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Technical Update Impact Letter Report

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Technical Update Impact Letter Report

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CHANGE HISTORY

Revision Number	Interim Change No.	Date	Description of Change
0	0	November 9, 2001	Initial issue.

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ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
NRC	U.S. Nuclear Regulatory Commission

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1. INTRODUCTION

In May 2001, the U.S. Department of Energy (DOE) released the *Yucca Mountain Science and Engineering Report* (DOE 2001a), which provided a technical summary of the latest scientific and engineering information about the potential repository at Yucca Mountain, to support public comment on the Secretary's consideration of the Yucca Mountain site for recommendation as a geologic repository. A second report, the *Yucca Mountain Preliminary Site Suitability Evaluation* (DOE 2001b), was released in August 2001. That report provided a preliminary evaluation of the Yucca Mountain site against the DOE's site suitability guidelines in proposed 10 CFR Part 963 (64 FR 67054). These two reports, as updated to reflect public comments and the final regulations, will form key parts of the information the Secretary will use to decide whether to recommend the Yucca Mountain site to the President for development as a geologic repository.

Since completion of the technical analyses that provided the technical basis for these reports, additional information has been collected through the ongoing testing program, as well as obtained from other sources. This *Technical Update Impact Letter Report* documents this additional information and evaluates the potential impacts that it could have on the results of the total system performance assessment and preclosure safety assessment referenced in the *Yucca Mountain Science and Engineering Report* and the *Yucca Mountain Preliminary Site Suitability Evaluation*.

The timeframe for this additional information varies, depending on the particular area being addressed. With respect to postclosure, the *Total System Performance Assessment for the Site Recommendation* (CRWMS M&O 2000a) was completed in December 2000 to support the *Yucca Mountain Science and Engineering Report* (DOE 2001a). The inputs to that total system performance assessment were documented in a set of analysis and model reports that were prepared in late 1999 and throughout 2000. Some of these inputs, as well as some models, were updated in early to mid-2001 and documented in the *FY01 Supplemental Science and Performance Analyses* (BSC 2001a; BSC 2001b), which was completed in July 2001. These supplemental analyses were conducted to support the *Yucca Mountain Preliminary Site Suitability Evaluation* (DOE 2001b). With respect to preclosure, the *Preliminary Preclosure Safety Assessment for Monitored Geologic Repository Site Recommendation* (CRWMS M&O 2000b) was completed in November 2000 to support the *Yucca Mountain Science and Engineering Report*. This safety assessment was later updated in July 2001 (BSC 2001c) to support the *Yucca Mountain Preliminary Site Suitability Evaluation* (DOE 2001b). Therefore, while most of the additional information documented in this letter report refers to test results or other information from early 2001 to the present, some of the information dates back to the year 2000.

It should be noted that the documentation of the additional information in this letter report is being done as an interim step, and primarily used to support impact reviews of how this information may potentially affect the reference technical analyses. The information will be formally documented in subsequent Project technical reports, as appropriate (e.g., analysis and model reports, process model reports, calculations).

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2. DESCRIPTION OF PROCESS

This section discusses the process that was used in documenting the additional information and evaluating the potential impacts of that information on the reference technical analyses. The process consisted of two key activities: (1) development of white papers on the additional information and (2) performing impact reviews of that information. These activities are discussed in the sections that follow.

2.1 DEVELOPMENT OF WHITE PAPERS

Since the objective of this effort was to evaluate the potential impact of the additional information on the results of the total system performance assessment and preclosure safety assessment that had been conducted to date, several white papers were developed to capture the information related to the key components of those assessments. Because of the complex nature of the total system performance assessment, ten white papers were prepared to address the key model components, with an additional white paper prepared for the information related to the preclosure safety assessment inputs. These 11 papers (which are contained in Appendices A through K) are listed in Table 1, along with testing programs or other information sources that were addressed.

