability and feasibility of this proposed compliance strategy option. This proposed strategy will be analyzed in the site-specific environmental assessment.

The purpose of this work plan is to summarize the data collection objectives (DCO) to fill those data needs, describe the data collection activities (DCA) that will be undertaken to meet those objectives, and elaborate on the data quality objectives (DQO) which define the procedures that will be followed to ensure that the quality of these data meet UMTRA Project needs.

1.2 DATA COLLECTION OBJECTIVES

The following DCOs will fill the data gaps identified in the SOWP:

- Acquire additional data on the hydraulic properties of the aquifer to more accurately model ground water flow.
- Acquire additional data on ground water quality to further characterize the plume.
- Acquire data on the geochemistry of the aquifer matrix and how it controls contaminant transport.
- Acquire information on the relative locations and elevations of wells, surface water bodies, and wetlands so as to establish ground water flow patterns.
- Acquire information on potential environmental and ecological impacts from ground water contamination.
- Meet the requirements for access permits and archeological and cultural clearances.
- Ensure that field activities are conducted safely and that they protect human health and the environment.

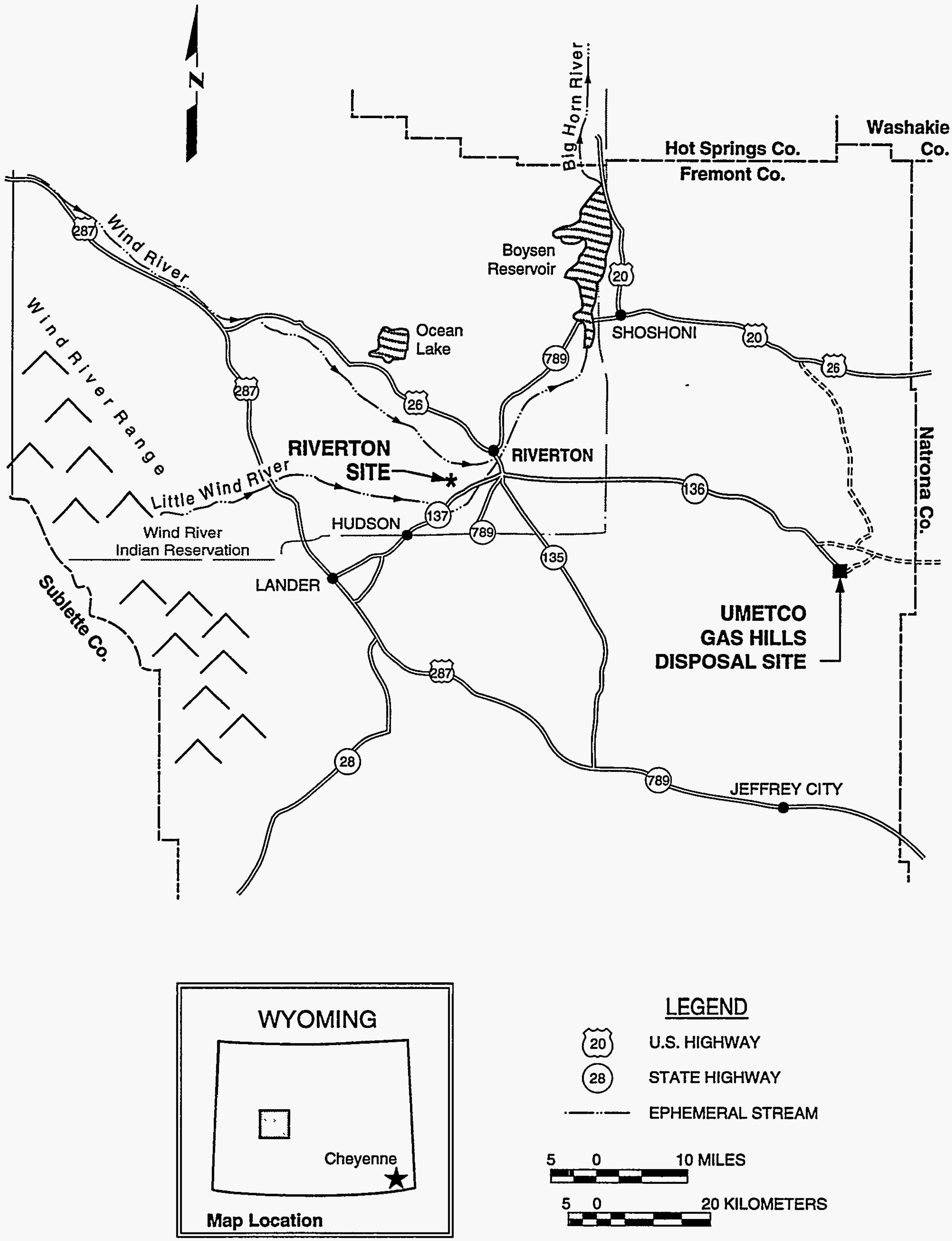

FIGURE 1
RIVERTON, WYOMING, SITE LOCATION MAP

1.3 DATA COLLECTION ACTIVITIES

The following DCAs will be undertaken to fill the above DCOs:

- Drilling and installing aquifer pumping test wells and tracer test wells.
- Performing aquifer pumping tests and tracer tests.
- Drilling and installing monitor wells.
- Collecting and analyzing ground water samples from monitor wells.
- Drilling core borings and collecting samples for analyzing the aquifer matrix.
- Surveying monitor wells and topographic features.
- Collecting and analyzing surface water, sediment, and biota samples.
- Acquiring access permits and archeological and cultural clearances.
- Preparing health and safety plans to protect workers at the site.

