Dr. Stephan Brocoum, Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, NV 89036-0307

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF ENERGY TECHNICAL EXCHANGE AND MANAGEMENT MEETING ON IGNEOUS ACTIVITY (SEPTEMBER 5, 2001)

Dear Dr. Brocoum:

Enclosed are the meeting summary highlights agreed upon during the September 5, 2001, Technical Exchange and Management meeting between the staff of the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. The main purpose of the meeting was to discuss one of the Key Technical Issues, Igneous Activity (IA). The meeting was held in Las Vegas, Nevada.

If you have any questions regarding this letter, please contact the technical lead for IA, Mr. John Trapp or the Senior Project Manager for issue closure, Mr. James Andersen. Mr. Trapp can be reached at (301) 415-8063 and Mr. Andersen at (301) 415-5717.

Sincerely,

C. William Reamer, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on IA

cc: See attached distribution list

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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Letter to S. Brocoum from C.W. Reamer dated: _____

cc:

R. Loux, State of Nevada
S. Frishman, State of Nevada
L. Barrett, DOE/Washington, DC
A. Brownstein, DOE/Washington, DC
S. Hanauer, DOE/Washington, DC
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T. Gunter, YMPO
K. Hess, BSC
D. Krisha, BSC
S. Cereghina, BSC
N. Williams, BSC
M. Voegele, BSC/SAIC
R. Henning, BSC
B. Price, Nevada Legislative Committee
J. Meder, Nevada Legislative Counsel Bureau
I. Navis, Clark County, NV
E. von Tiesenhausen, Clark County, NV
A. Kalt, Churchill County, NV
G. McCorkell, Esmeralda County, NV
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R. Clark, EPA
F. Marcinowski, EPA
R. Anderson, NEI
R. McCullum, NEI
S. Kraft, NEI
J. Kessler, EPRI
D. Duncan, USGS
R. Craig, USGS
W. Booth, Engineering Svcs, LTD
J. Curtiss, Winston & Strawn
S. Echols
N. Rice, NV Congressional Delegation
T. Story, NV Congressional Delegation
J. Reynoldson, NV Congressional Delegation
S. Joya, NV Congressional Delegation
J. Pegues, City of Las Vegas, NV
L. Lehman, T-REG, Inc.

Please Note: The enclosed letter to DOE documents a Technical Exchange and Management Meeting on the Key Technical Issue, "Igneous Activity," conducted on September 5, 2001. The meeting summary is included as an enclosure to the letter. Attachment 1 to the meeting summary lists the agreements made by the NRC/DOE at the meeting, Attachment 2 provides additional detail on existing agreements, Attachment 3 is the agenda, and Attachment 4 is the attendance list. Due to the size of Attachment 5 (presenter's slides), they are not included in this mailing. If you are interested in viewing or printing this attachment, it can be obtained from the NRC website (www.nrc.gov) under the ADAMS icon (or you can go directly to the ADAMS homepage at www.nrc.gov/NRC/ADAMS. If you do not have access to the website and/or are interested in getting a hard copy of Attachment 5, please contact Ms. Darlene Higgs at 301-415-6711 or e-mail at gdh1@nrc.gov.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Igneous Activity

September 5, 2001
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Igneous Activity is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with the DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of igneous activity most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues are "closed" if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are "open" if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application.

The objective of this meeting was to discuss and review the progress on resolving the Igneous Activity KTI, specifically Subissue 2 (see Attachment 1 for the description of the subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of the DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC stated that the status of Igneous Activity Subissues 1 and 2 are now closed-pending. Consistent with what was discussed during the Total System Performance Assessment and Integration (TSPAI) Technical Exchange and Management Meeting on August 6-10, 2001, with the status of

Igneous Activity Subissue 2 changing to closed-pending, TSPAI Subissue 3 can now be classified as closed-pending.

Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. A modification to an existing NRC/DOE agreement is provided as Attachment 2. The agenda and the attendance list are provided as Attachments 3 and 4, respectively. Copies of the presenters slides are provided as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments and Overview

NRC opened the meeting with an overview of igneous activity (see "Overview of Igneous Activity Meeting" presentation given by James Andersen) and stated that this meeting would address part of DOE's performance assessment related to igneous activity. NRC discussed what performance assessment is and the terms and definitions used. NRC then discussed igneous activity, the terms used, and the general areas within the Igneous Activity KTI which would be discussed during the meeting. NRC further stated that staff would be available to discuss general comments or questions with members of the public during the breaks and after the meeting.

NRC then provided an overview of the Igneous Activity KTI. NRC stated that during the June 21-22, 2001, Technical Exchange and Management Meeting, NRC and DOE reached six agreements related to the biosphere, modified five existing Igneous Activity agreements, and superceded three existing Igneous Activity agreements, but that NRC and DOE were not able to reach agreement in a number of areas for which NRC proposed 13 additional agreements. NRC stated that these 13 proposed agreements should provide a starting point for today's technical exchange.

2) Technical Discussions - Igneous Activity Subissue 2

DOE provided an overview of the Igneous Activity issue (see "DOE Plans to Address NRC Proposed Agreements Associated with the Igneous Activity Consequences Subissue" presentation given by Eric Smistad and Gregory Valentine). DOE stated that it has planned work to evaluate igneous consequences to strengthen the basis supporting any potential license application. DOE stated that its objective for the meeting is to discuss its plans to address NRC proposed agreements from the June 2001 technical exchange. DOE noted that any references to design elements refer to the license application design and that references to completion dates are expected dates (final dates are contingent on planning and budget).

DOE stated that the 13 NRC proposed agreements can be broken down into four areas: (1) ash and soil redistribution; (2) magma-drift interactions; (3) magma-waste package interactions; and (4) magma-waste form interactions. DOE then discussed each specific area and the NRC proposed agreements related to the area.

Ash and Soil Redistribution

DOE stated that the NRC proposed agreements in this area discussed: (1) the effects of eolian and fluvial remobilization are bounded; and (2) the effects of ash/soil suspension on radionuclide concentrations. DOE discussed its planned work in the ash/soil remobilization area. DOE stated that it will conduct analog studies of remobilized ash deposits, conduct field studies of Yucca Mountain surficial erosion rates, and develop mathematical models based on the first two studies. NRC questioned DOE's planning for eolian remobilization. DOE stated that it parallels what it is doing in the fluvial area. NRC asked if any of the analogs it is considering have tephra-fall deposits on low permeability soils that are analogous to the Yucca Mountain area. DOE stated that Lathrop Wells was one such analog site but that other analog sites had not yet been identified. NRC asked whether DOE is planning to look at flooding data at Yucca Mountain, such as from the 1996-1998 floods. DOE stated that it plans to do that. NRC questioned whether DOE will evaluate potential change in grain sizes due to transport and abrasion. DOE stated that it planned to look into this process.

