Technical Basis Agreement Document for Underground Test Area Corrective Action Unit 99
Rainier Mesa/Shoshone Mountain:

Final Rev. 1

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Introduction
This Technical Basis Agreement Document (TBAD) examines and provides documentation of a more efficient approach to implementing the Federal Facility Agreement and Consent Order (FFACO) Underground Test Area (UGTA) strategy for Corrective Action Unit (CAU) 99: Rainier Mesa/Shoshone Mountain (RM/SM). The UGTA corrective action strategy is described in Section 3.0 of Appendix VI to the FFACO strategy (1996, as amended); this is referred to as the FFACO strategy. The steps and decision points in the FFACO strategy are identified on Figure 3-2 of Appendix VI; this chart is referred to as the UGTA Strategy Flowchart. The strategy for CAU 99 is described in the Modeling Approach/Strategy for Corrective Action Unit 99: Rainier Mesa and Shoshone Mountain, Nevada Test Site, Nye County, Nevada (SNJV, 2008a); this is referred to as the Nevada Division of Environmental Protection (NDEP) accepted RM/SM strategy.

FFACO Strategy and Status of RM/SM Investigations
The UGTA FFACO strategy relies on four sequential stages to close a CAU (see the UGTA Strategy Flowchart). The first stage, the Corrective Action Investigation Plan (CAIP), compiles existing data and conducts limited analysis to develop a plan for characterizing the CAU. The second stage, the Corrective Action Investigation (CAI), implements the CAIP through data collection and data compilation as required to develop CAU-scale models of groundwater flow and radionuclide transport. The impact of uncertainty is included through the development of multiple alternative models used to develop ensembles of probabilistic contaminant boundaries. Success in the CAI stage is achieved through a peer-review process and NDEP acceptance of the flow and transport model (Decision 4 of the UGTA Strategy Flowchart). The third stage, the Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), establishes regulatory boundary objectives and initial use restriction boundaries. Model evaluation studies are conducted for the CADD/CAP to build confidence that the model results can be used to achieve the closure objective (closure in place with long-term monitoring and institutional controls). NDEP must accept the model and approve moving to the Closure Report (CR) stage (Decision 6 of the UGTA Strategy Flowchart). The CR stage consists of the design and implementation of a long-term monitoring network to ensure protection of the public and environment.

CAI activities conducted within the RM/SM CAU were summarized and interpreted in hydrologic and source term data documentation packages (SNJV, 2008b and c).
The RM/SM CAU has progressed through the CAIP (NNSA/NSO, 2004) and the majority of the CAI stage, with future progress pending resolution of Decisions 2 and 3 on the UGTA Strategy Flowchart.

**Hydrogeologic Setting of the RM/SM CAU**
The RM/SM CAU has unique attributes compared to other UGTA CAUs on the Nevada National Security Site (NNSS). These attributes include the following:

1. All underground tests were conducted in the unsaturated zone above the water table.
2. The total CAU inventory (radiologic source term [RST]) is low (0.7 percent of the total UGTA inventory [Bowen et al., 2001]).
3. Rainier Mesa is topographically high, and the hydrology of the CAU is dominated by local recharge (recharge mound).
4. Rainier Mesa and Shoshone Mountain are located in a transition zone between volcanic aquifers of the Pahute Mesa/Timber Mountain highlands to the west and the carbonate aquifers of Yucca Flat to the east.
5. Rainier Mesa is located at the eastern edge of a largely unextended volcanic highland that is bounded to the east by the extensional basin of Yucca Flat. Rainier Mesa overlies an imbricate thrust zone that juxtaposes the upper carbonate aquifer (LCA3) and the upper clastic confining unit (UCCU). The geology and structure at the water table can be complex; the spatial distribution of the rock units is difficult to characterize; and the continuity/interconnectivity of aquifer units is only partly known (significant components of irreducible structural uncertainty).
6. The CAU is located in the north part of the NNSS with probable southward flow of groundwater.

Downgradient transport will proceed through other UGTA CAUs. The likelihood of contaminated groundwater moving off the NSS boundaries is low.

**Model Results**
Data from the aforementioned CAI activities were used to develop sub-CAU flow and transport models of Shoshone Mountain; U12t tunnel; U12n tunnel; U12n, U12e, and U12t tunnel ponds; WINESKIN and CLEARWATER shaft tests; and a saturated-zone CAU model. Transport of radionuclides remains within the unsaturated zone for greater than 95 percent of the simulations for Shoshone Mountain, U12t tunnel, and U12t tunnel pond. Radionuclide transport to the saturated zone occurs from WINESKIN, CLEARWATER, U12n tunnel, and U12n and U12e tunnel ponds for more than 5 percent of the simulations. Transport of the radionuclides within the saturated-zone model occurs within the Red Rock Valley Aquifer (RVA) for CLEARWATER and WINESKIN, and within the LCA3 for U12n tunnel, and U12n and U12e tunnel ponds. One of 24 saturated-zone CAU-scale simulations resulted in exceeding the maximum contaminant level (MCL) at the model boundary (two times the MCL for tritium at 50 years), and none of the simulations resulted in transport that could credibly approach the boundaries of the NNSS.

Transport results were designed to maximize the potential for radionuclide transport. Assumptions used to achieve this goal include conceptualizations of the LCA3 as spatially extensive and continuous; tunnel pond source terms based on the 95th percentile of source term concentration; infiltration parameterized at
the upper permissible range and focused entirely into aquifers at the water table (thereby maximizing velocities); hybrid definitions of time $0\left(T_0\right)$ that coupled maximum radionuclide concentrations with maximum heads; and foregoing inclusion of some attenuating processes like colloidal filtration or sorption to fracture-filling minerals.