Table 1. White Papers on Additional Information

WHITE PAPER TOPIC	TESTING PROGRAM OR INFORMATION SOURCE
Additional Postclosure Information	
Integrated Site Model (Appendix A)	Fracture Studies (including excavation-induced fractures)
Unsaturated Zone Flow and Transport (Appendix B)	Systematic Hydrologic Characterization Cross-Drift Bulkhead Moisture/Seepage Observations Fault Testing at Alcove 8/Niche 3 Seepage Testing at Niches Chlorine-36 and Tritium Studies Geochemistry—Calcite, Pore Water, Fluid Inclusion, and Oxygen Isotope Studies Natural Analogue Studies Busted Butte Transport Testing Expected-Case Modeling Discrete Fracture Network Modeling
Near-Field Environment (Appendix C)	Drift Scale Test Natural Analogue Studies

Table 1. White Papers on Additional Information (Continued)

WHITE PAPER TOPIC	TESTING PROGRAM OR INFORMATION SOURCE
Additional Postclosure Information	
Engineered Barrier System Degradation, Flow, and Transport (Appendix D)	Analysis of Effect of Rock Fall on the Drip Shield and Waste Package Comparison of Preclosure Ventilation Models Forced and Natural Convection Modeling Ventilation Testing Validation of Multiscale Thermal-Hydrologic Model and Improvements to Supplemental Model Calculations Thermal Conductivity Modeling and Investigations Modeling Condensation on Engineered Barrier System Surfaces Dual Permeability Modeling of Invert Invert Diffusion Study Physical and Chemical Environment Modeling Modeling of Cement-Seepage Interactions Cross-Drift Bulkhead Test Results
Waste Package Degradation (Appendix E)	Environment on the Drip Shield and Waste Package Investigations Aging and Phase Stability Studies Passive Film Stability Investigations General and Localized Corrosion Experiments Stress Corrosion Cracking Studies Stress Mitigation and Weld Stress Measurements Waste Package Materials Performance Peer Review
Waste Form Degradation (Appendix F)	Refinement of Location of Radionuclide Inventory Commercial Spent Nuclear Fuel Dissolution Experiments Testing of Commercial Spent Nuclear Fuel Rod Segments on Exposure to Humid Air Commercial Spent Nuclear Fuel Colloid Generation Testing Experimental Evaluation of Np Incorporation into Uranyl Alteration Phases
Saturated Zone Flow and Transport (Appendix G)	Stratigraphy Studies from Nye County Early Warning Drilling Program Wells Hydrochemistry Studies from Nye County Early Warning Drilling Program Wells Hydraulic and Tracer Testing at the Alluvial Testing Complex Calibration of Different Conceptual Models of the Large Hydraulic Gradient Region Evaluation of Boundary to the Accessible Environment Parameter Sensitivity Analyses Uranium Mill Tailings Sites as Natural Analogues of Radionuclides in Alluvium A Realistic Case of Saturated Zone Flow and Transport Saturated Zone Results from the Atomic Energy of Canada Limited Busted Butte Experiments

Table 1. White Papers on Additional Information (Continued)

WHITE PAPER TOPIC	TESTING PROGRAM OR INFORMATION SOURCE
Additional Postclosure Information	
Biosphere (Appendix H)	Dietary and Lifestyle Characteristics of Receptor Dosimetric Model of Receptor
Disruptive Events—Volcanism/Seismicity (Appendix I)	Dike–Drift Interaction—Work Sponsored by the Center for Nuclear Waste Regulatory Analyses Additional Aeromagnetic Data and Interpretations Geotechnical Studies to Support Seismic Analyses Geodetic Investigations
Disruptive Events—Criticality (Appendix J)	Updated Criticality Analyses
Additional Preclosure Information	
Inputs Related to Preclosure Assessment (Appendix K)	Meteorological and Climatological Measurements Preclosure Rock Fall Analyses Studies of Seismic Parameters Aircraft Activity in the Vicinity of the Site Risk of Heavy Load Drops

As noted in Section 1, the documentation of the additional information in these white papers is being done as an interim step, and primarily used to support impact reviews of how this information may potentially affect the reference technical analyses. The information will be formally documented in subsequent Project technical reports, as appropriate. Because of the recent nature of the information provided in these papers, much of it is unpublished and, therefore, the source references have not been provided. However, this information is currently documented in the principal investigators' scientific notebooks, if applicable, in accordance with the Project's quality assurance procedure, AP-SIII.1Q, *Scientific Notebooks*.

2.2 IMPACT REVIEWS

The impact reviews of this information were conducted in accordance with the requirements in Section 5.1.3 of AP-2.14Q, *Review of Technical Products and Data*. To conduct these reviews, a three-day technical update meeting was held in Las Vegas on October 23–25, 2001. This was an internal Project meeting attended by the DOE, U.S. Geological Survey, and contractor scientists and engineers that are knowledgeable in the areas covered by each of the white papers, including how these inputs are used in the total system performance assessment and the preclosure safety assessment.