DOE then addressed ash/soil suspension effects. DOE discussed its planned work and stated that it would assess the waste incorporation mechanism in the ASHPLUME code and complete analysis of waste concentration on ash particles suspended in air versus concentration in soil. DOE also clarified which work would be covered by certain AMRs and noted that the planned work would be captured in the Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR or other appropriate technical documents.

Magma-Drift Interactions

The second area DOE discussed was magma-drift interactions. DOE stated that the NRC proposed agreements discussed an evaluation of: (1) stress accumulation from high-level waste thermal-mechanical effects; (2) how presence of engineered repository structures can affect magma flow processes for the duration of an igneous event; (3) how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system; and (4) mechanical strength of natural or engineered barriers that are proposed to restrict magma flow within intersected drifts.

DOE discussed its planned work to evaluate stress accumulation from high-level waste thermal-mechanical effects and stated that it would evaluate: (1) Yucca Mountain stress field and strain data; (2) analyze topographic effects on dike propagation; and (3) analyze effects of excavated structures and heat. NRC noted that the level of work in this area would depend on the exact assumptions used in the performance assessment. NRC asked whether DOE had models available to address the strain issue. DOE stated that existing models may need modification to evaluate strain response as well as stress accumulation.

DOE discussed its planned work to evaluate the effects of engineered repository structures on magma flow processes. DOE stated that it would perform a dike propagation analysis, exsolution/fragmentation kinetics analysis, and magma and gas flow analysis. NRC asked if the analysis would look at propagation of a dike through an intact block relative to propagation along a fault. DOE stated that the propagation study was directed towards the repository area and also asked if the question included capture of a dike by a fault. NRC stated it did. DOE stated that field studies on conduit geometry will examine the role of pre-existing faults on dike

and conduit formation. NRC asked whether DOE was using experiments in the fragmentation kinetics analysis. DOE described some of the experiments it planned to do in this area.

DOE discussed its planned work to evaluate the effects of subsurface repository structures on the ascent of basaltic magma. To address the issue, DOE stated that its planned analyses included dike propagation, magma and gas flow, and conduit size/geometry. The NRC had no questions in this area.

DOE discussed its planned work to evaluate the mechanical strength of natural or engineered barriers. DOE stated that it planned to perform a magma and gas flow analysis which would investigate erosion and entrainment of debris in drifts, as well as pressure-temperature conditions and durations. The NRC had no questions in this area.

DOE discussed its planned work to evaluate the presence of backfill or rockfall which may affect magma flow processes. DOE stated that this issue is closely related to the issue of mechanical strength of debris accumulations or barriers (discussed above). As discussed above, DOE stated that it planned to perform a magma and gas flow analysis to address this issue. The NRC noted a particular concern with the ability of partial blockage to affect flow processes in the drift. DOE indicated that planned studies would examine this process.

Magma-Waste Package Interactions

The third area DOE discussed was magma-waste package interactions. DOE stated that the NRC proposed agreements discussed an evaluation of: (1) canister responses to stress from dynamic magmatic repressurization, gravitational loading, and heating; (2) aging effects on materials strength properties resulting from basaltic magmatic conditions; and (3) the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gases. DOE noted that in the Total System Performance Assessment for Site Recommendation, it defined Zone 1 as those waste packages which totally breach due to the magma; Zone 2 as those waste packages which were affected by contact with magma but only partially breached, and Zone 3 as those remaining waste packages that were not directly contacted by magma.

DOE discussed its planned work to evaluate waste package response to stress. DOE stated that it planned to; (1) perform magma and gas flow and hydrothermal analyses which will provide pressure, temperature, chemistry, and dynamic conditions for analyses and waste package modeling; and (2) develop models for the response of the waste package to those conditions. NRC questioned whether the magma and gas flow analyses information would be coming out of the revised dike propagation analysis. DOE stated that it would be. NRC asked if the gas chemistry would consider changes in oxygen fugacity due to atmospheric mixing. DOE stated the studies would consider this. NRC asked if DOE will be providing a range of oxidation conditions to the DOE Waste Package Group for its models. DOE stated that this range would be provided.

DOE discussed its planned work to evaluate aging effects on materials strength properties when exposed to basaltic magma. DOE stated that it planned to perform: (1) waste package analyses which will include effects of aging prior to onset of an igneous event; (2) magma and gas flow analyses which provide pressure, temperature, chemistry, and dynamic conditions for

analyses and modeling of waste package response; and (3) analysis which will include aging effects after onset of an igneous event and will also address seismic vulnerability of aged waste packages. NRC clarified that its primary concern in this area was temperature/pressure effects on the waste package for the duration of the igneous event and what those effects have on subsequent waste package performance. NRC asked whether DOE would evaluate the exposure in Zones 1, 2, and 3. DOE stated that it would.

DOE discussed its planned work to evaluate the waste package response to magmatic gases. DOE stated that it planned to: (1) perform magma and gas flow and hydrothermal analyses which will provide information on the distribution and time histories of magmatic gases in the repository; and (2) develop models for the response of waste packages to those environmental conditions. DOE noted that, in general, all the igneous activity issues get wrapped up into the Igneous Activity Consequences AMR which in turn is an input into the total system performance assessment.

Magma-Waste Form Interactions

The fourth area DOE discussed was magma-waste form interactions. DOE stated that the NRC proposed agreements discussed: (1) an evaluation of how magma ascent and flow through repository structures may incorporate high-level waste located along potential flow paths; (2) the physical and chemical response of high-level waste and cladding after heating and potential disruption of waste package; and (3) providing an independent technical basis for the method of high-level waste incorporation used in DOE models.

DOE discussed its planned work to evaluate magma incorporation of high-level waste form into magma along flow paths. DOE stated that it planned to perform magma and gas flow analyses which would provide pressure, temperature, chemistry, and dynamic conditions for analyses and modeling by its Waste Form Department. DOE further stated that its Waste Form Department would: (1) analyze waste form response to magmatic environment in drifts both within and outside of waste packages to determine waste form physical and chemical phases; (2) determine waste form physical and chemical phases for waste brought to the surface by magma; (3) determine waste form physical and chemical phases for waste in ash plume; and (4) describe potential changes in waste form caused by surface transport processes. NRC asked if DOE plans to develop a model to determine what percentage of high-level waste could be entrained by lava flows, versus entrained in the tephra eruption. DOE indicated they would continue to consider a range of eruption models.

DOE discussed its planned work to evaluate physical and chemical response of high-level waste and cladding. DOE stated that it planned to perform magma and gas flow and hydrothermal studies to provide pressure, temperature, chemistry, and dynamic conditions for waste form analyses and modeling. DOE stated that its Waste Form Department would then evaluate: (1) commercial spent nuclear fuel/high-level waste glass/defense spent nuclear fuel dissolution kinetics after exposure to magma; and (2) commercial spent nuclear fuel cladding pressurization and creep/hydride failure. NRC clarified that dissolution processes included high-level waste dissolution into magma, and aqueous dissolution after the igneous event. DOE agreed that both dissolution processes would be considered.