1.4 DATA QUALITY OBJECTIVES

The DQOs for this work are presented below for each data collection objective and activity.

2.0 DATA COLLECTION OBJECTIVES, DATA COLLECTION ACTIVITIES, AND DATA QUALITY OBJECTIVES

2.1 HYDRAULIC PROPERTIES OF THE SURFICIAL AND SEMICONFINED AQUIFERS

2.1.1 Data collection objectives

One aquifer pumping test was conducted in the surficial aquifer and one was conducted in the semiconfined aquifer (DOE, 1987). Both tests were performed in wells upgradient of the former tailings site (well cluster 101 through 113) (Figure 2). To better evaluate aquifer variability, the connection between the aquifers, and the fate and transport of the contaminants within the aquifers, hydraulic conductivity data are needed from both the surficial and semiconfined aquifers downgradient of the site.

2.1.2 Data collection activities

2.1.2.1 A 6-inch (2.4-centimeter [cm])-diameter screened pumping well (well 737) with appropriate sand pack will be installed to test the surficial aquifer in the vicinity of existing monitor wells 705, 707, and 709 near the Little Wind River (Figure 2). This well will be fully screened from the water table to the top of the semiconfining unit separating the surficial and semiconfined aquifers. Table 1 outlines well construction details. Existing wells in the cluster will be used as observation wells in the surficial, semiconfined, and confined aquifers. The distances between the pumping well and the observation wells will be based on distance-drawdown predictions calculated with assumed aquifer properties.

2.1.2.2 Existing monitor well 705 is a 6-inch (2.4-cm)diameter well screened in the semiconfined sandstone. It will be used as a pumping well to test the semiconfined aquifer. Adjacent wells in the cluster will be used as observation wells in all three aquifers during the pumping test.

2.1.2.3 Two new 6-inch (2.4-cm)-diameter aquifer test wells (738 and 739) will be installed in the surficial and semiconfined aquifers near existing 2-inch (0.8-cm)-diameter monitor wells 716 and 717, near the southeast corner of the mill tailings site. The existing monitor wells will be used as observation wells.

2.1.2.4 Each aquifer pumping test will include a step drawdown test and a constant rate pumping test. The step test probably will include four or five steps ranging from 2 to 15 gallons (gal) (8.57 liters [L]) per minute and of approximately 0.5-hour duration each. The constant rate test probably will be at a rate of 10 gal (38 L) per minute and will last for 24 hours. The rate of water level recovery will be measured for at least 8 hours following the step tests and 24 hours following the constant rate test. Regional water levels changes will be recorded with the existing data loggers at 0.5-hour intervals throughout the tests.