On the first day of the meeting, the white paper leads provided briefings summarizing the content of the white papers. Later that day, a training session was conducted on the impact review provisions of AP-2.14Q, *Review of Technical Products and Data*, for those individuals that were part of the evaluation teams the following day. On the second day, breakout sessions for each of the individual white papers were held to evaluate the potential impact of the additional information to the results of the total system performance assessment or the preclosure safety assessment. Each of these teams consisted of Project experts technically qualified in the areas of

testing, technical analyses, and modeling of complex repository system components. On the third day, there was a general session during which each of the leads from the breakout sessions presented the preliminary evaluation of potential impacts resulting from each of their areas. Subsequent to the meeting, the manager responsible for the total system performance assessment within the Bechtel SAIC Company organization conducted an overall postclosure impact review using each of the ten individual preliminary evaluations done for each of the key postclosure components. A similar review was done by the manager responsible for preclosure safety assessment, using the one evaluation from the breakout team.

These impact reviews were formally documented in accordance with the documentation requirements of AP-2.14Q, *Review of Technical Products and Data*. This documentation is contained in Appendices L and M.

3. RESULTS OF IMPACT REVIEWS

This section summarizes the results of the postclosure and preclosure impact reviews that are documented in Appendices L and M, respectively.

3.1 POSTCLOSURE IMPACTS

To put the results of the postclosure impact review in perspective, the results of the reference total system performance assessments are summarized in Table 2.

Table 2. Summary of Reference Total System Performance Assessment Results

Documentation	10,000-Year Peak Mean Dose		Post-10,000-Year Peak Mean Dose	
	Nominal Scenario	**Disruptive Scenario**	**Nominal Scenario**	**Disruptive Scenario**
Total System Performance Assessment for the Site Recommendation (CRWMS M&O 2000a)	0.0 mrem/yr	0.08 mrem/yr	490 mrem/yr	0.2 mrem/yr
FY01 Supplemental Science and Performance Analyses (BSC 2001b)	0.0002 mrem/yr	0.1 mrem/yr	35 mrem/yr	0.1 mrem/yr

The postclosure impact review concluded that, compared to the results documented in the *Total System Performance Assessment for the Site Recommendation* (CRWMS M&O 2000a) and the *FY01 Supplemental Science and Performance Analyses* (BSC 2001b), the overall potential impact of the additional information on postclosure performance ranges from an order of magnitude decrease to no more than an order of magnitude increase in the postclosure dose. The additional information and analyses provide improved documentation; in some cases they improve the validation; and in others, the additional information may reduce the uncertainty or improve realism. Often the additional information is already included within the data distribution being utilized to model or analyze the process within the total system model.

Table 3 provides a summary of the potential system level impacts by component, for both 10,000 years and after 10,000 years. The table provides a range of potential change to calculated dose due to changes in each component and for the total system.

The basis for each of these potential impacts is contained in Appendix L. When described as a *negligible* change, the potential impact on the calculated postclosure dose might be a factor of 2 or less. When described as a *small* change, the potential impact on the calculated postclosure dose might be a factor of 5 or less. The change may also be described as *one order of magnitude*, which is a factor of 10 change in the calculated dose. For the nominal scenario, the potential impact is a one order of magnitude decrease to a small increase in the calculated nominal scenario dose. For the igneous disruptive scenario, the potential impact of the additional information ranges from a small decrease in dose to a one order of magnitude increase in dose.

Table 3. Summary of Potential of Additional Information by Total System Component

Component	Range of Potential Impacts on Postclosure Dose	
	10,000-Year Peak Mean Dose	**Post-10,000-Year Peak Mean Dose**
Integrated Site Model	No change	No change
Unsaturated Zone	One order of magnitude decrease to small increase	Small decrease to small increase
Near-Field Environment	Small decrease to small increase	Small decrease to small increase
Engineered Barrier System	Negligible decrease to negligible increase	Negligible decrease to negligible increase
Waste Package	No change	No change
Waste Form	Negligible decrease to negligible increase	No change to negligible increase
Saturated Zone	Negligible decrease to negligible increase	Negligible decrease to negligible increase
Biosphere	Negligible increase	Small decrease
Disruptive Events—Volcanism/Seismicity	No change to no more than one order of magnitude increase	No change to no more than one order of magnitude increase
Disruptive Events—Criticality	No change	No change
Total System	**One order of magnitude decrease to no more than one order of magnitude increase**	**Small decrease to no more than one order of magnitude increase**