DOE discussed its planned work to strengthen its technical basis for the method of high-level waste incorporation in DOE ash dispersion models. DOE stated that it planned to assess the waste incorporation mechanism that is implied in the ASHPLUME code. The NRC had no questions in this area.

3) DOE Proposed Igneous Activity Agreements

DOE then discussed four proposed agreements which it believed addressed the 13 NRC proposed agreements from the June 2001 technical exchange and management meeting. DOE presented each of the four agreements and how the agreements addressed the NRC issues (see "DOE Plans to Address NRC Proposed Agreements Associated with the Igneous Activity" presentation for the wording of the DOE proposed agreements - Attachment 5).

After caucusing on the DOE proposed agreements, the NRC stated that it agreed with Proposed Agreement 1, which would be renumbered to Igneous Activity Agreement 2.17, but noted that the NRC does not require bounding conservative modeling assumptions. The NRC stated that it needed DOE to justify its modeling assumptions. With regard to Proposed Agreement 2, the NRC stated that it agreed with the wording of the agreement. With regard to Proposed Agreements 3 and 4, the NRC agreed with the wording of the agreements with minor editorial changes.

DOE noted that it would like to include a reference to other appropriate technical documents in each agreement. The NRC agreed with the proposal. NRC and DOE also discussed the need to have additional technical exchanges, Appendix 7 meetings, and workshops to discuss DOE's progress and the NRC's work in the igneous activity consequence area. DOE stated that it was open to have additional pubic interactions as it moved forward in its plans and analyses, as appropriate.

Based on reaching these four agreements, the NRC stated that Igneous Activity Subissue 2 can be classified as closed-pending. Consistent with what was discussed during the TSPAI Technical Exchange and Management Meeting on August 6-10, 2001, with the status of Igneous Activity Subissue 2 changing to closed-pending, TSPAI Subissue 3 can now be classified as closed-pending.

4) Other Igneous Activity Agreements

NRC and DOE also discussed Igneous Activity Agreement 1.02. NRC stated that it needed a schedule and document reference. DOE stated that the schedule for the aeromagnetic data evaluation was fiscal year 2003 and that it would be documented in the Characterize Framework for Igneous Activity at Yucca Mountain AMR.

5) Public Comments

Elaine Hiruo (PLATT Publishing) asked whether the Igneous Activity consequences subissue was closed. The NRC clarified that with the agreements reached with DOE, the Igneous Activity consequence subissue is classified as closed-pending. The pending portion of this classification is the additional information DOE agreed to provide to the NRC.

for 9/5/01

C. William Reamer
Chief, High Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards
Nuclear Regulatory Commission

9/5/2001

April V. Gil
Team Lead
Regulatory Interactions and Policy Development
Office of Licensing & Regulatory Compliance
Department of Energy

Summary of the Resolution of the Key Technical Issue on Igneous Activity - Agreements Reached

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Probability of future igneous activity	Closed-Pending	See modification of Agreement IA.1.02 in Attachment 2
2	Consequences of future igneous activity	Closed-Pending	IA.2.17 - DOE will evaluate conclusions that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization are bounded by conservative modeling assumptions in the TSPA-SR, Rev 00, ICN1. DOE will examine rates of eolian and fluvial mobilization off slopes, rates of transport in Fortymile Wash, and rates of deposition or removal at proposed critical group location. DOE will evaluate changes in grain size caused by these processes for effects on airborne particle concentrations. DOE will also evaluate the inherent assumption in the mass loading model that the concentration of radionuclides on soil in the air is equivalent to the concentration of radionuclides on soil on the ground does not underestimate dose (i.e., radionuclides important to dose do not preferentially attach to smaller particles). DOE will document the results of investigations in the AMR, *Eruptive Processes and Soil Redistribution* ANL-MGR-GS-000002, expected to be available in fiscal year 2003 and in the AMR, *Input Parameter Values for External and Inhalation Radiation Exposure Analysis*, ANL-MGR-MD-000001, available FY 2003, or another appropriate technical document.

2	Consequences of future igneous activity - Cont.		IA.2.18 - DOE will evaluate how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system. The evaluation will include the potential effects of topography and stress, strain response on existing or new geologic structures resulting from thermal loading of HLW, in addition to a range of physical conditions appropriate for the duration of igneous events. DOE will also evaluate how the presence of engineered repository structures in the LA design (e.g., drifts, waste packages, backfill, etc.) could affect magma flow processes for the duration of an igneous event. The evaluation will include the mechanical strength and durability of natural or engineered barriers that could restrict magma flow within intersected drifts. The results of this investigation will be documented in an update to the AMR, *Dike Propagation and Interaction with Drifts*, ANL-WIS-MD-000015, expected to be available in FY 2003, or another appropriate technical document.
			IA.2.19 - DOE will evaluate waste package response to stresses from thermal and mechanical effects associated with exposure to basaltic magma, considering the results of evaluations attendant to IA Agreement 2.18. As currently planned, the evaluation, if implemented, would include (1) appropriate at-condition strength properties and magma flow paths, for duration of an igneous event; and (2) aging effects on materials strength properties when exposed to basaltic magmatic conditions for the duration of an igneous event, which will include the potential effects of subsequent seismically induced stresses on substantially intact waste packages. DOE will also evaluate the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gases at conditions appropriate for an igneous event, considering the results of evaluations attendant to IA Agreement 2.18. If models take credit for engineered barriers providing delay in radionuclide release, DOE will evaluate barrier performance for the duration of the hypothetical igneous event. The results of this investigation would be documented in an update to the technical product *Waste Package Behavior in Magma* CAL-EBS-ME-000002, which would be available by the end of FY 2003, or another appropriate technical document.

2	Consequences of future igneous activity - Cont.		IA.2.20 - DOE will evaluate how ascent and flow of basaltic magma through repository structures could result in processes that might incorporate HLW, considering the results of evaluations attendant to IA Agreements 2.18 and 2.19. As currently planned, the evaluation, if implemented, would include the potential for HLW incorporation along reasonable potential flow paths that could develop during an igneous event. The evaluation would also include the physical and chemical response of HLW and cladding after heating and potential disruption of waste package and contents, for waste packages remaining in drifts. The evaluation would examine effects that may result in increased solubility potential relative to undisturbed HLW forms. The results of this investigation would be documented in a new AMR to document the waste form response to magmatic conditions, which is expected to be available by the end of FY 2003. DOE will describe the method of HLW incorporation used in DOE models, including consideration of particle aggregation and the effect on waste transport. If models take credit for engineered barriers providing delay in radionuclide release, DOE will evaluate barrier performance for the duration of the hypothetical igneous event. This will be documented in an update to the igneous consequences AMR, ANL-WIS-MD-000017, which is expected to be available in FY 2003, or another appropriate technical document.