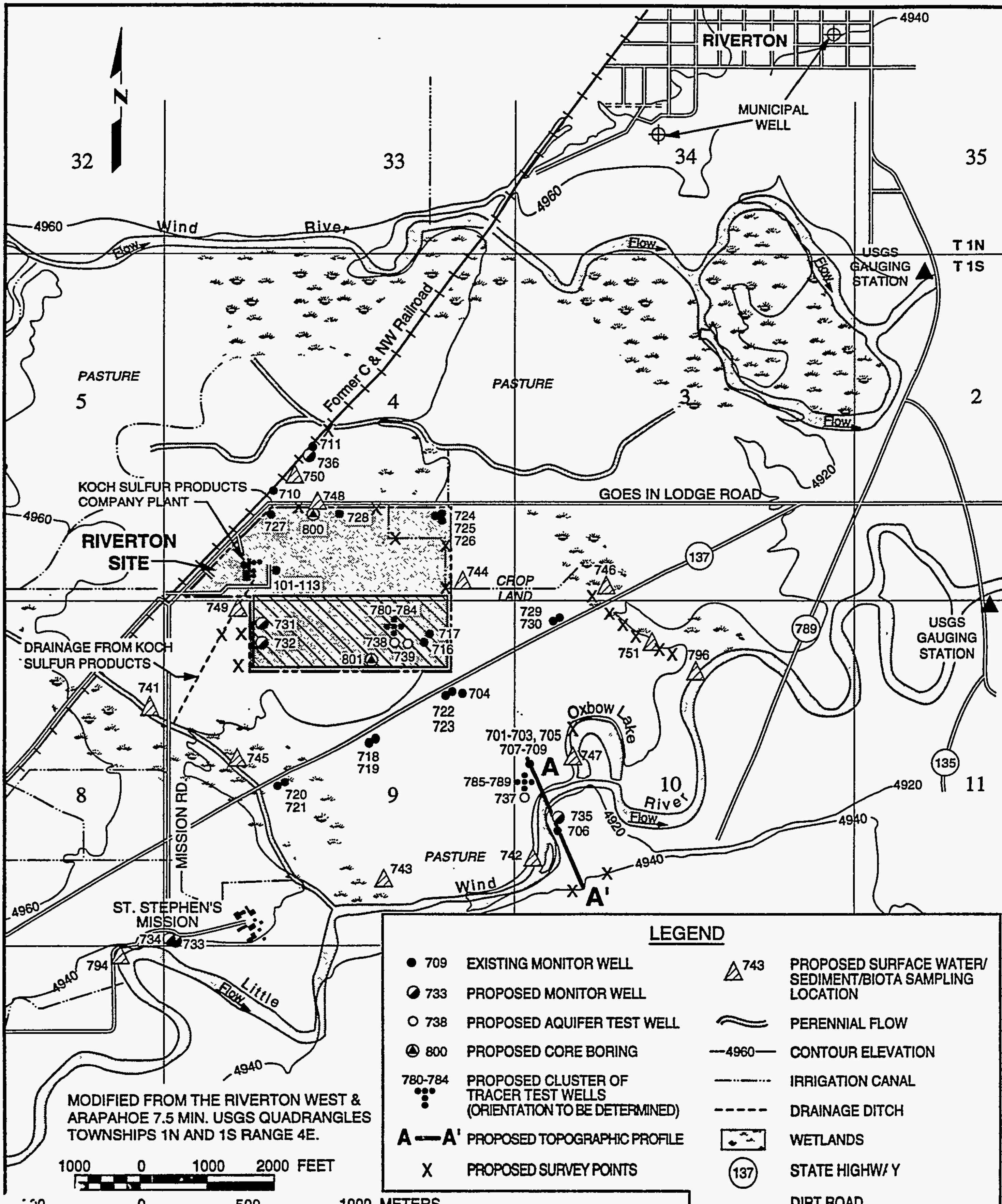

FIGURE 2

EXISTING AND PROPOSED WELL, CORE BORING, SURFACE WATER/SEDIMENT/BIOTA SAMPLING LOCATIONS AND TOPOGRAPHIC SURVEYS RIVERTON, WYOMING, SITE

MAC: SITE/RVT/WORKPLAN/BASE1-TOPO-EXISTWELLS

Table 1 Well construction details, Riverton, Wyoming, site

Well type	Well location	Water depth (feet)	Well dia. (inches)	Total depth (feet)	Riser length (feet)	Screened interval/ length (feet/feet)	Filter pack (feet)	Steel casing diameter/ length (inches/ feet)	Aquifer
Monitor well									
RVT-01-731	Western boundary	5	4	15	7	5-15/10	5-15	8/7	Surficial
RVT-01-732	Western boundary	5	4	43	24	22-42/20	20-43	8/22	Semiconfined sandstone
RVT-01-733	Near river	12	4	25	12	10-20/10	8-25	8/9	Surficial
RVT-01-734	Near river	12	4	55	42	40-55/15	38-55	8/38	Semiconfined sandstone
RVT-01-735	Near well 706	7	4	50	37	35-50/15	33-50	8/33	Semiconfined sandstone
RVT-01-736	Near well 711	6	4	40	24	22-37/15	20-40	8/20	Semiconfined sandstone
Aquifer test									
RVT-01-737	Near well 707	5	6	18	8	6-18/12	5-18	10/7	Surficial
RVT-01-738	Near well 716	5	6	12	6	4-11/7	5-11	10/4	Surficial
RVT-01-739	Near well 717	5	6	50	24	22-47/25	20-48	10/21	Semiconfined sandstone
Tracer test									
RVT-01-780 to 784	Near well 738	5	2	11	6	4-11/7	3-11	6/4	Surficial
RVT-01-785 to 789	Near well 737	5	2	18	7	5-17/12	3-18	6/4	Surficial

Notes:

1. Water depths, screened intervals, and filter pack lengths are estimated from findings in nearby wells, and are assumed to be approximate and subject to change.
2. All wells will be constructed with 0.040-inch (0.018-cm) polyvinyl chloride slotted screens and 8-12 sieve size filter pack. The monitor wells will be constructed of screens with 0.25-inch (0.1-cm) slot spacing. The screens for the aquifer test and tracer test wells will have slots spaced 1/8 inch (0.05 cm) apart.

2.1.2.5 Sandia National Laboratories/New Mexico (SNL/NM) will conduct tracer tests in a cluster of five new 2-inch (0.8-cm)-diameter wells (785 through 789) that will be installed in the surficial aquifer near new well 737. A second cluster of five 2-inch (0.8-cm)-diameter tracer test wells (780 through 784) will installed near existing monitor wells 716 and 717. The aquifer test wells to be installed in the surficial aquifer near these well clusters will be located downgradient of the tracer test wells and can be used to induce a gradient for the tracer test. A select number of these tracer test wells will be used as observation wells during the pumping tests. However, none of these wells are proposed for use as monitor wells in the future. The details of the tracer test are described in Attachment 1 of this work plan.

2.1.2.6 To better define the areal variability of the aquifer, slug tests will be conducted in selected existing monitor wells, especially in wells along State Highway 137. First, slug tests will be conducted in the observation wells used in the pumping tests so as to compare the conductivity calculated from the aquifer pumping test with the slug test results. This ratio then will be used to assess the variability of the aquifer's permeability in the other tested locations. In addition, SNL/NM performed a single well dilution test in these monitor wells to measure the ground water velocity and to ensure correct placement of the tracer test wells.

2.1.2.7 Cuttings-and-development water generated during the installation of the aquifer test and tracer test wells will be disposed of at the Umetco Gas Hills disposal facility (Figure 1).

Review of the water quality data from the existing monitor well clusters where the tests will be performed confirms that water from the tests can be discharged via spray nozzles to the ground surface in accordance with the guidelines set forth in the technical approach to managing UMTRA ground water investigation-derived wastes (DOE, 1994). Attachment 2 of this document includes calculations supporting this approach.

2.1.3 Data quality objectives

2.1.3.1 Aquifer test and tracer test well installation and development

The aquifer test and tracer test wells will be installed and developed in accordance with the following applicable standard operating procedures (SOP):

16.1.1, "Monitor Well Installation" (JEG, n.d.).

D 5092-90, "Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers" (ASTM, 1994).

2.1.3.2 Pumping tests

The aquifer pumping tests will be performed in accordance with the following SOPs:

16.1.5, "Pumping Tests for Aquifers" (JEG, n.d.).

D 4050-91, "Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems" (ASTM, 1994).

2.1.3.3 Slug tests

The slug tests will be performed in accordance with the following SOPs:

16.1.3, "Slug Testing" (JEG, n.d.).