The area contributing to the largest potential impact is disruptive events—volcanism and seismicity. This is from the information provided on dike–drift interaction by the U.S. Nuclear Regulatory Commission (NRC)-funded Center for Nuclear Waste Regulatory Analysis at the Southwest Research Institute (non-Project). These analyses represent an initial attempt to mathematically model in more detail the dike–drift interaction process and present an idealized conceptual model for further evaluating igneous consequences of dike–drift interactions. Even if all assumptions contained in the analyses are valid, and incorporating those assumptions into the Project's total system performance assessment model for extrusive igneous consequences, the number of degraded waste packages are not expected to increase by more than an order of magnitude. Therefore, the dose is not expected to increase by more than an order of magnitude (i.e., from approximately 0.1 mrem/yr to 1 mrem/yr in the supplemental TSPA model). It should be noted that the Project is not adopting the Center's approach until a more thorough evaluation has been done. Should ongoing work performed by Project scientists substantiate the hypothesis proposed by the Center, this may warrant potential inclusion in the total system performance assessment.

An area of considerable interest during the impact review was the near field environment thermal-hydrologic-chemical data. Four recent water samples condensed from high temperature vapor in the Drift Scale Test show fluoride concentrations as high as 66 ppm and pH values as low as 3.1 at the sample collection temperature of about 50°C (120°F). At present, the source of this solution is unknown. However, it is considered likely to be an experimental artifact, from fluoride leached either from Viton used in borehole packers or from Teflon-lined sampling tubes. This is based on information provided by the Viton packer manufacturer (Dupont Dow Elastomers, LLC) regarding the leaching potential of these packers, as well as experience gained

from hydrothermal autoclave experiments using Teflon. This is further discussed in the white paper on the near-field environment (Appendix C).

Another possibility for the source of this solution that cannot be ruled out until further information is collected on the behavior of the introduced materials is that the presence of fluoride may have resulted from the interaction of steam with fluoride-bearing minerals in the rock. If this is the case, hydrogen fluoride gas could be produced within the host rock at sustained temperatures as low as 138°C (280°F). If the hydrogen fluoride gas is transported to the engineered barrier system and dissolved into an aqueous phase, this could have the potential to enhance corrosion on the drip shields and waste packages. Analyses have not been conducted to determine the extent of such corrosion or the resulting potential impact on performance.

Current Project efforts are focused on determining the actual source of this fluoride solution. As indicated earlier, it is considered likely to be an experimental artifact. To confirm this, some sampling will be conducted in existing "blank" boreholes that are at similar high temperatures to determine if this solution is present. The boreholes will then be filled with Viton and Teflon and additional samples taken. This sampling is to be completed by mid-December 2001.

3.2 PRECLOSURE IMPACTS

The preclosure impact review concluded that the additional information relevant to the various preclosure inputs does not result in any significant impact to the results of the preclosure safety assessment documented in the *Preliminary Preclosure Safety Assessment for Monitored Geologic Repository Site Recommendation* (BSC 2001c).

Additional meteorological information could potentially affect the analysis of the atmospheric dispersion factors (χ/Qs) used in the consequence analyses in the preclosure safety assessment. However, since the additional meteorological and climatological data do not vary significantly from the previously collected data used to calculate atmospheric dispersion factors, there is no impact on the results of the reference analyses.

The design basis for the monitored geologic repository ground support is to prevent a 6-metric-ton rock or larger from falling on the waste package during the preclosure period. Based on the information at the time, it was concluded in the preclosure safety assessment (BSC 2001c) that the frequency of a rockfall was less than 1×10^{-6} events per year for the cases with preclosure scenarios lasting 50 years (standard/base-case scenario) and 125 years and greater than 1×10^{-6} events per year for the cases with preclosure scenarios lasting 325 years. The draft rockfall analysis (BSC, in preparation) results indicate that for the standard-case/base-case scenario (with 50-year preclosure period) loaded with 70,000 metric tons of heavy metal, the frequency of a rockfall of 6 metric tons or larger is less than 1×10^{-6} events per year. This met the ground support design basis requirement. However, for other repository scenarios, the frequency of a rockfall of at least 6 metric tons is greater than 1×10^{-6} events per year (i.e., areas with lithophysal rock units supported only by steel sets, scenarios with larger footprints, longer preclosure periods, and/or greater spacing between waste packages). However, it was stated in the preclosure safety assessment that the final potential repository design is not complete and that design optimizations (such as use of more rock bolts, early placement of drip shields) are available to ensure that the frequency of this event remains less than 1×10^{-6} events per year