CHANGES TO EXISTING IGNEOUS ACTIVITY NRC/DOE AGREEMENTS

IA.1.02 -Examine new aeromagnetic data for potential buried igneous features (see U.S. Geological Survey, Open-File Report 00-188, Online Version 1.0), and evaluate the effect on the probability estimate. If the data survey specifications are not adequate for this use, this action is not required. DOE agreed and ~~its initial evaluation of the report with proposed actions resulting from the review will be available to the NRC by October 11, 2000.~~ will document the results of the evaluation in an update to the AMR, *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (ANL-MGR-GS-000001), expected to be available in FY 2003.

Agenda Igneous Activity Technical Exchange September 5, 2001 Las Vegas, Nevada	
Time	Agenda Item
8:00 – 8:15 AM	Opening Remarks - DOE/NRC
8:15 – 8:30 AM	Introductory Remarks - NRC
8:30 – 9:15 AM	Tephra Redistribution and Preferential Relationship of Radionuclides to Soil Particle Size
9:15 – 9:30 AM	BREAK
9:30 – 11:00 AM	Magma-Drift, Magma-Waste Package, and Magma-Waste Form Interactions
11:00 – 11:15 AM	DOE Proposed Agreements
11:15 – 12:15 PM	Caucus
12:15 – 1:15 PM	LUNCH
1:15 – 1:45 PM	Discussion of Caucus Results
1:45 – 2:15 PM	Caucus (if necessary)
2:15 – 2:30 PM	Final Comments
2:30 PM	Adjourn technical exchange

Techical Exchange - Igneous Activity
September 5, 2001
Summerlin Offices - Bldg. 9
Las Vegas, Nevada
Sign In Sheet

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Techical Exchange - Igneous Activity
September 5, 2001
Summerlin Offices - Bldg. 9
Las Vegas, Nevada
Sign In Sheet

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	Terry Crump	BSC	702 295 7476
	John McCord	BSC	(505) 246-1600
	George Ackstrom	DOE	702-794-1419
	Don Krier	LANL	505-665-7834
	Larry McKague	CNWRA	210 522-5183
	Tom Thornton	BSC	702-295-4177
	Bob Andrews	BSC	702 295 5549
	Greg Valentine	BSC/LANL	505 665 0289
	Ed Gaffney	LANL	505 665 6387
	A.J. Smith	DOE	702-295-4040
	Maryla A. Wasiolek	BSC	702-295-3990
	Zekai Ceylan	BSC	702-295 4741
	John Savino	MTS	794-5574
	Mark Tynan	DOE/YMP	794-5457
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	Jim York	Bridge	
	Tae Ahn	NRC - Bridge	
	Sandi Wastler	NRC - Bridge	
	Elaine Hirao	PLATT Publishing - Bridge	
	King Stablein	NRC - Bridge	
	Tim McCartin	NRC - Bridge	

Attachment 5

Presenters' Slides

Overview of Igneous Activity Meeting

Las Vegas, Nevada
September 5, 2001

Presented by
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- **Meeting will address the part of the Department of Energy's (DOE) performance assessment related to igneous activity.**

- **Performance Assessment is**
  - **Systematic analysis of what could happen at a repository. This means answering three questions:**
    - **what can happen?**
    - **how likely is it?**
    - **what can result?**
  - **Conducted by**
    - **Collecting data**
    - **Developing conceptual and mathematical models**
    - **Combining models and evaluating performance**
  - **One of many NRC safety requirements**

Performance Assessment terms and definitions

- **Scenario** - another way of saying "what can happen?"
- **Probability** - another way of saying "how likely?"
- **Consequence** - another way of saying "what can result?"
- **Scenario analysis** - an evaluation of what can happen
- **Features, Events, and Processes (FEPs)** - factors that are necessary to describe what can potentially happen to the repository.
  - Examples include: design of the repository, construction of the repository, strength of the waste containers and how well they resist corrosion, the nature of the waste, and natural events such as volcanoes.

- **<u>Igneous Activity</u> is**
  - **Process of formation of rocks from molten rock.**
  - **Defined by the NRC as predicting the consequence and probability of igneous processes affecting the repository in relationship to overall system safety objective.**

Igneous Activity terms and definitions

- **Magma** - molten rock with crystals and gas bubbles
- **Intrusive** - magma flow below ground surface
- **Extrusive** - magma flow above ground surface
- **Volcanic** - extrusive process at a volcano
- **Tephra** - pieces of magma flung out of a volcano
- **Ash** - pieces of tephra smaller than 0.5 inches
- **Volatiles** - gases such as steam
- **Biosphere** - environment in which people live

- **Meeting will address the DOE's treatment of igneous activity in their performance assessment**
  - **How would rising magma interact with a tunnel, and what results from the interaction?**
  - **How would flowing magma interact with waste packages, and what results from the interaction?**
  - **How would flowing magma interact with the contents of waste packages, and what results from the interaction?**
  - **How would volcanic ash derived from an eruption thru the repository move in the environment, and what are the results of these ash movements?**

- **Our independent review of the DOE's performance assessment currently questions how DOE treated**
  - **Magma interactions with a tunnel**
  - **Magma interactions with waste packages**
  - **Magma interactions with wastes within packages**
  - **Volcanic ash movement in the environment**
    - **During an eruption**
    - **During long-term erosion**

Summary of June 21-22, 2001, Igneous Activity Meeting

- During the June 21-22, 2001, technical exchange, the NRC and DOE reached six agreements related to the biosphere
- Igneous Activity Agreements 2.02, 2.03, 2.04, 2.09, and 2.10 were modified to reflect that TSPA-SR, Rev. 01 would not be issued in June 2001.
- Igneous Activity Agreements 2.05, 2.06, and 2.07 were superceded by Agreements 2.11 through 2.16 and the proposed NRC agreements
- However, NRC and DOE were not able to reach agreement in a number of areas, for which NRC proposed 13 additional agreements

NRC Goals for this Technical Exchange

- Use the proposed NRC agreements from the June 21-22, 2001, meeting as a starting point for today's discussions

- Reach agreement with DOE on what additional information DOE will provide in order for the NRC to make a regulatory decision at the time of any future license application

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

DOE Plans to Address NRC Proposed Agreements Associated with the Igneous Activity Consequences Subissue

Presented to:
DOE-NRC Technical Exchange on Key Technical Issues Topics Related to Igneous Activity