Modeling studies were completed for the RM/SM CAU and presented to the Preemptive Review Committee on July 11 and 12, 2012, and to NDEP on November 27 and 28, 2012. These studies provide important constraints on radionuclide transport, including the following:

1. Shoshone Mountain, U12t tunnel, and U12t tunnel pond models do not appear to be sources exceeding the MCL at the upper boundaries of the saturated zone model.

2. WINESKIN, CLEARWATER, U12n tunnel, U12n tunnel pond, and U12e tunnel pond are sources exceeding the MCL at the upper boundary of the saturated zone model.

3. Saturated zone contaminant transport is consistent in terms of direction of transport; however, the extent of transport is variable—the latter is supported by only 1 out of 24 simulations exceeding the MCL at the model boundary.

4. Flow and transport results are based on compounding conservatism.

As presented, current modeling results are not sufficient to define contaminant boundaries or develop ensembles of contaminant boundaries. They are based on compounded conservatisms biased toward overestimating the extent of transport.

**Rationale for Why Developing Ensembles of Contaminant Boundaries Is Not Achievable (Impractical and Inefficient)**

The premise for developing ensembles of contaminant boundaries is to obtain information on the range of permissive model responses to uncertainty in model input (statistical uncertainty) and alternative representations of structural uncertainty (boundary conditions, recharge, and alternative hydrogeological framework models) for groundwater flow and contaminant transport models.

Credible contaminant boundaries are difficult to develop for the RM/SM CAU because of significant discrete structural uncertainty that must be evaluated through alternative model representations (cannot be assessed through Monte Carlo simulations sampling continuous probability distributions). Moreover, structural uncertainty in the complex hydrogeological setting of the RM/SM CAU is difficult to reduce through additional characterization (irreducible uncertainty because of technical challenges and high cost/low benefit of continuing characterization studies).

Examples of structural uncertainty for the RM/SM CAU include the following:

1. The boundary conditions are difficult to constrain, and the boundary fluxes—particularly groundwater flux from the north—are uncertain.

2. Representative models of infiltration are challenging because of steep topography, and variable vegetation and soil cover.
3. The continuity of critical aquifer units at the water table is uncertain because of the combination of the complex structure of imbricate thrusts and the location of the CAU at a transition between extended and unextended terrain. The continuity of thrust slivers of the LCA3 beneath Rainier Mesa is uncertain at both the local and regional scale.

4. The properties of the hydrologic connections between the LCA on the east and the volcanic aquifers on the west are only partly constrained along the north–south length of the CAU.

5. The Red Rock Valley caldera is an inferred caldera that is buried by younger volcanic rocks and truncated on the west by the Timber Mountain caldera. The nature and continuity of both intra- and extra-caldera volcanic rocks of the Red Rock Valley caldera are known only from limited local outcrops and drill-hole information.

The FFACO strategy requires model evaluations in the CADD/CAP stage to test model results and build confidence that model results for flow and transport studies can be used to achieve the closure goal of the FFACO strategy (closure in place with long-term monitoring and institutional control). However, model evaluations are complicated by the same issues affecting contaminant boundaries: significant structural uncertainty is irreducible from a practical viewpoint because of technical difficulties and expected high cost of drilling boreholes in the steep topography, and complex hydrogeological setting of Rainier Mesa and Shoshone Mountain.

In summary, sufficient uncertainty exists where development of ensembles of contaminant boundaries would be computationally burdensome given the range of permissible scenarios. In addition, attempts to represent the full range of permissible scenarios would be difficult and resource intensive given the complexity of the subsurface environment and depth to the regional water table. Moreover, while studies could feasibly be conducted to reduce uncertainty, it would be inefficient and impractical to do so because the simulations that result in a maximized potential for contaminant transport show no credible scenarios for radionuclide transport to or across NNSS boundaries.

Reasons and Rationale for Not Pursuing the Accepted RM/SM Strategy
The NDEP-accepted RM/SM strategy (SNIV, 2008a) consists of a Phase II of additional site characterization, and flow and transport modeling studies as required for achieving data and model adequacy at Decision 2 of the UGTA Strategy Flowchart. Decision 2 cannot be achieved because of the complexity of the hydrogeological setting of Rainier Mesa and the resources required for complete characterization of the CAU.

Additionally, the RM/SM CAU is geographically isolated within the north-central portion in the interior of the NNSS and contains only 0.7 percent of the UGTA radiological inventory. The bulk of the contaminant sources are located above the water table of the regional aquifers where the thick, partially saturated zone provides attenuation before the saturated zone is reached, reducing the need for a comprehensive saturated-zone model. Simulated transport of the radionuclides, based on compounded conservatism, does not challenge NNSS boundaries, and the probability of public exposure to contaminated groundwater is low. The development of a defensible regional flow conceptual framework for Rainier Mesa may be prohibitively expensive owing to a superimposed hydrologic divide and complex structural setting.
Furthermore, model evaluations, based on testing radionuclide transport simulations using compounded conservatisms, are unlikely to meet the objectives of the accepted RM/SM strategy.

**Request To Propose an Alternative Strategy for the RM/SM CAU**
Modeling studies completed for the RM/SM CAU and presented to the Preemptive Review Committee and NDEP are adequate to achieve the closure goal without completion of probabilistic contaminant boundaries. The results of the modeling studies will be documented in a modified flow and transport document. DOE requests NDEP’s concurrence to propose an alternative RM/SM strategy.
References Cited


NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

SNJV, see Stoller-Navarro Joint Venture.


Additional References


Stoller-Navarro Joint Venture. 2006c. Underground Test Area Fracture Analysis Report for Rainier Mesa Wells ER-12-3 and ER-12-4, and Shoshone Mountain Well ER-16-1, Nevada Test Site, Nevada, S-N/99205–085. Las Vegas, NV.