D 4044-91, "Field Procedures for Instantaneous Change In Head Tests for Determining Hydraulic Properties of Aquifers" (ASTM, 1994).

2.2 GROUND WATER INVESTIGATIONS

2.2.1 Data collection objectives

2.2.1.1 While meeting state discharge requirements, infiltration of the sulfur-rich discharge from the Koch Sulfur Products Company plant could be affecting the quality of the shallow ground water and the flow regime along the western, upgradient edge of the site. To evaluate this possibility, the elevation and quality of the ground water in the surficial and semiconfined aquifer entering the site along the western boundary must be determined.

2.2.1.2 Background ground water quality in the surficial and semiconfined aquifers along the Little Wind River upstream of the site must be determined for comparison to ground water near the river downgradient of the site.

2.2.1.3 The quality of the ground water in the semiconfined aquifer south of the Little Wind River must be measured to determine if any contamination is moving under the river and affecting ground water south of the river.

2.2.1.4 Ground water quality samples are needed to confirm the unexplained presence of molybdenum in semiconfined aquifer well 108, and sulfate in semiconfined aquifer well 725.

2.2.1.5 Background ground water quality samples from the semiconfined aquifer upgradient of the site are needed to support the results from well 727, which is upgradient of the former mill tailings pile but still within the site boundaries.

Because of its location, this well may have been affected by former milling operations.

2.2.2 Data collection activities

2.2.2.1 Two monitor wells (731 and 732) will be installed in the surficial and semiconfined aquifers along the western boundary of the site south of the Koch Sulfur Products Company plant (Figure 2) to measure water level elevations and collect ground water samples. These wells will be nested together, with one screened in the surficial aquifer and the other completed in the semiconfined aquifer.

Ground water samples from these and other newly installed wells will be collected during the next regularly scheduled sampling round. They will be analyzed for the same suite of field parameters and analytes as the other wells in the June 1995 sampling and analysis plan (SAP) (DOE, 1995).

2.2.2.2 Two monitor wells (733 and 734) will be installed in the surficial and semiconfined aquifers near the Little Wind River upstream of the contaminant plume to collect ground water samples representative of background conditions near the river.

2.2.2.3 One monitor well (735) will be installed in the semiconfined aquifer next to well 706 on the south side of the Little Wind River. This well will be sampled and compared to background water quality.

2.2.2.4 One monitor well (736) will be installed in the semiconfined aquifer next to existing background well 710 upgradient of the site to confirm the background water quality in that aquifer.

2.2.2.5 The locations and elevations of the new monitor wells will be surveyed.

2.2.2.6 Existing monitor wells 108 and 725 will be pumped for at least 6 hours to compare earlier samples with high molybdenum and sulfate concentrations to the ground water in the aquifer. Five sets of analytical samples for molybdenum will be collected from well 108 and five sets of analytical samples for sulfate will be collected from well 725. The first set of samples will be collected from the wells after 0.5 hour of continuous pumping. The second samples will be collected after 1 hour; the third after 2 hours, the fourth after 4 hours, and the fifth after 6 hours. One sample will also be collected from well 111, which is near 108 and is screened in the same aquifer.

2.2.2.7 Cuttings-and-development water from the monitor wells will be collected and disposed of at the Umetco Gas Hills disposal facility.

2.2.2.8 A water and a sediment sample will be collected from the discharge canal leading from the Koch Sulfur Products Company. These samples will be analyzed for sulfate to assess the current quality of water infiltrating the ground upgradient of the site.

2.2.2.9 A sample of the water and a sample of sediment from the irrigation ditch along the northern boundary of the site will be collected. These samples will be analyzed for standard field parameters and for the constituents listed in the 1995 SAP (DOE, 1995) to assess the quality of water infiltrating the ground upgradient of the site.

2.2.3 Data quality objectives

Ground water samples from the six new monitor wells and existing monitor wells 108, 111, and 725 will be collected, handled, and analyzed in accordance with one or more of the following applicable SOPs:

16.1.10, "Field Measurements for Temperature, Conductivity, pH, and Alkalinity" (JEG, n.d.).

16.1.13, "Field Measurement of Oxidation/Reduction Potential in Water Samples" (JEG, n.d.).

16.1.14, "Field Determination of Dissolved Oxygen in Water Samples" (JEG, n.d.).

16.1.16, "Alternate Method for Determination of Dissolved Oxygen" (JEG, n.d.).

16.1.21, "Measurement of Water Turbidity" (JEG, n.d.).

16.2.1, "Sample Collection, Preservation, and Shipment of Water Samples" (JEG, n.d.).

16.2.5, "Monitor Well Sampling With an Electric Submersible Pump" (JEG, n.d.).

16.2.6, "Monitor Well Sampling With a Bladder Pump" (JEG, n.d.).

16.2.7, "Monitor Well Sampling With a Peristaltic Pump" (JEG, n.d.).

16.2.8, "Quality Control Samples for Water Sampling" (JEG, n.d.).

16.2.9, "Monitor Well Sampling With a Bailer" (JEG, n.d.).

D 4448, "Standard Guide for Sampling Groundwater Monitoring Wells" (ASTM, 1994).

2.3 GEOCHEMICAL EVALUATIONS OF AQUIFER MIX

2.3.1 Data collection objective

Geochemical data on the aquifer matrices must be collected to quantify the interaction of the contaminant plume as it moves through the aquifer (i.e., distribution coefficients, retardation coefficients, and contaminant-specific velocities). The current Riverton site data base does not contain these data.

2.3.2 Data collection activities

2.3.2.1 Samples of the aquifer matrices will be collected from an upgradient core boring (800) along the northern site boundary and from a downgradient core boring (801) near the southeastern corner of the site (Figure 2).