Presented by:
E. T. Smistad
U.S. Department of Energy

G. A. Valentine
Disruptive Events Department

September 5, 2001
Las Vegas, Nevada

Outline

- Overview
- NRC proposed agreements and DOE plans to address them
- DOE proposed agreements
- Summary

Overview

- At the June 20-21, 2001 technical exchange, an igneous activity consequence model that depicts the magma-repository interactions more mechanistically was described
- DOE has planned work to evaluate igneous consequences to strengthen the basis supporting any potential license application
- The objective of this meeting is to discuss DOE plans to address NRC proposed agreements from the June 2001 technical exchange
  - Tephra redistribution and soil suspension effects
  - Interactions between an ascending basaltic magma and repository system components

Overview
(Continued)

- Any references to design elements refers to license application design
- References to completion dates are expected dates. Final dates are contingent on planning and budget

Summary of NRC Proposed Agreements

- **NRC proposed agreements can be separated into four topics**
  - **Ash and Soil Redistribution**
  - **Magma-Drift Interactions**
  - **Magma-Waste Package Interactions**
  - **Magma-Waste From Interactions**

NRC Proposed Agreements
Ash and Soil Redistribution

- **Effects of eolian and fluvial remobilization are bounded**
- **Effects of ash/soil suspension on radionuclide concentrations**

Eolian and Fluvial Remobilization

- **NRC Proposed Agreement 11: Provide a technical basis to support conclusions that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization are bounded by conservative modeling assumptions in the TSPA-SR, Rev 00, ICN01. Particular attention should be paid to: (i) rate of mobilization off slopes, (ii) rate of transport in Fortymile Wash drainages, (iii) rate of transport from eolian processes, (iv) deposition rate at proposed critical group location, (v) changes in particle-size distributions during fluvial transport**

Eolian and Fluvial Remobilization

(Continued)

- **Planned Work**
  - **Ash/Soil Remobilization Effects**
    - **Analog studies of remobilized ash deposits**
    - **Field study of Yucca Mountain surficial erosion rates**
    - **Development of mathematical models**
  - **Revise Eruptive Processes and Soil Redistribution AMR, ANL-MGR-GS-000002, expected FY 2003**
  - **Revise Igneous Consequences AMR, ANL-WIS-MD-000017, expected FY 2003**
- **Discussion**

Ash/Soil Suspension Effects

- **NRC Proposed Agreement 13: Provide support that the inherent assumption in the mass loading model that the concentration of radionuclides on soil in the air is equivalent to the concentration of radionuclides on soil on the ground does not underestimate dose (i.e., radionuclides important to dose do not preferentially attach to smaller particles)**

Ash/Soil Suspension Effects

- **Planned Work**
  - **Assess waste incorporation mechanism in the ASHPLUME code**
  - **Complete analysis of waste concentration on ash particles suspended in air versus concentration in soil in place**
  - **Revise AMR, Input Parameter Values for External and Inhalation Radiation Exposure Analysis, ANL-MGR-MD-000001, REV 01, available FY 2003**
  - **Revise igneous consequences AMR, ANL-WIS-MD-000017, expected FY 2003**
- **Discussion**

NRC Proposed Agreements
Magma-Drift Interactions

- Evaluate stress accumulation from high-level waste (HLW) thermal-mechanical effects
- Evaluate how presence of engineered repository structures can affect magma flow processes for the duration of an igneous event
- Evaluate how the presence of repository structures may affect magma ascent, conduit localization and evolution of the conduit and flow system
- Evaluate mechanical strength of natural or engineered barriers that are proposed to restrict magma flow within intersected drifts

Stress Accumulation From HLW Thermal-Mechanical Effects

- **NRC Proposed Agreement 1: Evaluate the stress distribution and strain response on existing or new geologic structures resulting from thermal loading of HLW. The evaluation should include appropriate spatial variations in overlying topography and appropriate spatial and temporal variations in thermal load**

Stress Accumulation From HLW Thermal-Mechanical Effects

(Continued)

- **Planned Work**
  - **Dike Propagation Analysis**
    - **Evaluate Yucca Mountain stress field and strain data**
    - **Analyze topographic effects on dike propagation**
    - **Analyze effects of excavated structures and heat**
  - **Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003**
- **Discussion**

Effects of Engineered Repository Structures on Magma Flow Processes

- **NRC Proposed Agreement 2: Evaluate how the presence of engineered repository structures (e.g., drifts, waste packages, etc.) can affect magma flow processes for the duration of an igneous event. Include in this evaluation the potential effects on initial magma flow characteristics, diversion of ascending magma into repository structures, reestablishment of multiple flow paths to the surface, two phase flow, reaction of the geologic and engineered system to over and under pressure, gas separation, heat transfer, magma recirculation, and range of steady and nonsteady flow conditions that could occur for the duration of an igneous event**

Effects of Engineered Repository Structures on Magma Flow Processes
(Continued)

- **Planned Work**
  - Dike Propagation Analysis
  - Exsolution/Fragmentation Kinetics Analysis
  - Magma and Gas Flow Analysis
  - Revise Eruptive Processes and Soil Redistribution AMR, ANL-MGR-GS-000002, expected FY 2003
  - Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003
- **Discussion**

Effects of Subsurface Repository Structures on the Ascent of Basaltic Magma

- **NRC Proposed Agreement 3: Evaluate how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system. Include in this evaluation the potential effects of topography and stress in addition to a range of physical conditions appropriate for the duration of igneous events**

Effects of Subsurface Repository Structures on the Ascent of Basaltic Magma

(Continued)

- **Planned Work**
  - **Dike Propagation Analysis**
  - **Magma and Gas Flow Analysis**
  - **Conduit Size/Geometry Analysis**
  - **Revise Eruptive Processes and Soil Redistribution AMR, ANL-MGR-GS-000002, expected FY 2003**
  - **Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003**
- **Discussion**

Mechanical Strength of Natural or Engineered Barriers

- **NRC Proposed Agreement 4: Evaluate mechanical strength of natural or engineered barriers that are proposed to restrict magma flow within intersected drifts. A range of physical conditions appropriate for the duration of igneous events should be used in the evaluation**
- **Planned Work**
  - **Magma and Gas Flow Analysis**
    - **Erosion and entrainment of debris in drifts**
    - **Pressure-temperature conditions and durations**
  - **Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003**
- **Discussion**

Presence of Backfill or Rockfall May Affect Magma Flow Processes

- **NRC Proposed Agreement 5: If significant amounts of backfill or rockfall are thought to occur in repository drifts, evaluate the effects of these materials on magma flow processes throughout the duration of an igneous event. The analysis should include the potential effects of entrainment, meltback, and displacement of backfill**
- **This issue is closely related to the issue of Mechanical Strength of Debris Accumulations or Barriers (item 4)**

Presence of Backfill or Rockfall May Affect Magma Flow Processes

(Continued)