such that the ground support design basis requirement is met. This conclusion remains valid. Consequently, there is no impact to the conclusions made in the preclosure safety assessment concerning the rockfall event.

With respect to seismic parameters, the expanded geotechnical data set and the ongoing analyses are expected to result in added confidence in the existing ground motion estimates. The amount of uncertainty incorporated into the site-specific ground motions for the potential repository block (based on limited velocity data available in 1999) appears to be greater than is warranted based on the additional data for the block, as discussed in Section 4.3 of Appendix I. Higher ground motions resulting from this uncertainty, therefore, should be reduced, although it is noted that other changes associated with the expanded data set may offset this effect. Therefore, there is no impact to the conclusions reached in the preclosure safety assessment concerning earthquake-related events.

Regarding the topic of aircraft activity, based on recent information on the average number of flights increasing over the Nevada Test Site (from 12,717 to 17,394 per year), the mean aircraft crash frequency will increase by approximately 37 percent. The preclosure safety assessment concluded that the frequency of an aircraft crash event is less than 1×10^{-6} events per year, based on the use of 12,717 flights per year. The mean frequency of an aircraft crash event increases from 2.8×10^{-7} events per year to 3.84×10^{-7} events per year based on the increase in flights per year. However, the frequency of this event remains less than 1×10^{-6} events per year, even with a 37 percent increase in the annual aircraft activity. Therefore, there is no impact to the conclusions reached in the reference analyses.

With respect to heavy load drops, the estimate of load drop frequency (drops/number of lifts) from a recent draft NRC report (Lloyd 2001) is a factor of 1.4 higher than used in the preclosure safety assessment. However, using a more realistic statistical model (such as the Bayesian statistical model), the drop frequency based on the additional information is 1.1×10^{-5} drops per lift (based on 47,400 lifts with no drops of any consequence). This drop frequency is smaller than the value used in the reference analyses (1.4×10^{-5} drops per lift). Therefore, no significant impact is expected to the conclusions in the analyses.

4. CONCLUSIONS

Several conclusions can be drawn from the evaluation of the additional information contained in this letter report.

1. The additional information for the most part provides supplemental input that confirms the results (and in some cases reduces the uncertainty) of the postclosure and preclosure technical analyses used as the technical basis for the *Yucca Mountain Science and Engineering Report* (DOE 2001a) and the *Yucca Mountain Preliminary Site Suitability Evaluation* (DOE 2001b). Where this is not the case, the impacts of the additional information on the results of the analyses are not significant.

2. The current DOE technical basis regarding igneous consequence analyses is appropriate to support the site suitability determination and to support the Secretary's consideration regarding a possible site recommendation. The work done provides a defensible basis (the low probability of an event and the robustness of the hazard estimate, the waning character of volcanism in the region, localization of igneous activity away from Yucca Mountain), and the analyses of igneous consequences are representative of a range of effects. The DOE analyses appropriately demonstrate the probabilistic risk to a potential receptor represented by a basaltic volcanic event intersecting a repository at Yucca Mountain, within the framework of the state of knowledge on magma–repository–waste package–waste form interactions that existed at the time of the *FY01 Supplemental Science and Performance Analyses* (BSC 2001a; BSC 2001b).

3. At present, the source of the solution containing high fluoride concentrations and low pH values found in the sampling done in the Drift Scale Test is unknown. While it is considered likely to be an experimental artifact (from fluoride leached either from Viton used in borehole packers or from Teflon-lined sampling tubes), the possibility that the presence of this fluoride may have resulted from the interaction of steam with fluoride-bearing minerals in the rock cannot be ruled out at this time until further information is collected on the behavior of the introduced materials. Therefore, it is appropriate that current Project efforts are focused on determining the actual source of this fluoride solution through additional sampling in existing boreholes that are at similar high temperatures.

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