2.3.2.2 Aquifer matrix samples will be collected using standard split spoon samplers and triple tube core barrels. The split spoon samples will be collected from the ground surface down to approximately 6 feet (ft) (1.8 meters [m]), the minimum depth that will allow use of the 5-ft (1.5-m) core barrel. Continuous rock will be collected from 6 ft (1.8 m) to the bottom of the semiconfined aquifer (approximately 50 ft [15 m]).

2.3.2.3 SNL/NM will transport the aquifer matrix samples to Albuquerque, where they will be analyzed. SNL/NM will use the analytical results in a computer model to predict the rate of contaminant transport and attenuation. This analysis also will consider the possibility that clean ground water moving downgradient beneath the site could be recontaminated by constituent desorbing from the aquifer matrix (Attachment 3).

2.3.2.4 If SNL/NM requests them, additional well cuttings will be collected and preserved during the installation of the other monitor and aquifer test wells for possible matrix analyses.

2.3.3 Data quality objectives

Aquifer matrix core boring operations will be under the direction of the Jacobs Engineering Group Inc. (Jacobs) field technical representative. The borings will be drilled and the samples will be collected and handled in accordance with the following applicable SOPs:

14.4.1, "Soil and Rock Core Borehole and Test Pit Logging" (JEG, n.d.).

14.5.1, "Procedures for Handling and Shipping of Geotechnical Samples" (JEG, n.d.).

D 1586, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils" (ASTM, 1994).

D 2113, "Standard Practice for Diamond Core Drilling for Site Investigations" (ASTM, 1994).

2.4 GROUND WATER DISCHARGE ZONE DELINEATIONS AND VERTICAL GRADIENT CONFIRMATION

2.4.1 Data collection objectives

2.4.1.1 The conceptual site model indicates the Little Wind River is the local base level for the ground water regime in the surficial and semiconfined aquifers. According to this model, contaminated ground water beneath the site discharges into the river but does not cross under it. The detection of sulfate and uranium in well 706 south of the river at concentrations above the concentrations in upgradient wells (710 and 711) north of the site raises questions regarding the conceptual model. Therefore, additional information is needed on the water elevation in the Little Wind River relative to the ground water elevations on both sides of the river.

2.4.1.2 Ground water seepage at the ground surface, observed on aerial photographs and during a site visit in March 1995, indicates ground water flows into the wetland southeast of the site during the nonirrigation season. Irrigation water being added to the wetland north of State Highway 137 may be raising the water level in the wetland so the irrigation water actually recharges the aquifer during the irrigation season. Data on the elevation of the water in the wetland areas during both the irrigation and nonirrigation seasons are needed to address these uncertainties.

2.4.1.3 The relationship between the water in the irrigation canals, the drainage from the Koch Sulfur Products Company plant, and the ground water flow regime must be more fully understood to evaluate contaminant transport patterns.

2.4.1.4 Ground water elevations in some monitor well clusters must be confirmed to resolve inconsistencies in the interpretation of vertical gradients between aquifers.

2.4.2 Data collection activities

2.4.2.1 A topographic profile (Figure 2) will be surveyed across the Little Wind River from well 702, down the northern bank of the Little Wind River, across the river (including both the river bottom and water elevations), up the southern bank, through well 706, and up to the top of the escarpment south of well 706. The east-west trend of the escarpment also will be delineated to further define the physiographic setting.

2.4.2.2 Ground water seepage points along the western edge of the wetland and the oxbow lake southeast of the site along the river will be visually identified and their elevations surveyed (Figure 2). The location and elevation of the culvert leading under State Highway 137 also will be surveyed.

2.4.2.3 The elevations of the bottoms of the irrigation canals and the sulphur plant drainage ditch and the water elevations in the trenches along the eastern site boundary and in a pit on the Koch property west of the western site boundary will be surveyed.

2.4.2.4 The elevations of the tops of the casings in well clusters 101 through 113 and 701 though 709 will be surveyed to confirm the presence and magnitude of the vertical gradients in those areas.

2.4.2.5 The locations and elevations of all new wells will be surveyed.

2.4.3 Data quality objectives

The surveying work will be conducted by a surveyor registered in the state of Wyoming. The work will meet 3rd Order topographic surveying accuracy criteria. Elevations will be measured to the nearest 0.01 ft (0.003 m), and will be referenced to mean sea level. Horizontal coordinates will be referenced to the existing site coordinate system.

2.5 SURFACE WATER AND SEDIMENT IMPACTS

2.5.1 Data collection objectives

The environmental impacts resulting from ground water migration into the Little Wind River, the newly formed oxbow lake cut off from the Little Wind River, and the wetland areas east and southeast of the site must be determined to confirm the feasibility of the proposed natural flushing compliance strategy.

2.5.2 Data collection activities

2.5.2.1 Surface water, biota, and sediment samples will be collected from the approximate locations shown on Figure 2.

2.5.2.2 The surface water, sediment, and biota samples will analyzed for the constituents listed in the 1995 SAP (DOE, 1995).

2.5.3 Data quality objectives

The surface water and sediment samples will be collected in accordance with the U.S. Environmental Protection Agency (EPA) Region IV SOP and quality assurance manual (EPA, 1991) and with the EPA field and laboratory reference manual (EPA, 1989).

2.6 ACQUISITIONS OF NECESSARY PERMITS

2.6.1 Wells

Access agreements and easements for on-site drilling will not be needed; however, renewable 5-year agreements and easements will be needed for the off-site wells before field activities begin. State and tribal construction permits are required for all wells.

2.6.2 Borings

Because the core borings for collecting aquifer matrix samples will all be within the site boundary, clearance or access agreements are not needed. Because the core borings will be backfilled upon completion, well permits will not be needed.