- **Planned Work**
  - **Magma and Gas Flow Analysis**
  - **Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003**
- **Discussion**

NRC Proposed Agreements
Magma-Waste Package Interactions

- **Evaluate canister responses to stress from dynamic magmatic repressurization, gravitational loading, and heating**
- **Evaluate aging effects on materials strength properties when exposed to basaltic magmatic conditions**
- **Evaluate the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gases**

Waste Package Response to Stress

- **NRC Proposed Agreement 7: Evaluate waste package response to stress from dynamic magmatic pressurization, internal pressurization, gravitational loading, and heating, using appropriate at-condition strength properties and flow paths, for duration of event**
- **Planned Work**
  - **Magma and gas flow and hydrothermal analyses will provide pressure, temperature, chemistry, and dynamic conditions for analyses and waste package modeling**
  - **Models will be developed for the response of the waste package to those conditions**
  - **Documentation will be provided in the appropriate technical document, expected FY 2003**
- **Discussion**

Aging Effects on Materials Strength Properties When Exposed to Basaltic Magma

- **NRC Proposed Agreement 8: Evaluate aging effects on materials strength properties when exposed to basaltic magmatic conditions for duration of an igneous event. Include in this evaluation the potential effects of seismically induced stresses on substantially intact waste packages**

Aging Effects on Materials Strength Properties When Exposed to Basaltic Magma

(Continued)

- **Planned Work**
  - Waste package analyses will include effects of aging prior to onset of an igneous event
  - Magma and gas flow analysis provides pressure, temperature, chemistry, and dynamic conditions for analyses and modeling of waste package response
  - Analysis will include aging effects after onset of an igneous event and will also address seismic vulnerability of aged waste packages
  - Document the waste package response to magmatic condition in an appropriate technical document, expected FY 2003
- **Discussion**

Waste Package Response to Magmatic Gases

- **NRC Proposed Agreement 9: Evaluate the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gases at conditions appropriate for a basaltic igneous event**
- **Planned work**
  - **Magma and gas flow and hydrothermal analyses will provide information on the distribution and time histories of magmatic gases in the repository**
  - **Models will be developed for the response of waste packages to those environmental conditions**
  - **Document the waste form response to magmatic condition in an appropriate technical document, expected FY 2003**

NRC Proposed Agreements
Magma-Waste Form Interactions

- Evaluate how ascent and flow through repository structures may incorporate HLW located along potential flow paths
- Physical and chemical response of HLW and cladding after heating and potential disruption of waste package (WP)
- Provide independent technical basis for the method of HLW incorporation used in DOE models

Magma Incorporation of HLW from Along Flow Paths

- NRC Proposed Agreement 6: Evaluate how ascent and flow through repository structures may incorporate HLW located along all potential flow paths that may occur during an igneous event. The evaluation should include such processes as segregation, two phase flow, heat transfer, convective flow, gas circulation of the magma, and evolution of the conduit and flow system
- Planned Work
  - Magma and gas flow analysis provides pressure, temperature, chemistry, and dynamic conditions for analyses and modeling by Waste Form Department
  - Revise Dike Propagation and Interaction with Drifts AMR, ANL-WIS-MD-000015, expected FY 2003

Magma Incorporation of HLW from Along Flow Paths

(Continued)

- **Planned Work**
  - **Analyze waste form response to magmatic environment in drifts within and outside of waste packages to determine waste form physical and chemical phases**
  - **Determine waste form physical and chemical phases for waste at surface in lava flows**
  - **Determine waste form physical and chemical phases for waste in ash plume**
  - **Describe potential changes in waste form caused by surface transport processes**
  - **Document the waste form response to magmatic condition in an appropriate technical document, expected FY 2003**
- **Discussion**

Physical and Chemical Response of HLW and Cladding

- **NRC Proposed Agreement 10: Evaluate the physical and chemical response of HLW and cladding after heating and potential disruption of waste package and contents, for waste packages remaining in drifts. Particular attention should be given to effects that may result in increased solubility potential relative to undisturbed HLW forms**
- **Planned Work**
  - **Magma and gas flow and hydrothermal studies provide pressure, temperature, chemistry, and dynamic conditions for waste form analyses and modeling**

Physical and Chemical Response of HLW and Cladding

(Continued)

- **Planned Work**
  - **Evaluate Commercial Spent Nuclear Fuel/High-Level Waste Glass/Defense Spent Nuclear Fuel dissolution kinetics after exposure to magma**
  - **Evaluate Commercial Spent Nuclear Fuel cladding pressurization; creep/hydride failure**
  - **Document the waste form response to magmatic conditions in an appropriate technical document, expected FY 2003**
- **Discussion**

Technical Basis for the Method of HLW Incorporation in DOE Models

- **NRC Proposed Agreement 12: Provide an independent technical basis for the method of HLW incorporation used in DOE models, including consideration of particle aggregation and the effect on waste transport**
- **Planned Work**
  - **Assess the waste incorporation mechanism that is implied in the ASHPLUME code**
  - **Revise Igneous Consequences AMR, ANL-WIS-MD-000017, expected FY 2003**
- **Discussion**

DOE Proposed Agreements

- **DOE proposes four agreements to address NRC igneous consequences concerns**
  1. **Tephra redistribution and soil suspension effects**
  2. **Effects of repository and contents on magma flow, including stress distribution and strain response**
  3. **Response of waste packages to magmatic conditions**
  4. **Incorporation of HLW in magma**

Tephra Redistribution and Soil Suspension Effects

- **DOE Proposed Agreement 1: DOE will evaluate conclusions that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization are bounded by conservative modeling assumptions in the TSPA-SR, Rev 00, ICN 01. DOE will examine rates of eolian and fluvial mobilization off slopes, rates of transport in Fortymile Wash, and rates of deposition or removal at proposed critical group location. DOE will evaluate changes in grain size caused by these processes for effects on airborne particle concentrations. DOE will also evaluate the inherent assumption in the mass loading model that the concentration of radionuclides on soil in the air is equivalent to the concentration of radionuclides on soil on the ground does not underestimate dose (i.e., radionuclides important to dose do not preferentially attach to smaller particles). DOE will document the results of investigations in the AMR, Eruptive Processes and Soil Redistribution ANL-MGR-GS-000002, expected to be available in FY 2003 and in the AMR, Input Parameter Values for External and Inhalation Radiation Exposure Analysis, ANL-MGR-MD-000001, REV 01, available FY 2003. Addresses NRC items 11 and 13.**

Effects of Repository and Contents on Magma Flow

- **DOE Proposed Agreement 2: DOE will evaluate how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system. The evaluation will include the potential effects of topography and stress, strain response on existing or new geologic structures resulting from thermal loading of HLW, in addition to a range of physical conditions appropriate for the duration of igneous events. DOE will also evaluate how the presence of engineered repository structures in the LA design (e.g., drifts, waste packages, backfill, etc.) could affect magma flow processes for the duration of an igneous event. The evaluation will include the mechanical strength and durability of natural or engineered barriers that could restrict magma flow within intersected drifts. The results of this investigation will be documented in an update to the AMR, Dike Propagation and Interaction with Drifts, ANL-WIS-MD-000015, expected to be available in FY 2003. Addresses NRC items 1, 2, 3, 4, and 5.**

Response of Waste Packages to Magmatic Conditions

- **DOE Proposed Agreement 3: Depending on the results of evaluations attendant to proposed agreement 2, DOE would evaluate waste package response to stresses from thermal and mechanical effects associated with exposure to basaltic magma, considering the results of evaluations attendant to proposed agreement 2. As currently planned, the evaluation, if implemented, would include (1) appropriate at-condition strength properties and magma flow paths, for duration of an igneous event; (2) aging effects on materials strength properties when exposed to basaltic magmatic conditions for the duration of an igneous event, which would include the potential effects of subsequent seismically induced stresses on substantially intact waste packages. DOE would also evaluate the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gasses at conditions appropriate for an igneous event, considering the results of evaluations attendant to proposed agreement 2. If models take credit for engineered barriers providing delay in radionuclide release, DOE would evaluate barrier performance for the duration of the hypothetical igneous event. The results of this investigation would be documented in an update to the technical product Waste Package Behavior in Magma CAL-EBS-ME-000002, which would be available by the end of FY 2003. Addresses NRC items 7, 8, and 9.**

Incorporation of HLW in Magma

- **DOE Proposed Agreement 4: Depending on the results of evaluations attendant to proposed agreements 2 and 3, DOE would evaluate how ascent and flow of basaltic magma through repository structures could result in processes that might incorporate HLW, considering the results of evaluations attendant to proposed agreements 2 and 3. As currently planned, the evaluation, if implemented, would include the potential for HLW incorporation along reasonable potential flow paths that could develop during an igneous event. The evaluation would also include the physical and chemical response of HLW and cladding after heating and potential disruption of waste package and contents, for waste packages remaining in drifts. The evaluation would examine effects that may result in increased solubility potential relative to undisturbed HLW forms. The results of this investigation would be documented in a new AMR to document the waste form response to magmatic conditions, which is expected to be available by the end of FY 2003**

DOE would describe the method of HLW incorporation used in DOE models, including consideration of particle aggregation and the effect on waste transport. If models take credit for engineered barriers providing delay in radionuclide release, DOE would evaluate barrier performance for the duration of the hypothetical igneous event. This would documented in an update to the igneous consequences AMR, ANL-WIS-MD-000017, which is expected to be available in FY 2003.
Addresses NRC items 6, 10, and 12.

Summary

- New information on magma-repository interactions was identified at the June 21-22, 2001 DOE-NRC technical exchange
- NRC proposed 13 agreements as the basis to close-pend the consequences subissue
- DOE has developed plans to evaluate igneous consequences to strengthen the basis supporting any potential license application
- Completed and planned work will provide the technical basis for a risk-informed defensible position on igneous activity for the license application
- Completed and planned work is sufficient to address NRC concerns and close-pend the consequences subissue

Summary of the Resolution of the Key Technical Issue on Igneous Activity - Agreements Reached

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Probability of future igneous activity	Closed-Pending	See agreements from August 29-31, 2000.
2	Consequences of future igneous activity	Open	IA.2.11 - Provide an analysis that shows the relationship between any static measurements used in the TSPA and expected types and durations of surface disturbing activities associated with the habits and lifestyles of the critical group. DOE will provide an analysis that shows the relationship between any static measurements used in the TSPA and expected types and durations of surface disturbing activities associated with the habits and lifestyles of the critical group in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document. This will be available to the NRC in FY02. IA.2.12 - Provide clarifying information on how PM10 measurements have been extrapolated to TSP concentrations. This should include consideration of the difference in behavior between PM10 and TSP particulates under both static and disturbed conditions. DOE will provide clarifying information on how PM10 measurements have been extrapolated to TSP concentrations. This will include consideration of the difference in behavior between PM10 and TSP particulates under both static and disturbed conditions in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document. This will be available to the NRC in FY02.

			IA.2.13 - Provide the justification that sampling of range of transition period BDCFs is necessarily conservative in evaluating long-term remobilization processes. DOE will provide the justification that sampling of range of transition period BDCFs is necessarily conservative in evaluating long-term remobilization processes in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document. This will be available to the NRC in FY02. IA.2.14 - Provide information clarifying the method used in TSPA to calculate how deposit thickness effects the average mass load over the transition period. DOE will provide information clarifying the method used in TSPA to calculate how deposit thickness effects the average mass load over the transition period in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document. This will be available to the NRC in FY02. IA.2.15 - Clarify that external exposure from HLW-contaminated ash, in addition to inhalation and ingestion, was considered in the TSPA. Include in this clarification the consideration of external exposure during indoor occupancy times, or provide basis for dwelling shielding from outdoor gamma emitters. DOE will clarify that external exposure from HLW-contaminated ash, in addition to inhalation and ingestion, was considered in the TSPA. DOE will include in this clarification the consideration of external exposure during indoor occupancy times, or provide basis for dwelling shielding from outdoor gamma emitters in a subsequent revision to the AMR Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) or equivalent document. This will be available to the NRC in FY02.

			IA.2.16 - Document that neglecting the effects of climate change on disruptive event BDCFs is conservative. DOE will document that neglecting the effects of climate change on disruptive event BDCFs is conservative in a subsequent revision to the AMRs Input Parameter Values for External and Inhalation Radiation Exposure Analysis (ANL-MGR-MD-000001) and Disruptive Event Biosphere Dose Conversion Factor Analysis (ANL-MGR-MD-000003) or equivalent document. This will be available to the NRC in FY02.

Summary of the Resolution of the Key Technical Issue on Igneous Activity - Agreements Not Reached

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Probability of future igneous activity	Closed-Pending	N/A
2	Consequences of future igneous activity	Open	1) Evaluate the stress distribution and strain response on existing or new geologic structures resulting from thermal loading of HLW. The evaluation should include appropriate spatial variations in overlying topography and appropriate spatial and temporal variations in thermal load. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 2) Evaluate how the presence of engineered repository structures (e.g., drifts, waste packages, etc.) can affect magma flow processes for the duration of an igneous event. Include in this evaluation the potential effects on initial magma flow characteristics, diversion of ascending magma into repository structures, reestablishment of multiple flow-paths to the surface, two phase flow, reaction of the geologic and engineered system to over and under pressure, gas separation, heat transfer, magma recirculation, and range of steady and nonsteady flow conditions that could occur for the duration of an igneous event. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue.