2.6.3 Surveying

Permission is needed from the land owners to conduct topographic surveys across their land and to collect surface water, sediment, and biota samples.

2.6.4 Archaeological

Archaeological/cultural clearances are needed for all areas where the planned activities will disturb the land. In addition, cultural-use clearance will be needed for the areas that already have archaeological clearances.

2.6.5 Tracer tests

Jacobs will assist SNL/NM in acquiring necessary permits and approvals for the tracer tests from the state of Wyoming, St. Stephens Mission, and the tribes.

2.6.6 Sample transportation

SNL/NM will acquire the permits, if needed, for transferring the samples from the site to Albuquerque and for their eventual disposal.

2.7 HEALTH AND SAFETY PLAN

Health and safety plan requirements for the drilling, core boring, and installing monitor wells are discussed in the scope of work for the drilling. No special health and safety considerations are required for the aquifer testing or surveying, other than a general field health and safety plan appropriate to the season of the year. SNL/NM has its own health and safety plans for its on-site work (Attachment 1) and for the laboratory.

3.0 REFERENCES

ASTM (American Society for Testing and Materials), 1994. ASTM Standards on Ground Water and Vadose Zone Investigations, second edition.

DOE (U.S. Department of Energy), 1995. *Sampling and Analysis Plan*, UPDCC File Location No. 7.19.2.1, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

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DOE (U.S. Department of Energy), 1987. *Environmental Assessment - Remedial Action at the Riverton Uranium Mill Tailings Site, Riverton, Wyoming*, final, UMTRA-DOE/EA-0254, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, June 1987.

EPA (U.S. Environmental Protection Agency), 1991. Region IV Standard Operating Procedures and Quality Assurance Manual, Atlanta, Georgia.

EPA (U.S. Environmental Protection Agency), 1989. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Manual*, EPA 600/3-89/013, March 1989, Environmental Research Laboratory, Corvallis, Oregon.

JEG (Jacobs Engineering Group Inc.), n.d. Albuquerque Operations Manual, standard operating procedures, prepared by Jacobs Engineering Group Inc., Albuquerque, New Mexico, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

ATTACHMENT 1

TRACER TESTS AND EVALUATIONS AT THE RIVERTON, WYOMING, UMTRA PROJECT SITE

PREPARED BY

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1.0 PURPOSE

This addendum describes ground water tracer tests and environmental tracer evaluations planned for the Riverton, Wyoming, Uranium Mill Tailings Remedial Action (UMTRA) Project site. This work will measure the rate of ground water and contaminant movement to evaluate the feasibility of natural flushing with institutional controls as a proposed ground water remediation strategy. The work will be conducted by Sandia National Laboratories/New Mexico (SNL/NM).

2.0 DATA COLLECTION OBJECTIVES, ACTIVITIES, AND QUALITY CONTROLS

Data collection objectives (DCO) identify the reasons for performing the studies, the data collection activities are the actual tasks undertaken, and the data quality objectives are the techniques employed to ensure that the results of these activities meet their intended purpose. These objectives, activities, and quality controls are described below.

2.1 GROUND WATER TRACER TESTS

2.1.1 Data collection objectives

To evaluate the natural flushing potential of the surficial aquifer at the site, several parameters must be assessed, including the velocity of the ground water and the hydraulic conductivity and porosity of the aquifer. Ground water tracer tests are a way to directly measure the ground water velocity; the remaining parameters can then be calculated.

2.1.2 Data collection activities

Tracer tests are planned at two locations at the Riverton site. One is in the vicinity of existing monitor wells 701 to 703, 705, and 707 to 709 near the Little Wind River. The second location is in the vicinity of 716 and 717 near the southeast corner of the site. The ground water tracer tests will use up to five 2-inch (0.8-centimeter [cm]) internal-diameter tracer wells screened in the surficial aquifer at each location. The tracer tests will use dilution tests in the injection well, natural gradient tests between the tracer wells, and/or induced gradient tests between the tracer wells and the aquifer test wells. A simple analytical model will be prepared before fieldwork begins to assess and optimize the design of the tracer tests and the tracer well configurations and pumping rates.

The tracers planned for use are very low concentrations (measured in parts per million [ppm]) of natural salts such as sodium bromide (NaBr) and potassium iodide (KI) and/or very low concentrations (in ppm) of nontoxic compounds such as perfluorobenzoate. These tracers present no health or environmental concern at these concentrations. For example, perfluorobenzoate is used in diagnostic medical tests on humans, and sodium, bromide, potassium, and iodine are trace constituents necessary for life. Material safety data sheets (MSDS) for exposure to and handling of pure concentrations of the powdered form of these tracers follow this attachment. In addition, the tracer tests are designed to affect only the area of the aquifer in the immediate vicinity of the test wells and are not expected to be detectable more than 100 feet (30 meters) away from the injection well.

Ground water direction will be measured using water table maps and/or *in situ* directional indicators (e.g., the KVA Model-40 Geoflo ground water flow meter, which uses thermistors to measure flow direction in a well). Tracer analysis will use on-site analytical equipment (conductivity meters and specific-ion electrodes) and/or off-site laboratory analyses for water samples.

Ground water direction measurements and tracer dilution tests are planned for the same wells as those planned for the slug tests along State Highway 137 as described in the primary work plan.

2.1.3 Data quality objectives

The ground water tracer tests will follow methods described by Davis et al. (1985). Field instrumentation will be used in accordance with technical guidelines from the manufacturers, and off-site analyses will follow standard analytical procedures. Computer modeling will be conducted in accordance with Jacobs Engineering Group Inc. standard operating procedures "Desktop Procedure for Ground Water Flow and Transport Modeling Analysis" and "Computer Modeling Verification, Validation, and Documentation" (JEG, n.d.).