			3) Evaluate how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system. Include in this evaluation the potential effects of topography and stress, in addition to a range of physical conditions appropriate for the duration of igneous events. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 4) Evaluate the mechanical strength of natural or engineered barriers that are proposed to restrict magma flow within intersected drifts. A range of physical conditions appropriate for the duration of igneous events should be used in the evaluation. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 5) If significant amounts of backfill or rockfall are thought to occur in repository drifts, evaluate the effects of these materials on magma flow processes throughout the duration of an igneous event. The analysis should include the potential effects of entrainment, meltback, and displacement of backfill. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 6) Evaluate how ascent and flow through repository structures may incorporate HLW located along all potential flow paths that may occur during an igneous event. The evaluation should include such processes as segregation, two phase flow, heat transfer, convective flow, gas circulation of the magma, and evolution of the conduit and flow system. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue.

			7) Evaluate waste package response to stresses from dynamic magmatic pressurization, internal pressurization, gravitational loading, and heating, using appropriate at-condition strength properties and magma flow paths, for duration of an igneous event. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 8) Evaluate aging effects on materials strength properties when exposed to basaltic magmatic conditions for the duration of an igneous event. Include in this evaluation the potential effects of subsequent seismically induced stresses on substantially intact waste packages. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 9) Evaluate the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gasses at conditions appropriate for an igneous event. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 10) Evaluate the physical and chemical response of HLW and cladding after heating and potential disruption of waste package and contents, for waste packages remaining in drifts. Particular attention should be given to effects that may result in increased solubility potential relative to undisturbed HLW forms. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue.

			11) Provide a technical basis to support conclusions that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization are bounded by conservative modeling assumptions in the TSPA-SR, Rev00, ICN1. Particular attention should be paid to: (i) rate of mobilization off slopes, (ii) rate of transport in Fortymile Wash drainages, (iii) rate of transport from eolian processes, (iv) deposition rate at proposed critical group location, (v) changes in particle-size distributions during fluvial transport. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 12) Provide an independent technical basis for the method of HLW incorporation used in DOE models, including consideration of particle aggregation and the effect on waste transport. DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue. 13) Provide support that the inherent assumption in the mass loading model that the concentration of radionuclides on soil in the air is equivalent to the concentration of radionuclides on soil on the ground does not underestimate dose (i.e., radionuclides important to dose do not preferentially attach to smaller particles). DOE acknowledges the NRC proposed agreement and will address this agreement as part of the consolidated response to NRC's proposed agreement items for the consequence subissue.

CHANGES TO EXISTING IGNEOUS ACTIVITY NRC/DOE AGREEMENTS

IA.2.02 - Document results of sensitivity studies for particle size, consistent with (1) above. DOE agreed and will document the waste particle size sensitivity study in ~~TSPA-SR, Rev. 1~~ a calculation document. This will be available to the NRC in ~~June 2001~~ FY2002.

IA.2.03 - Document how the tephra volumes from analog volcanos represent the likely range of tephra volumes from Yucca Mountain Region (YMR) volcanos. DOE agreed and will document the basis for determining the range of tephra volumes that is likely from possible future volcanoes in the YMR in ~~TSPA-SR, Rev. 1 or demonstrate that TSPA-SR results are insensitive to uncertainties in the reasonably expected volumes of tephra in the YMR~~ the Eruptive Processes AMR (ANL-MGR-GS-000002). This will be available to the NRC in ~~June 2001~~ FY2002.

IA.2.04 - Document that the ASHPLUME model, as used in the DOE performance assessment, has been compared with an analog igneous system. DOE agreed and will complete calculation CAL-WIS-MD-000011 that will document a comparison of the ASHPLUME code results to observed data from the 1995 Cerro Negro eruption. This will be available to the NRC in January 2001. DOE will consider Cerro Negro as an analog and document that in ~~TSPA-SR Rev. 1~~ the Eruptive Processes AMR (ANL-MGR-GS-000002). This will be available to the NRC in ~~June 2001~~ FY2002.

IA.2.05 - Document how the current approach to calculating the number of waste packages intersected by conduits addresses potential effects of conduit elongation along a drift. DOE agreed and will document the way in which the change in geometry of the repository drifts affects the number of waste packages incorporated into the volcanic conduit. Possible consequences of conduit elongation parallel to drifts will be documented in TSPA-SR Rev. 1, available to the NRC in June 2001. This agreement has been superceded by the proposed NRC Agreements in Attachment 2.

IA.2.06 - Develop a linkage between soil removal rate used in TSPA and surface remobilization processes characteristics of the Yucca Mountain region (which includes additions and deletions to the system). DOE agreed and will document its approach to include uncertainty related to surface-redistribution processes in TSPA-SR, Rev. 0. DOE will revisit the approach in TSPA-SR, Rev. 1. This documentation will be available to the NRC in June 2001. This agreement has been superceded by the proposed NRC Agreement 11 in Attachment 2.

IA.2.07 - Document the basis for airborne particle concentrations used in TSPA in Rev. 1 to the Input Values for External and Inhalation Radiation Exposure AMR. DOE agreed and will provide documentation for the input values in the Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR [ANL-MGR-MD-000001] Rev. 1. This will be available to NRC in January 2001. This agreement has been superceded by the NRC/DOE Agreements IA.2.11 to 2.16 in Attachment 1.

IA.2.09 - Use the appropriate wind speeds for the various heights of eruption columns being modeled. DOE agreed and will evaluate the wind speed data appropriate for the height of the eruptive columns being modeled. This will be documented in ~~TSPA-SR, Rev. 1~~ a calculation document. This will be available to the NRC in ~~June 2001~~ FY2002.

IA.2.10 - Document the ICNs to the Igneous Consequences AMR and the Dike Propagation AMR regarding the calculation of the number of waste packages hit by the intrusion. Include in these or other documents (1) the intermediate results of the releases from Zone 1 and 2, separately, and (2) the evaluation of thermal and mechanical effects, as well as shock, in assessing the degree of waste package damage in Zone 1 and 2. DOE agreed and will provide ICN 1 of the following AMRs: Igneous Consequences Modeling for TSPA-SR AMR [ANL-WIS-MD-000017], the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015], the Characterize Framework for Igneous Activity at Yucca Mountain, Nevada AMR [ANL-MGR-GS-000001], and the Calculation Number of Waste Packages Hit by Igneous Intrusion [CAL-WIS-PA-000001]. This will be available to the NRC in January 2001. DOE will provide the results showing the relative contributions of releases from Zones 1 and 2 in ~~TSPA-SR, Rev. 1~~ a calculation document. This will be available to the NRC in ~~June 2001~~ FY2002. DOE will provide the evaluation of thermal mechanical effects on waste package damage in Zones 1 and 2 in ICN 1 of the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015]. This will be available to the NRC in January 2001.