2.2 ENVIRONMENTAL TRACER EVALUATIONS

2.2.1 Data collection objectives

To support the evaluation of natural flushing at the site, travel times and concentration decreases of the contaminants of concern can be evaluated using environmental tracers already present in the ground water. Environmental tracers can also be used to evaluate and discriminate the contaminant sources.

2.2.2 Data collection activities

Environmental tracer evaluations include analysis of ratios of constituents in the ground water. The environmental tracers planned for evaluation include bromide/chloride ratios, sulphur-34/sulphur-32 ratios, and oxygen-18/oxygen-16 ratios. Samples will be collected from selected monitor wells and surface water at the site. To avoid interference from the ground water tracer tests, the environmental tracer samples will be collected before the tracer tests are conducted. Analysis will be performed at off-site laboratories. Data evaluations are planned so as to identify contaminant sources and to estimate the ground water flushing rate.

2.2.3 Data quality objectives

Samples for the environmental tracer evaluations will be collected, shipped, and analyzed consistent with UMTRA Project protocols and standard analytical procedures.

3.0 HEALTH AND SAFETY PLAN

The MSDS recommendations for the safe handling and use of the tracer compounds will be followed. For example, when the dry tracer reagents are mixed with water before they are added to a well, safety goggles and gloves should be worn, and respiratory protection should be available if windy conditions are encountered. SNL/NM will abide by the UMTRA health and safety plan and the SNL/NM plan (SNL/NM, 1995). No other health and safety requirements or considerations are needed for the tracer tests activities, except a general field health and safety plan appropriate to the season of the year.

4.0 REFERENCES

Davis et al. (1985). *Ground Water Tracers.*

JEG (Jacobs Engineering Group Inc.), n.d. Albuquerque Operations Manual, standard operating procedures, prepared by Jacobs Engineering Group Inc., Albuquerque, New Mexico, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

SNL/NM (Sandia National Laboratories/New Mexico), 1995. *Health and Safety Plan for Dept. 6621, Mixed Waste Landfill Integrated Demonstration Program.*

ATTACHMENT 2

CALCULATIONS OF IMPACTS BY PUMPING WATER DISCHARGE FROM AQUIFER TESTS

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1.0 PURPOSE

Determine the mass of contaminants applied to the ground surface as a result of the discharge of aquifer test water.

2.0 AQUIFER TEST

Aquifer tests will be performed in four wells. The water from each well will be distributed to the ground surface via spray irrigation. A different application area will be used for each test.

Quantity of water from each well test:

1. Step test: 6 hours at an average of 20 liters (L) (5 gallons [gal]) per minute = 7,000 L (2,000 gal).

2. Pumping test: 24 hours at 38 L (10 gal) per minute = 55,000 L (14,000 gal).

   TOTAL: 62,000 L (16,000 gal) = 62 cubic meters (m^3) per well.

3.0 DISPOSAL

Application area: 1,000 square meters (m^2) area (±0.25) acre).
Application rate: 0.06 m^3/m^2 = 60 L.

Soil has a dry density of approximately 1,800 kilograms per cubic milligram (kg/mg^3) and a porosity of 20 percent.

Sixty L (_____gal) of water will saturate approximately 0.3 m or 600 kg of soil: 60 L/600 kg = 0.1 L/kg. Therefore, the mass of contaminants added to the soil by the applied water in milligrams per kilogram is equal to 0.1 X the concentration in the water.

4.0 CONCENTRATIONS OF CONSTITUENTS IN SOIL

Using maximum concentrations in ground water from surficial wells 707 and 716, the following mass of contaminants will be added to soil:

Constituent	Concentration in ground water (mg/L)	Factor (L/kg)	Resulting soil concentration (mg/kg)
Manganese	4.26	0.1	0.43
Molybdenum	0.83	0.1	0.08
Nickel	0.15	0.1	0.02
Sulfate	2970	0.1	297
Uranium	0.96	0.1	0.1

5.0 POTENTIAL ENVIRONMENTAL IMPACTS

The concentrations of manganese, molybdenum, nickel, and uranium in the ground water and the estimated concentrations in the soil as a result of applying the ground water to the ground were compared to screening level benchmarks for terrestrial plants and wildlife (Opresko et al, 1994; Will and Suter, 1994). A benchmark has not been established for sulfate.

Constituent	Ground water concentration (mg/L)	Soil concentration (mg/kg)	Terrestrial plant benchmark Soil (mg/L)	Terrestrial plant benchmark Water (mg/L	Wildlife benchmark water (mg/L)
Manganese	4.26	0.43	500	4	258 to 1995
Molybdenum	0.83	0.08	2	0.5	Not available
Nickel	0.15	0.015	30	0.2	1205 to 1240
Uranium	0.96	0.1	5	40	4 to 30

These benchmarks indicate the quantities and concentrations of constituents being discharged to the ground surface will not build up in the soil to levels that would be toxic to plants. In addition, if wildlife consumed the water before it disappeared from the land surface, detrimental effects would not be expected. The levels of manganese and molybdenum in the ground water, however, slightly exceed their respective benchmarks for terrestrial plants. Therefore, these two constituents may have a slight detrimental effect on sensitive plant species within the immediate area of discharge, but no widespread effects are expected.

Similarly, the molybdenum concentration in the ground water exceeds the level considered protective of plants used for animal feed (0.01 mg/L) (EPA, 1973). To estimate the amount of molybdenum in the vegetation growing in the area that will be irrigated during the aquifer pumping test, the estimated concentration of molybdenum in the soil (0.08 mg/kg) was multiplied by the transfer coefficient for soil to plants of 0.12 (NRC, 1977).

The resulting concentration in the plants would be 0.01 mg/kg, which is much lower than the molybdenum levels in forage (2 to 5 mg/kg) that can be tolerated by livestock (Erdman et al., 1978). Therefore, applying aquifer test water to the ground will not have a detrimental effect on livestock. This conclusion is further supported by the fact that the water spraying is a one-time event, not continuing irrigation. Also, because the irrigated area is small compared to the amount of land needed to feed even one cow, the amount of uptake will be minor.

6.0 REFERENCES

Erdman et al. (J. A. Erdman, R. J. Ebens, and A. A. Case), 1978. "Molybdenosis: A Potential Problem in Ruminants Grazing on Coal Mine Spoils, " in *Journal of Range Management*, Vol. 31, No. 1, pp. 34-36.

EPA (U.S. Environmental Protection Agency), 1973. Water Quality Criteria, National Academy of Sciences and National Academy of Engineering, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1977. Calculations of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50, Appendix I, Regulatory Guide 1.109, U.S. Nuclear Regulatory Commission, Washington, D.C.

Opresko et al. (D. M. Opresko, B. E. Sample, and G. W. Suter), 1994. Toxicological Benchmarks for Wildlife: 1994 Revision, ES/ER/TM-86/RI, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Will, M. E., and G. W. Suter, 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1994 Revision, ES/ER/TM-85/RI, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

ATTACHMENT 3

NATURAL ATTENUATION OF HEAVY METALS AT THE RIVERTON, WYOMING, UMTRA PROJECT SITE

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1.0 RESEARCH OBJECTIVES

Data will be collected to quantify the interaction of aquifer materials with contaminants in ground water at the Riverton, Wyoming, site. The role of natural attenuation in reducing the concentration of radionuclides/heavy metals will be studied by a combination of laboratory and computer modeling approaches. The experimental program will determine the following:

- The geochemical characteristic of the Riverton aquifer material that will dominate chemical retardation of contaminants.
- The role of minor mineral phases in the overall sorption behavior of the aquifer material.

The ultimate goal of this investigation is the development of improved models for predicting the migration of contaminants in permeable zones. Data collected from this laboratory evaluation will provide insight into the nature of the hydrogeochemical systems that cause subsurface attenuation of radioactive and nonradioactive constituents and assist in predicting the remobilization of constituents into fresh ground water moving beneath the site.

2.0 DATA COLLECTION ACTIVITIES

The drill cores will be logged as they are recovered from drill holes 800 and 801. All drill cores will be labeled and prepared for shipment to Sandia National Laboratories/New Mexico (SNL/NM) in accordance with U.S. Department of Transportation requirements and SNL/NM standard operating procedures (SOP).

In the laboratory, the drill cores will be evaluated and classified into zones that represent variations in the geology of the site. Representative samples will be taken from each zone and prepared for use in the laboratory testing program.

3.0 LABORATORY TESTING ACTIVITIES

Mineralogical components of the representative aquifer materials will be determined by x-ray diffraction analysis. Laboratory estimations of the adsorptive capacity of the minerals identified in the Riverton samples will be collected. Samples of upgradient and downgradient mineralogy will be compared to identify the mechanism responsible for metal attenuation (i.e., adsorption, precipitation, reduction).

Batch experiments will be used to quantify the interaction of the aquifer material with fluid samples containing uranium and other metal contaminants at levels typical of the Riverton site. Representative samples from each zone in both the upgradient and downgradient drill holes will be mixed with fluid in a batch reactor system. The changes in fluid chemistry will be recorded with time and partition coefficients will be calculated from the collected data.

To determine the long-term stability of attenuated constituents at the Riverton site, batch experiments will be conducted to quantify the interaction of background quality water and Riverton aquifer samples that contain uranium and other constituents that were attenuated from the plume. Representative samples of the downgradient core materials will be mixed with fluid in a batch reactor system. The changes in fluid chemistry will be recorded with time and partition coefficients will be calculated from the collected data.

4.0 COMPUTER MODELING ACTIVITIES

The computer code LEHGC (Lagrangian-Eularian Model of Hydro-Geochemical Transport) will be used to predict the long-term mobility of contaminants in ground water at the Riverton site. LEHGC is capable of modeling the transport of metals through saturated/unsaturated media. The model accounts for both chemical reactions and hydrologic transport in predicting contaminant mobility. Coupled chemical reaction/transport codes like LEHGC are the only computer models that can simulate changes in sorption due to dynamic evolution of the ground water in response to chemical reactions with the surrounding media. Thus complex chemical behaviors such as multiple dissolution-precipitation fronts, elevated releases of contaminants from secondary enrichments, and large variations in partition coefficients can be simulated. LEHGC also will be used to determine if the mineral reactivity data collected from the geologic characterization of the Riverton core are consistent with the metal attenuation capacity determined in the batch reactor studies. Model input will be adjusted, based on the ability of the theoretical model to predict the experimental results.

LEHGC evaluation of the Riverton site data will provide site scale calculations of the long-term contaminant mobility in the ground water plume. LEHGC also will be used to evaluate the sensitivity of possible hydrogeologic variations that are expected to influence metal mobility at the site.

5.0 DATA QUALITY OBJECTIVES

Laboratory experiments will be conducted at ambient temperature conditions. Uranium will be analyzed by accepted chemical analysis and quality control protocols and will follow SNL/NM SOP guidelines.

LEHGC was comprehensively and systematically evaluated for its use in the Yucca Mountain site characterization project. The same procedures used to evaluate the quality of the data produced at Yucca Mountain will be used to qualify LEHGC's applicability at the Riverton site.